CONFERENCE PROCEEDINGS

Organisation For Women in Science
For the Developing World (OWSD)

2nd AFRICA REGIONAL CONFERENCE 2013

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Climate Change and its Impact on Africa:
The Role of Science and Engineering for Combat
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FOREWORD

The era of great inventions and far reaching scientific ideas has its own accompanying devastating effects which has left the world still researching and thinking for commensurate solutions to tackle the problems head on. Researchers all over the world are now saddled with an enormous responsibility of finding practically workable solutions to climate change issues in a manner that will ensure sustainability of the environment. Climate patterns play a fundamental role in shaping natural ecosystem which, invariably influence the human economies and cultures. Nations vary in their ability to cope and adapt to climate change and it is disheartening that Africa has been identified as the most vulnerable to projected climate change impacts based on her widespread poverty which in turn limits her adaptation capabilities, unfortunately women are mostly affected.

It was in the light of this that the Organization of Women in Science for the Developing World (OWSD) organized the 2nd Africa Regional Conference in October, 2013 under the theme " **Climate Change and Its Impact on Africa: The Role of Sciences and Engineering"**. The conference was hosted by the University of Energy and Natural Resources (UENR), Sunyani in the Brong Ahafo Region of Ghana and attended by over 400 scientists, researchers, academicians and practitioners across the sub-Saharan Africa. The conference covered twelve (12) thematic issues in the area of Climate Change and its linkages with i) Biodiversity; ii) Education; iii) Energy; iv) Food Security; v) Gender Mainstreaming; vi) Health Delivery; vii) Legislation and Policy for sustainable Development; viii) Millennium Development Goals; ix) Natural Resource Management; x) Political Instability in Africa; xi) Technology and Climate Change and xii) Water Resources.

The proceedings comprises the scientific papers within the scope of research of the participants. It is full of relevant information on climate change with respect to the above mentioned topical issues which lend special credence to the African terrain. With the rich research experience of the participants coupled with their in-depth analyses of the data, the proceedings have the potential of fostering mitigation and adaptation of the adverse effect of climate change.

Prof. (Mrs) Esi Awuah
Vice Chancellor, UENR and Executive Board member of OWSD Africa Region

MESSAGES AND CONFERENCE COMMUNIQUE

Welcome Address By Prof. Mrs. Esi Awuah, Vice-Chancellor, UENR

Oh Lord I will honour you and praise your name, for you are my God. You do such wonderful things. You planned them long ago and you have accomplished it. Isaiah 25:1

Science and engineering have played a very important role in the development of several technologies, including air planes, blenders, space exploration. Our quest to explore science and technology has brought mankind far. No country can develop and reach a higher economic status without science and engineering. Many countries made it a point to develop their science and engineering and have made giant strides. If you take 154 Chinese one of them is an engineer. In Africa it could be as high as 1 in 10,000. Climate change impact on the continent cannot be solved without science and engineering. The papers we will be presenting show how serious climate change is and the need to wake up as a continent before we experience disasters unawares. You students here present must take your studies seriously to combat climate change as your debate on gender and climate Change will show in the course of the program. You must study science and mathematics. It is not what you want to learn but what needs to learned.

We at UENR would like to train scientists and engineers to handle fire and disasters associated with Climate change and other hazards due to improper planning. You will remember not long ago, that one of the big shopping malls in Ghana collapsed and we had to bring engineers and technicians from Israel to help us. We want to collaborate with Israeli institutions who are offering such programs to train our students beginning next academic year. Mankind is looking up to women scientists and engineers to help and Africa should not be left out. God bless you all for coming and making Africa great with scientists and engineers to help combat climate change impacts

Keynote Address By Dr.Letitia Obeng

1st Woman Scientist in Ghana

Judging from the history, climate change on our planet is a uniquely grave event. It produces major catastrophes, disrupts the lives of people, destroys key resources and causes the extinction of plant and animal species. Even more serious, it can cause death of people unable to adapt to it. Your Conference to consider it is therefore most appropriate.

With that realization, I am encouraged to use the time that you have given me to share my thought with you on the subject of climate change in Africa in a different way. I leave the consideration of the technicalities of climate change in your capable hands.

Instead, I should like to urge you, to include in your intended program, specific, investigative and innovative studies that will produce practicable strategies against the impact of climate change on our continent. I should like to urge that you consider research and studies that ensure that your hard work, as scientists and engineers, produces ultimately, down- to- earth, concrete action to be implemented at the level of the people!

A glaring point of worry is that, in spite of our continent's wide range of inadequacies, its stated vulnerability to climate change and tight links of economies of our countries to climate-sensitive sectors, so far, our continent's essential adaptive responses have been extremely limited. And, even where adaptation plans have been prepared, hardly any attention is being paid to starting implementation.

And, an even more worrying fact is that, up till now, our people – mother, daughters, sisters, sons, brothers and husbands do not know what is going on! Among ordinary people in many countries, the level of awareness of the current climate change appears non-existent or negligible! They need to know!

For some time now, we have been aware of a formidable range of strange and unusual climatic events in many regions of the world. There have been extremes of flooding, landslides, droughts, violent storms, brutal hurricanes and destructive typhoons and cyclones.

Ask our own farmers – and they will tell you their worry because of less rain, of changed and shorter growing seasons of floods, landslides and droughts destroying their crops and livestock. We ourselves can testify to unusual impacts – through rains which may be too much or too little or in the wrong place or not fall at all!

All these extreme climatic events have water as common factor. And, now, it has been reasonably established that, of all the earth's resources, the most vulnerable through which the impact of global climate change will be most severely felt by human communities, is water

I hope that each one of you, Members of OWSD Africa here present will develop a clear vision towards understanding the intricacies of the problem that our continent faces so that with your expertise and overwhelming capabilities, you find practical basis for effective action to help and protect our people.

To this end, I suggest that each one of you should make a special effort to dialogue with your leaders, with members of the governing bodies of your counties, your national policy and decision makers, your parliamentarians and citizens who will listen – and persuade them to accept responsibility for the organization of your country's program of adaptation to the impacts of climate change.

A further reason why you have to court dialogue with them is because it is important that they buy into the solutions that you, as scientists and engineers, may develop in response to the impact of climate change. If your scientific and technological initiatives are to be integrated into national policy, there must be a close dialogue between you , your decision makers and implementers.

I must however still stress that, facing the impact of climate change is far from being an academic matter! Escalating challenges will have a direct impact on lives of real, live people: our people who, unable to adapt to adverse conditions may very well die and perish!.

So reach out and interact with other, and with the many researchers and scientists around the world. Consult, preferably in small, cost–effective groups. Get close to the youth and to ordinary people. Talk to them in languages that they understand. You will be pleasantly surprised and inspired by the refreshing local, African experiences that you may find. And, when you do, share and pass them on!

I also believe that, with other women on our continent who are also richly endowed with varying forms of knowledge and expertise, OSWD Africa can initiate and develop constructive changes to help our people.

At this moment in history, our world is rich in ideas and awash with new, amazing and pleasantly exciting technologies. I urge you to embrace them to help mould and move our continent forward into a great future.

Fratenity Message: OWSD President, Prof. Fang Xin

It is wonderful to see how many African women scientists are involved in this crucial research topic. Men and women are affected by climate change in different ways. Women are often the primary food producers and providers of water for their families for example. Women have to pick up the pieces when homes are destroyed by sudden flooding, or when there is not enough wheat to make the bread. Climate change for many reasons can place a greater burden on women.

We look forward to hearing the results of this conference and are sure that your research will contribute to helping resolve climate issues and women's roles on these issues. As an international organization OWSD has been promoting more women in science for the past quarter of a century - indeed we celebrate our 25th anniversary next year in Mexico and we hope to see many of you there. I send you my best wishes for ongoing collaboration and networking opportunities and wish you safe journeys home.

Fratenity Message: Prof.Romain Murenzi Executive Director of TWAS, *The World Academy of Sciences for the Advancement of Science in the Developing Countries*

TWAS believes in increasing the number of women in science in Africa. I believe in OWSD and support your activities. Congratulations!.

Guest Address: Prof. (Mrs.) Dolly Awani Ighoroje, Vice President OWSD African Region

OWSD in general and in Africa in particular is playing a vital role in enhancing women's access to and participation in, science, technology and development. It is not surprising therefore that we have been able to attract this high number of women scientists in the region with the best brains in science and technology to Sunyani, Ghana to come and report and show case their research work and contributions to knowledge and development geared towards tackling the menace of climatic change and it consequences on the environment.

OWSD is a great organization and its membership in the region is the largest currently totalling more than 1614 registered members, this number is rapidly and constantly increasing.

OWSD Africa I can assure you is forging ahead in the right direction.Since my tenure as the Vice President of OWSD African Region we have published (i) Proceedings of TWOWS African Regional Conference 16-20 Nov. 2009, (ii) Biannual publications of TWOWS Africa International Journal of Science and Technology (TAIJST) since 2010. We are the only region that currently has a regional scientific journal designed to meet the developmental needs not only of her members in the region but also the needs of scientists globally. TAIJST is peer reviewed, 3 volumes from 2010 -2012 have been published so far (Online and hard copies are available) 4th Vol for 2013 is in preparation. A decision to go purely online and free accessing has been considered by the Editorial Board to reduce cost and to have a global reach with greater impact value. The process for it to be indexed has begun. At this point I wish to thank the editorial board and especially the managing editor Professor Mary Edema who has tirelessly worked very hard to sustain its publication despite the teething challenges encountered most prevalently poor patronage. We hope to overcome this as soon as it is indexed and her impact factor and visibility is increased. (iii) Various newsletters by individual chapters as well as conference brochures have been released and are available.(iv) Capacity building is achieved through programs and various activities including training workshops, seminars and conferences carried out at all levels and also through the various fellowships and scholarships programs coordinated from Trieste in collaboration with UNESCO and awarded to OWSD members. (v) The central mentor- mentee programme designed and proposed is yet to fully be operational but I am hoping that together with other programs it will promote and enhance the development of females in areas of science and technology at all levels.

I plead with Governments at all levels in the African Continent to give due recognition to OWSD, her activities and the power she has through the large pool of quality scientists she is contributing to the national human resource pool and which is readily made available for national development. I wish to extend my immense gratitude to the local organizers who worked so tirelessly to ensure that this conference was executed. Enjoy the warm hospitality of Ghana and build memories as you settle down and enjoy the conference.

Communiqué of the 2nd Africa Regional Conference of the Organization of Women in Science for the Developing World (OWSD)

October 15-18, 2013

University of Energy and Natural Resources (UENR)

Sunyani, Ghana

Preamble

The Organization for Women in Science for the Developing World (OWSD) is an independent, non-governmental, nonprofit body based at the headquarters of the Third World Academy of Sciences (TWAS) in Trieste, Italy. OWSD unites women scientists from both developing and developed countries with the objective of strengthening their role in the development process and promoting their representation in scientific and technological leadership. OWSD Africa works through its regional conferences, national conferences and national chapters to support and promote both in-country and continent-wide activities and policies which improve female participation in science and technology.

The 2nd Africa Regional Conference of OWSD was hosted by the University of Energy and Natural Resources (UENR), from October 15 - 18, 2013 in Sunyani, Ghana, under the theme, ***"Climate Change and its Impact on Africa: the Role of Science and Engineering for Combat."*** Under the main theme, conference presenters and participants deliberated on twelve thematic areas: i) climate change and legislation and policy for sustainable development; ii) climate change and gender mainstreaming; iii) climate change and natural resource management; iv) climate change and ecosystems/biodiversity; v) climate change and energy; vi) climate change and millennium development goals, vii) climate change and education, viii) climate change and food security; ix) climate change and water resource management; x) climate change and health delivery; xi) climate change and political instability in Africa, and xii) climate change and technology.

In addition to addressing climate change and education as a sub-theme, this conference also featured a unique day-long program for Senior High School students from ten schools in Ghana, held at the University of Energy and Natural Resources (UENR) premises on Wednesday, October 16, 2013. The students received both mentorship and an opportunity to practice their public speaking skills.

The key findings, observations and recommendations on climate change as it relates to the afore-mentioned themes are herein summarized:

Findings and Observations

- Climate change has both direct and indirect effects on health, including thermal stress leading to cardiovascular and respiratory morbidity, an increased burden of malaria and decreased access to healthcare facilities due to damaged infrastructure, and malnutrition, which can cause an increase in infectious disease spread.
- Food availability, stability, quality and access in Africa are extremely sensitive to climate change. This is because food production is largely through rain-fed agriculture.
- Heavy dependence on fossil fuels has long been recognized as a major contributor to greenhouse gas emissions and climate change patterns across the world.

Africa's situation is further complicated by a relatively high reliance on forest resources for charcoal and firewood production, which further contribute to climate change.

- Extreme weather conditions caused by climate change, such as floods and droughts, threaten Africa's progress towards achievement of the MDGs in wastewater management, food security, health delivery and water supply.
- The impact of climate change in Africa is undeniably gendered. When extreme weather patterns lead to floods and persistent droughts, women usually bear the greatest burden as they struggle to secure food and/or water, often not just for themselves, but for their entire families. This may worsen poverty and lead to climate-related migration, putting women at even greater risk for violence and disease.
- The quest to address the impact of climate change, promote effective waste-reduction, and shrink our carbon footprints, requires involvement from and cooperation among individuals, educators, communities, private companies and governments. Researchers are central to this process because they can provide a reliable evidence-base to facilitate an informed policy making process.
- Climate patterns play a fundamental role in shaping natural ecosystems, which invariably influence human economies and cultures.
- There are millions across Africa without access to safe drinking water and sanitation. Climate change has led to the emergence of new diarrheal agents, extreme heat rises and pollution of natural water resources, worsening the water crisis.
- Technological devices with mobile alert systems are indispensable for enhancing disaster preparedness.
- Climate change has the potential to threaten peace and security in some sub-regions in Africa. Cooperation among African governments in the fight against climate change is thus imperative.

Recommendations

In view of the afore-mentioned observations and findings, OWSD Africa recommends that:

1. specific, investigative and innovative research be conducted to produce practical strategies for climate change mitigation and adaptation in Africa, such as drip irrigation to improve the vulnerable rain-fed agricultural system;

2. climate change be recognized as a significant public health threat in Africa, one that must be on the continent's public health agenda, along with tropical, infectious and non-communicable diseases;

3. members of Parliament be paired with Fellows of Academic, Research, or Scientific bodies like OWSD to promote collaboration and facilitate dialogue to harness policy–science synergy;
4. female scientists be encouraged to pursue technology-oriented study and research, since there are few female scientists in this area as observed in the papers presented;
5. women be empowered and included in the policy making process, in view of the gendered dimension of vulnerability to climate change;
6. climate change research and public education efforts be doubled, drawing upon relevant information and local examples to heighten awareness of the need for climate change mitigation and adaptation;
7. there must be a dedicated effort on the part of developed countries to reduce greenhouse gas emissions, and that they contribute to research funding to develop Africa's capacity for climate change adaptation;
8. educational curricula, from primary school through tertiary, include intentional training on climate change adaptation and mitigation;
9. policies be reformulated and new ones created to effectively promote climate change mitigation and adaptation governance;
10. the agricultural sector encourage crop substitution, the use of environmentally safe bio-fungicides, capacity building for crop and livestock farmers, rural agricultural credit schemes, land management practices that protect soil carbon, as well as investment in sustainable agricultural and food system; and
11. governments must promote research on renewable and clean energy development - including converting wood residue to energy and harnessing solar, hydro, biogas and wind energy - to successfully mitigate the energy impact of climate change in Africa.

Prof. (Mrs). Esi Awuah
Vice-Chancellor
University of Energy and Natural

Ighoroje

Prof. Ahbor D.A. Ighoroje
Vice President
OWSD Africa Region

THEME 1: CLIMATE CHANGE AND BIODIVERSITY

Effect of Priming and Scarification Techniques on Seed Germination for Indigenous Fruit Trees, Strategy against Climate Change: A case study of *Maesobotrya barteri*

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ABSTRACT

Poor seed germination has drastically constrained wide spread of Red Maeso (*M*aesobotrya *barteri* /Bush cherry) coupled with rapid industrialization and deforestation as a result of climate change. Clonal propagation is the alternative but slow. A seed germination experiment was conducted in the screen house, the Federal University of Technology, Owerri. The pre-sowing seed treatments *M. barteri were soaked* in cold water (hydropriming) and 5g Potassium chloride solution (halopriming) for 6,12,24 hours respectively. Similarly, the seeds were soaked in 0.5% concentrated sulphuric acid for 1,30, 60 seconds, sand scarification involving seed-sand mixture in a shaker for 30 minutes and control (no treatment applied). All treated seeds were sowed in sawdust as a growth medium. A total of 11 treatments replicated three (3) times. The experiment lasted for 4 weeks after emergence, during which data were collected to calculate percentage seed emergence (PSE), emergence index (EI), mean emergence time (MET), coefficient velocity of emergence (CVE), root and shoot lengths, seedling fresh and dry weight of Red Maeso*.* Data collected were analysed using general ANOVA at 5% significance level. Sand scarification, cold water (6 hours) and potassium chloride solution (24hours) improved *M. barteri* percentage seed emergence (95%, 95% and 70%), coefficient velocity of emergence (3.46, 3.27 and 3.57), emergence index (549. 0, 581.0 and 392. 0) and mean emergence time (28.8, 30.6 and 28.0 days) and seedling growth parameters respectively. These seedlings when established will protect our environment against species extinction.

Keywords: Seed, Priming, *Maesobotrya barteri,* Scarification, Climate Change

INTRODUCTION

Tropical forests are an important reservoir of crop and animal biodiversity and play a fundamental role in giving satisfaction to many needs of the people. Nowadays, the non-timber forest products, exploited and consumed by Nigeria are becoming very scarce due to high human pressure, over exploitation, non-sufficient silvicultural data and climate change highlighted by the recurrent dry and rainy seasons. The situation compromises most local people food security and income (Ouinsavi, 2011). Most edible fruits are commonly collected from in the wild, often kept in protected systems and widely consumed. Some have excellent flavour, attractive fragrance and delicious taste (Pantastico, 1975).

Fruits often form a vital part of human nutrition. Some are eaten as a refreshing delicacy, others make up a meal. In whatever way consumed, they are valuable because of the minerals and vitamins they contribute to the diet. Campbell (1986) noted that women and children know many wild fruits which can be used for food and medicine. They know how to gather, prepare and use different kinds of wild fruits. The harvesting, utilizing and marketing of indigenous fruit and nuts have been central to the livelihoods of majority of rural communities throughout Africa (Akinnifesi *et al.,* 2007; Leakey *et al.,* 2005) and can make a difference during period of famine and food scarcity (Mithofer and Waibel, 2003;Akinnifesi *et al.,* 2006). Wild harvesting of fruits from forests and semi-domesticated trees growing on-farm and homesteads can substantially boost rural income and employment opportunities in Africa (Leakey *et al.*, 2005; Ruiz-Perez *et al.*, 2004). In Nigeria, the species Red Maeso (Photo 1) is under-exploited although the tree is of both medicinal and nutritional importance. It bears edible succulent black-purple berries usually marketed and hawked by women and children, male and female alike.

Climate change is considered to be a critical global challenge and recent events have demonstrated the world's growing vulnerability to climate change. The impacts of climate change range from affecting agriculture to further endangering food security, to rising sea-levels and the accelerated erosion of coastal zones, increasing intensity of natural disasters, species extinction and the spread of vector-borne diseases. Rapid and uniform seed emergence is an essential prerequisite to natural volunteer expansion, increased yield, quality and ultimately profits to marketer. This scenario of volunteer seed germination is very rare in Red Maeso and so suggests very serious seed dormancy implication. Several studies on seed dormancy break, germination and emergence revealed the beneficial effects of seed priming by several ways including heat, smoke, soaking leaching, temperature, scarification and including NaCl salinity (Hassanein, 2010). Poor seed germination has drastically constrain wide spread of *M. barteri*. Thus, different scarification techniques were tried to facilitate seed germination in Red Maeso.

This study investigated the effects of priming and scarification techniques of *M. barteri,* an indigenous fruit tree in sawdust growth medium in the screen house nursery as a strategy to combat climate change

Unripped Ripped fruits loose fruits

Plate 1: Fruits of *Maesobotryabarteri* (Red Maeso/ bush cherry).

MATERIALS AND METHODS

The experiment of pre-sowing treatments of *Mesobotrya barteri* was conducted in the Screen house of the Federal University of Technology, Owerri, Imo state. The treatments were six seed soaking regimes in cold water and 5g of potassium chloride/litre of water for 6, 12 and 24 hours respectively, three seed soaking regimes in 0.5% of concentrated sulphuric acid (quick dip, 30 and 60 seconds), sand scarification for 30 minutes and control (unsoaked) seeds. The treatments were 11 replicated 3 times with a total number of 330 fruit seeds and sown in sawdust growth medium.

The fresh fruits were harvested from healthy stands of protected Red Maeso trees at the University farms, Owerri in Imo state, Nigeria. A total number of three hundred and thirty seeds (330) seedlot was subdivided into 10 seedlot per treatment of three replicates. Each seedlot was introduced into a 50cl beaker containing appropriate solution for specific periods using stop clock and decanted into disposal sink. Sand scarification involved 1:1 seed: sand mixture in a shaker held beaker for 30 minutes. The untreated seedlot was the control. Seeds treated with chemicals were rinsed clean in a running tap. All seeds were spread out dry over night before seeding in sawdust. The experiment lasted for 4 weeks after seed emergence.

Data were collected for percentage seed emergence(number of germinated seeds/ Total number of planted seeds) multiplied by 100.Germination Index (GI) according to theequation of Kader and Jutzi, (2004): $GI = \Sigma (T_iN_i)$.Ti: number of day after sowing and Ni: number of germinated seeds in the day. Mean germination time (MGT) calculated according the formula of Ellis and Roberts, (1981). $MGT = \Sigma (n_i/d_i)$. With ni: number of germinated seeds and di: day of counting.

Coefficient of velocity (CV) = (number of germinated seeds per day) according to Kader and Jutzi formula, 2004. CV= (ΣNi /100) x (Σ Ti Ni). Root length, seedling height meter rule, seedling fresh weight and seedling dry weight were weighed using a sensitive weighing balance. All data were analysed using general ANOVA at 5% significance level Genestat(2004) discovery model. The means were separated for significance using Least Significance Difference.

RESULTS AND DISCUSSION

Results

The results (Table 1) on germination indices suggested that various levels of hydropriming (cold water) and halopriming (Potassium chloride)of various levels 6,12 and 24 hours respectively; sand scarification, sulphuric scarification and control (unprimed) significantly ($P<0.05$) affected seed percentage emergence, coefficient velocity of emergence, emergence index and mean emergence time of *M. barteri* seeds.

Table 1: Emergence indices of *M. barteri*

Treatments	E %	CVE	GI	MET (Days)
H_2O				
6h	95.00	3.27	581.00	30.60
12h	65.00	3.08	424.00	32.50
24h	45.00	3.10	283.00	32.80
Kcl				
6h	45.00	3.02	216.00	34.20
12h	65.00	3.01	380.00	32.40
24h	70.00	3.57	392.00	28.00
H_2SO_4				
Quick dip	10.00	2.94	67.00	34.00
30 Sec.	0.00	0.00	0.00	0.00
60 Sec.	0.00	0.00	0.00	0.00
Scarification	95.00	3.46	549.00	28.80
Control	35.00	3.01	202.00	33.50
$LSD_{(0.05)}$	15.32	0.10	107.70	2.31

Emergence percentage

Hydro primed (6h) and sand scarified seeds had 95% emergence respectively and was significantly ($P<0.05$) higher, followed by halo primed (24h) seeds. Primed KCl (12h) seeds were significantly higher than unprimed (35%).

The results suggested that the highest coefficient velocity of emergence of 3.57 was observed on halo primed (24h) followed by sand scarification (3.46) and hydro primed

(6h) seeds. Sulpuric acid scarification seeds had the least coefficient velocity of emergence of 2.94.

Emergence index

Emergence index (EI) showed that the highest of 581 was found in the presence of hydro primed (6h) followed by 549 (sand scarification) and 424(KCl 12h). H_2SO_4 Quick dip) had the least emergence index of 67.

The shortest emergence time of 28.0 and 28.8 days were observed in KCl (24h) and sand scarification respectively and followed by 30.6 of 6h (hydro primed). H_2SO_4 Quick dip and control (unprimed) had 34.0 and 33.5 days respectively.

The growth indices of M. barteri

Table (2) showed that root length of 6h (8.07) hydro primed seeds were significantly ($P<0.05$) longer than those of KCl, sulphuric acid treatments and unprimed. The shoot heights of sand scarification (3.53cm) is significantly ($P<0.05$) taller than those halo primed (12 and 24h; H_2SO_4 and control respectively. Fresh weight of *M. barteri*seedling from hydoprimed (24h) was 0.33g and significantly ($P<0.05$) bulkier than those of KCl 12h (0.22g) and control (0.24g) respectively.Dry matter weight from 24h water priming and sand scarification were significantly heavier than those of 12h water and 12h KCl treatments. Furthermore, hydro primed (6h) seedlings were significantly heavier than those in 6hs of KCl.

Table 2: Growth parameter of *M. barteri* seedlings

Treatment	Shoot Ht (cm)	Root Lt (cm)	Fresh wt (g)	Dry matter wt (g)
H_2O				
6h	3.23	8.07	0.31	0.07
12h	3.00	7.30	0.30	0.05
24h	2.90	5.70	0.33	0.08
Kcl				
6h	3.00.	5.57	0.29	0.04
12h	2.60	6.16	0.22	0.05
24h	2.77	6.03	0.27	0.06
H_2S0_4				
Quick dip	2.50	3.23	0.14	0.05
30	0.00	0.00	0.00	0.00
60	0.00	0.00	0.00	0.00
Sand scarification				
	3.53	7.77	0.31	0.08
Control	2.40	5.57	0.24	0.05
$LSD_{(0.05)}$	O.70	1.86	0.06	0.02

DISCUSSION

Poor seed germination naturally exists in *M. barteri.* It is therefore necessary to improve its seed germination and growth. Priming induces a range of biochemical changes in the seed that required initiating the germination process through breaking of dormancy, hydrolysis or metabolism of inhibitors, imbibitions and enzymes activation (Ajouri *et al.,*2004).Priming is an effective technique that improves germination of several crop species (Singh, 1995)*. The M. barteri* seed emergence was improved by applying several priming methods and duration. These findings are in line with the work of Mubshar*et al*., (2006), which stated that improvement in priming is affected by some factors such as plant species, priming media type and concentration and priming duration. Potassium chloride improved *M. barteri* emergence, as already reported in Misra and Dwibedi (1980) who found that seed soaking in 2.5% potassium chloride (KCl) for 12h before sowing increased wheat yield by 15%.

The probable reason for early germination of primed seed maybe due to the completion of pre-germination metabolic activities making the seed ready for radicle protrusion and the primed seed germinated soon after planting compared with untreated dry seed (Arif, 2005).Priming improved the coefficient velocity of emergence of *M. barteri.* Early germination of primed seeds over other treatments is probably due to water and gases entering the embryo early through the cracks and causing a series of enzymatic breakdown and resulted in the transformation of the embryo into a seedling early enough than other seed treatments (Odunfa, 1989).

Primed seeds had lower mean emergence time (MET) compared with unprimed seeds. These positive effects are probably due to the stimulatory effects of priming on the early stages of germination process by mediation of cell division in germinating seeds (Sivritepe *et al*., 2003).

Coefficient of velocity of germination increases as more seeds germinate and with shorter emergence time (Busso*et al.,* 2005) and decreases as less seeds germinate and with a higher germination time (Isfahan and Shariati, 2007). The lower the coefficient velocity of emergence value the lower the germination capacity and the longer it takes for seeds to germinate. Haloprimed (24h) and sand scarification which had the highest coefficient of velocity of germination, are considered superior seed germination improvement technique for the nature of seed dormancy in *M. barteri* (RedMaeso). *M. barteri* seeds that were primed had higher shoot height and radicle length than unprimed seeds.

Significant improvement in the growth of the emerging seedlings (root and shoot) may be attributed to early germination induced by primed over unprimed seeds (Farooq *et al*. 2005), which resulted in vigorous seedlings with more root and shoot length than the seedlings from un-primed seeds. Stofella *et al*. (1992) reported also that priming of pepper seeds significantly improved radicle length. It is clear from these results that priming improves germination and growth of M. barteri (Red Maeso).

CONCLUSION

M. barteri seeds showed improved germination responses to priming techniques over the control. Sand scarification, hydro primed (6h) and KCl (24h) seed priming significantly increased germination of *M. barteri* seeds. Thus, the priming is an effective method to meet the demands of farmers during the installation of the culture in the field and also enhance fruit and environmental security. The technology is simple, cheap and affordable by growers of RedMaeso (*Maesobotryabarteri*).

REFERENCES

Ajouri, A., Haben, A., & Becker, M. (2004). Seed priming enhances germination and seedling growth of barley under conditions of P and Zn deficiency. *J. Plant Nut. Soil Sci*. 167, 630-636.

Akinnifesi, F.K., Kwesiga, F., Mhango, J., Chilanga, T., Mkonda, A., Kadu, C.A.C., Kadzere, I., Mithofer, D., Saka, J.D.K., Sileshi, G., Ramadhani, T. & Dhliwayo, P. (2006). Towards the development of miombo fruit trees as commercial tree crops in southern Africa. *Forests,Trees and Livelihoods* 16:103-121.

Akinnifesi, F.K., Mhango, J., Sileshi, G. &Chilanga, T. (2007). Early growth and survival of three miombo indigenous fruit tree species under fertilizer, manure and dry-season irrigation in southern Malawi. *Forest Ecology and Management* (in press).

Arif, M. (2005). Seed priming improves emergence, yield and storability of soybean. PhD thesis in Agronomy. NWFP Agricultural University Peshawar, Pakistan.

Busso, A.C., Mazzola,M & Perryman, B.L. (2005).Seed germination and viability of Wyoming Sagebrush in Northern Nevada. INCI, 30: 631-637.

Campbell B.M.(1986). *Food and Nutrition*, 12, 28-44.

Ellis R.A &Roberts E.H. (1984).The quantification of ageing and survival in orthodox seeds. Seed Science Technology 9: 373-409

Farooq M, Basra S.M.A, Saleem B.A, Nafees M., & Chishti S.A. (2005). Enhancement of tomato seed germination and seedling vigour by osmopriming. *Pakistan Journal of Agricultural Sciences* 42(3-4): 36-41.

Hassanein, A.M.A. (2010). Improving seed germination and seedling growth of some economically important trees. Biology production Text production, Ibadan. Pp. 133-137.

Isfahan, M.N. and M. Shariati, (2007).The effect of some allelochemicals on seed germination of *Coronillavaria* L. seeds. Am. Eurasian *J. Agric. Environ. Sci.,* 2: 534-538.

Kader, M.A. &Jutzi, S.C. 2004. Effects of Thermal and Salt Treatments During Imbibitions on GERMINATION 42/190C. J. *Agron. Crop Sci.,* 190: 35-38

Leakey, R.R.B., Tchoundjeu, Z., Schreckenberg, K., Shackleton, S.E. and Shackleton, C.M. (2005) Agroforestry Tree Products (AFTPs): Targeting poverty reduction and enhanced livelihoods. *International Journal for Agricultural Sustainability* 3, 1-23.

Mithöfer, D. and Waibel, H. (2003) Income and labour productivity of collection and use of indigenous fruit tree products in Zimbabwe. *Agroforestry Systems* 59: 295-305.

Mubshar, H., Farooq M., Basra, S.M.A. and Ahmad, N. (2006) Influence of seed priming techniques on the seedling establishment, yield and quality of hybrid Sunflower. *Int. J. Agri. Biol.* 8(1), 14-18.

Ouinsavi, C Charlemagne Gbémavo, Nestor Sokpon (2011).Ecological Structure and Fruit Production of African Fan Palm (*Borassusaethiopum*) Populations. *American Journal of Plant Sciences*, 2011, 2, 733-743 Doi:10.4236/ajps.2011.26088 Published Online December 2011 (http://www.SciRP.org/journal/ajps)

Pantastico ERB. (1975) Postharvest physiology, handling and utilization of Tropical and subtropical fruits and vegetables. The AVI Publishing Company Inc.pp.29-31 Plant Physiology 38: 66-68.

Ramadhani, T. (2002) Marketing of indigenous fruits in Zimbabwe. *Socio-economic Studies on Rural Development*, Vol 129. WissenschaftsverlagVauk. Kiel, Germany.

Ruiz-Perez, M., Belcher, B., Achdiawan, R., Alexiades, M., Aubertin, C., Caballero, J.,Campbell, B., Clement, C., Cunningham, T., Martinez, A., Jong, W. de, Kusters, K., Kutty,M.G., Lopez, C., Fu, M., Alfaro, M.A., Nair, T.K., Ndoye, O., Ocampo, R., Rai, N., Ricker,M., Schreckenberg, K., Shakleton, S., Shanley, P., Sun, T. and Young, Y-C. (2004) Markets drive the specialization strategies of forest peoples. *Ecology and Society* 9.1-9.

Singh B.G (1995) Effect of hydration-dehydration seed treatments on vigor and yield of sunflower.ScientiaHorticulturae 96(3-4): 229-234. doi:10.1016/S0304-4238(02)00198-X

Sivritepe, N., Sivritepe H.O., and Eris, A. (2003) The effects of NaCl priming on salt tolerance in melon seedling grown under saline conditions. *ScientiaHolti*. 97, 229-237.

Stofella PJ, Lipucci DP, Pardossi A, Toganoni F (1992) Seedling root morphology and shoot growth after seed priming or pre-emergence of bell pepper. Journal of American Society of Horticultural Sciences 27: 214-215.

Floral Diversity Conservation of Opada Forest Reserve

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ABSTRACT

The role that science can play in combating "Climate Change and its Impact on Africa" is to evolve ways for the conservation and management of the present biodiversity, especially biodiversity in the wild and make provisions or simulate ideas for meeting the needs of man for food, herbs and wood from outside the nature reserves such as forest reserves and national parks. In line with this, the main objectives of this study were to identify the non-tree vegetation of Opada Forest Reserve (OFR) and provide comprehensive vegetation data (information) for effective conservation, monitoring and management of the flora diversity of OFR. The study was carried out in OFR, Kogi State, Nigeria. It is about 215.76km^2 in size. The map of the reserve was gridded at an interval of one degree and each grid was about 3.61 km^2. Using a table of random numbers, ten of the grids were randomly selected. Within each grid, a straight line transect of 2km long was randomly laid. The transect lines were established with the help of a Global Positioning System, in order to locate transects in the right grids and a prismatic compass to maintain straight line transects. 25m × 25m quadrants were taken at regular intervals of 500m. Each transect accommodated four quadrants and they were 40 altogether. 1m^2 sub-plots were located at the four corners of the quadrants for the thorough identification and counting of grass species. There were 160 sub-plots for grass assessment. About 48- grass species, 12- climbers, 39- herbs, 4- shrubs and 5- sedges were identified. Discoveries of plants with good life supporting potentials, as well as advancements in health care deliveries depend on the availability of the right resources in adequate amounts; conservation ensures sustainability of the wild species of these resources in continuity.

Keywords: Kogi State, Opada forest reserve, conservation, non-tree vegetation

INTRODUCTION

Biodiversity refers to the total variety of living organisms (plants, animals, macro and microorganisms) that exist on planet earth. The biodiversity of a place is the totality of the genes, species and ecosystems that exist in that place (Ayodele and Lameed, 1999).

Flora or Plant diversity refers to the variety of plants that exist in the world. Plants compete with other plants and organisms to survive in an ecosystem. Over time, they develop various characteristics to help them survive, which leads to plant diversity. Plant diversity is important because various species come to depend on each other; therefore, eliminating one species can cause several other species to suffer, Diversity comes from adaptation and species conflict (Charles, 2013).

Objectives of the Study

1. To identify the non-tree vegetation of Opada Forest Reserve (OFR) .
2. To provide comprehensive vegetation data (information) for effective conservation, monitoring and management of the flora diversity of OFR.

METHODOLOGY

Description of the Study Area

Opada Forest Reserve is located in the eastern part of Kogi State, Nigeria. It has a total land area of 215.96km^2 (83.08sq miles). It lies between latitude 07^{0} $48^{/}$ $00.00^{//}$ N to Latitude 07^{0} $57^{/}$ $00.00^{//}$ N and Longitude 007^{0} $19^{/}$ $00.00^{//}$ E to Longitude 07^{0} $31^{/}$ $00.00^{//}$ E. the forest is watered by the following six rivers; Egashi, Iyale, Ojuajoma-egbi, Emae, Inergia and Oje-ajokpa rivers. The forest reserve was set aside in accordance with section 36 of the forestry ordinance of Nigeria, it was surveyed in Feb, 1933, mapped in March, 1933 and approved 29^{th} January, 1934.

Data Collection

Coordinates were taken round the boundaries of the reserve to assess the integrity of the size of the place with the aid of Global Positioning Systems (GPS). Data generated from GPS assessment were sent to a GIS station for the production of a map. The resulting map was gridded to obtain 41 plots, 25% (10 plots) were selected using a table of random numbers by Steel *et al* (1997). Within each study plot, a straight line transect of 2km long was randomly laid. The transect lines were established with the help of a GPS, in order to locate transects in the right sampling plots and a prismatic compass was used to maintain straight line transects. In the process of establishing the transect lines, tree trunks, low hanging branches and shrubs were tagged at 25m interval along the transect lines, in areas where there were no vegetation to tag, stem cuttings were firmly dug into the soil at the point to be tagged, however some spots were too rocky to be dug, big rock pieces were piled and the peak of the pack tagged. Each tag was given a numerical number. This was necessary for easy identification of sampling routes. Tall grasses, shrubs and herbs along transect lines were simply reduced to ease movement in very bushy areas. 25m × 25m quadrants, were established at regular intervals of 500m along the transect lines and alternately located on either side of the transect lines. Each transect accommodated four quadrants, there were 40 quadrants altogether.

$1m^2$ sub-plots were located at the four corners of each quadrant for the thorough identification and counting of grass species (Annex 1), there were 160 such sub-plots for grass assessment. Within each sub-plot, each non-tree plant was thoroughly counted; samples of each plant species were uprooted and carefully preserved in poly-bags and brought to the office for identification. The figures obtained from this exercise within the sub-plots are intended to be used to extrapolate the population of each grass species identified within the quadrant.

RESULTS AND DISCUSSION

Table 1 reveals 48- grass species identified in the course of the studies from the 10 transects used for the study where Table 2 presents 12- climbers, 38- herbs, 4- shrubs and 5- sedges .The above vegetation lists were compiled with the aid of 'The useful plants of West tropical Africa' (Daziel, 1953), A hand book of West African weeds (Okezie *et al.,* 1998)," The flora of Nigeria": grasses (Lowe, 1989), Traditional medicine and Pharmacopoeia (Mashana, 2000).

There is more to non-tree forest vegetation than meets the eyes, important products derived from non-tree forest vegetation abound and include: Food products, edible fruits, Vegetables, Spices, condiments and herbs. Industrial plant oils and waxes, plant gums, natural plant pigments, seeds, fibers and rattern, vegetable tanning materials, essential oils, Plant insecticides and medicinal plants. The grass species are working hard to keep us cool, soak up carbon, capture particulates in the air, produce oxygen, capture rain water and reduce run-off (Lowe, 2010), which results in land degradation like erosion. However, keeping lawns green in Southern California is said to increase greenhouse gas emissions, rather than absorbing them, the problem is all the emissions needed to keep the lawns healthy: mowing, leaf-blowing, production of fertilizer all these add up to four times the amount of greenhouse gas that the grass can store in its soil as carbon. Spreading fertilizer causes soil beneath the grass to release nitrous oxide, and while its warming effects are dwarfed by those of carbon dioxide, it is, 300 times more potent as a greenhouse gas. "An athletic field gets tilled every year, over a 35-year timescale; there's no net storage of carbon." (Brennan, 2010). While these findings hold true for Southern California, they might not for parts of the world with enough rainfall to keep lawns green without watering — "in a place where lawns grow naturally, where you don't have to irrigate or fertilize them, and you don't have to mow them all the time," (Townsend, 2010). Furthermore, cattle emit huge amounts of methane, especially if corn-fed. Grass that may help tackle global warming by cutting the level of methane given off by cows is being developed reports the latest issue of the Society of Chemical Industry (2008). Methane is denser than and 23 times more effective as a global warming agent than carbon dioxide" (Timothy, 2009). Grasses can sequester huge amounts of carbon annually, especially when grazing practices include high density, short-term exposure efforts with the cattle eating the grasses down and moving on to let the grasses grow back. This sustainable grazing technique causes some root shedding below the soil line, leaving lots of organic matter, and thus, carbon. On just one acre of biologically healthy grassland soil, there can be between 0.5 - 1.5 tons of carbon deposited in the soil annually. This is equivalent to taking up to 5.5 tons of CO_2out of the atmosphere and sinking it into an acre of soil.

While this impressive level of carbon sequestration is impossible in the high desert with little rainfall, it is absolutely viable where there is rain or available water to grow pasture. With proper management, ruminants can once again contribute to the life and water cycle supporting ecology of our biological system. This amazing ecological interaction on 11 billion global acres of grazed land would equate to sequestering 60% of human-caused CO_2 (Timothy, 2009).

Table 1: Grasses of Opada Forest Reserve Study Sites

S/N	**SCIENTIFIC NAME**	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**	**T_9**	**T_{10}**	Total
1.	*Andropogon tectorum*	128	8o		50	130	7	360	230	164	772	1921
2.	*Andropogon gayanus*							10				10
3.	*Afranum angustifolium*					79	35	16				130
4.	*Aneilema aequinoctiale*		10									10
5.	*Asystasia gangetica*			10	70			50			100	230
6.	*Borreria verticillata*										15	15
7.	*Byrsocarpus coccineus*				100		20			20		140
8.	*Cana Indica*		76	22								98
9.	*Cassia obtusifolia*		3									3
10.	*Cissampelos mucronata*					40	20					60
11.	*Cymperus dilataus.*		41				12	25	80			158
12.	*Commelina benghalensis*		104	65	70							239
13.	*Colocasia esculentum*		20									20
14.	*Costus afer*				50	263	7	27	85	212		644
15.	*Crinum zeylanicus*					374	206	170				750
16.	*Culcasia scandens*				7							7
17.	*Cyperus esculentus*		20			60						80
18.	*Cynodon dactylon*			180								180
19.	*Desmodium gengeticum*	6			62	54	32					154
20.	*Desmodium solicifolium*		20			10	7					37
21.	*Dissotis irvingiana*			35	12				30			77
22.	*Fimbristylis dichotoma*			177								177
23.	*Gunterbergi nigritana*				15							15
24.	*Imparata cylindrical*	14	10	12	20		12					68

25.	*Impomoea involucrate*			15	40							55
26.	*Jussiaea decurrens*	10										10
27.	*Mariscus alternifolius*					216	32	84	36	10		378
28.	*Melanthera scandens*			5								5
29.	*Mimosa Invisa*		35									35
30.	*Monilia whitei*	30										30
31.	*Oldenlandia alfinis*				80		10					90
32.	*Oplismenus hirtellus*				80							80
33.	*Panicum brevifolium*					140	550					590
34.	*Panicum maximum*			40	29	140	10					219
35.	*Pennisetum bizantha*							20				20
36.	*Pennisetum polystachyon*				80	100	13					193
37.	*Phyllanthum amarus,*										15	15
38.	*Piliostigma thonningii*	40										40
39.	*Rottboellia cochinchinensis*	84	54			5	45	8	150		170	516
40.	*Scleria boivinii*	40									30	70
41.	*Scleria naumanniana*			60		110						170
42.	*Stylosanthes erecta*		30									30
43.	*Spigelia anthelinia*				10	30						40
44.	*Sesanum indicum*					50						50
45.	*Seteria anceps*										95	95
46.	*Schizachyrium sanguineum*					100					105	205
47.	*Tephrosia bracteolate*		40		200							240
48.	Vigna pubigura			40	10	35						85

Source: Field survey, 2010.
Where: T_1- T_{10} refers to transects 1- 10.
Table 1 revealed 48- grass species identified in the course of the studies from the 10 transects used for the study.

Table 2: Climber, Herb, Shrub, and Sedge Vegetation of Opada Forest Reserve Study Sites

s/n	Name of plant	Total	Types	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_0	T_9	T_{10}
1.	*Aframum Angustifoliu*	127	Herb				16	95	16				
2.	*Asystasia gagetica*	230	Herb			10	70			50			100
3.	*Aneilema Aeqinoctiale*	10	Herb	10									
4.	*Cana indica*	85	Herb	63	22								
5.	*Colocasia Esculentum*	20	Climber	20									
6.	*Commelina Benghalensis*	259	Herb	104	65	90							
7.	*Commelina Diffusa*	451	Herb	158	23		45	106	23	8	30		58
8.	*Crinum Zeylanicus*	754	Herb				378	206	170				
9.	*Cissampelos Mucronata*	60	Climber				40	20					
10.	*Cissus populnea*	669	Climber		15	70	265	7	17	85	212		
11.	*Cymperus Dilatatus*	158	Sedge	41				12	25	80			
12.	*Cymperus Esculentus*	80	Sedge		20		60						
13.	*Culcasia scandens*	7	Herb			7							
14.	*Desmodium Gangeticum*	202	Herb	6		112	54	30					
15.	*Desmodium Salicifolium*	17	Herb				10	7					
16.	*Dioscorea Bulbifera*	982	Herb		50		250		116	107	300		159
17.	*Dissotis Irvingiana*	77	Herb	35	12				30				
18.	*Fimbristylis Dichotoma*	117	Herb		117								
19.	*Guntenbergia Nigritana*	15	Herb			15							
20.	*Impomoea Involucrate*	55	Climber				15	40					
21.	*Jussiaea decurrens*	10	Herb	10									
22.	*Mariscus alternitolius*	384	Sedge				6	216	32	84	36	10	
23.	*Melanthera Scandens*	5	Herb			5							
24.	*Mimosa invisa*	35	Shrub		35								
25.	*Oldenlandia Affinis*	90	Herb				80		10				

26.	*Phyllanthus Amarus*	15	Herb										15
27.	*Scleria boivinii*	180	Sedge	40		110							30
28.	*Scleria Naumanniana*	110	Sedge	60		50							
29.	*Sesamum indicum*	95	Herb										95
30.	*Stylosanthes*	39	Herb		30								
31.	*Spigelia anthelmia*	40	Herb				10	30					
32.	*Tephrosia Bracteolate*	240	Shrub		40		200						
33.	*Vigna gracils*	75	Herb		15	30		30					
34	*Asparagus africanus Ixnn & A. Pauli*	109	Climber				1	35	63		10		
35	*Byrso carpus Coccineus (schum & Thinn)*	160	Herb				100		30			30	
36	*Choclospernum Tictorium*	4	Herb		3		1						
37	*Combretum molle (R.Br.Ex G.Don)*	17	Climber	5	10								2
38	*Desmodium solicifolium (Poir)DC*	27	Herb				10	7			10		
39	*Desmodium velutinum DC*	135	Herb				35		40			60	
40	*Eriosema elomeratum Hook.F.*	5	Herb	5									
41	*Gongronema Latifolium*	8	Climber	5		3							
42	*Gardenia terifolia schum & Thinn*	15	Shrub	1				1	11	1	1		
43	*Icacina terifolia olie*	110	Herb			110							
44	*Lantana spp*	66	Herb		15			21			30		
45	*Mucuna pruriens DC*	10	Climber	10									
46	*Nelsonia campestris R.Br.*	100	Herb										100
47	*Olax viridis*	102	Herb									101	1
48	*Pipper guineensis*	2	Herb	1		1							
49	*Palisota hirsute K.Schum*	65	Herb	20			35			10			
50	*Paulinia pinattu. Linn*	95	Climber									40	55
51	*Sarcoce phallus latifolius (S.M) Bruce*	13	Shrub				2		1			10	
52	*Siphonochilius aethiopicus*	89	Herb	20		5					64		
53	*Sidalinifolia juss ex cav.*	59	Herb	20			12		27				
54	*Tregia spp pax*	44	Herb	17		3		22					
55	*Urena lobata Linn*	180	Herb		40					100		40	
56	*Uvaria chamae*	7	Climber							7			
57	Vigna gracilis	198		15	30		30					24	99
58	*Wissudula spp.Linn*	30	Herb						20	10			

Source: field survey 2010

In the course of this study, 12- climbers, 38- herbs, 4- shrubs and 5- sedges were identified.

The above vegetation lists were compiled with the aid of 'The useful plants of West tropical Africa' (Daziel, 1953), A hand book of West African weeds (Okezie *et al.,* 1998)," The flora of Nigeria": grasses (Lowe, 1989), Traditional medicine and Pharmacopoeia (Mashana, 2000).

CONCLUSION

The non-tree forest products are of extreme importance in today's world economy considering the long list of products and benefits derivable from them. Except their use is properly studied and known, abuse, indiscriminate utilization of the wild species and possible extinction is inevitable.

RECOMMENDATION

Information on the possible contribution in combating "Climate Change and its Impact on Africa" by this group of plant species that are so abundant in the environment is scanty and so needs scientific attention and results made public. Even if the use of some of them are not currently known, conservation should of a necessity and be promoted pending when knowledge is acquired in that respect.

REFERENCES

Ayodele, I.A. and Lameed, G.A. (1999).Essentials of biodiversity management.The current status of Biodiversity management. Ibadan. 74 pp.

Brennan P. (2010). Greenhouse grass: Do lawns make global warming worse?http://greenoc.freedomblogging.com/2010/01/19/greenhouse-grass-do-lawns-make-global-warming-worse/18809/

Charles P. (2013). What Is Plant Diversity? http://www.ehow.com/info_7934410_plant-diversity.html.

Daiziel, J. M (1953).The useful plants of West Tropical Africa. Britain. 610pp.

Lowe, J. (1989). The flora of Nigeria: Grasses. Second edition.Ibadan University press.326pp.

Lowe, J. (2010).Lawns may contribute to global warming. http://www.csmonitor.com/Environment/Bright-Green/2010/0122/Lawns-may-contribute-to-global-warming.

Mashana, N.R., Abbiw, D.K., Addae-Mensah, I., Adjanouhoun,E., Ahyi,M.R.A., Ekpere, J.A., Enow-Drock, E.G., Gbile, Z.O., Naomesi,G.K., Odei, M.A., Odunlami, H., Oteng-Yeboah, A.A., Sarpong, K.,Sofowora, A and Takie, A. N.(2000). Traditional medicine and pharmacopoeia.Contribution to the revision of ethno-botanical and floristic studies in Ghana. Accra. 920pp.

Okezie, I.A. and Agyakwa C.W. (1998). A hand book of West African weeds.International institute of Tropical Agriculture.Second edition. Ibadan. 565pp.

Society of Chemical Industry, (2008).Burpless' Grass Cuts Methane Gas From Cattle, May Help Reduce Global Warming http://www.sciencedaily.com/releases/2008/05/080506120859

Townsend, S (2010). Lawns may contribute to global warming. http://www.csmonitor.com/Environment/Bright-Green/2010/0122/Lawns-may-contribute-to global-warming.

Timothy J. L (2009). In Defense of the Cow: How Eating Meat Could Help Slow Climate Change http://www.treehugger.com/green-food/in-defense-of-the-cow-how-eating-meat-could-help slow-climate-change.html

Annex .1: Shrub and Grass Survey Sheet
Name of Protected Area……………………………….. Name of Recorder ………………………….. Title ……………..
Date………………….. Season …………………….. Weather ………………………..Range ……………………………
Transect No ……………………… Transect length ………………..Start Time ……………………….. End time……………

S/N	Specie s	Transect dist	Perennial grass	Annual grass	Shrubs	Vegetation type	Man-made features	Water body				Land features					
								Swamp	Stream	Pond	Flowing River	Cave	Mountain	Rock	Steep slope	Slopy	Fla t
1																	
2																	
3																	
4																	
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Impact of Vermicompost on Peas Cultivated Soil

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ABSTRACT

Vermicomposting is an environmentally friendly technique that is used for organic solid waste management. Waste corn pulp blended with cow dung and office paper was vermicomposted over 30 days to produce vermicompost which is a solid bio-fertilizer. The vermicompost was applied to clay-loam soil cultivated with peas at the planting phase and after every four weeks. The impact of vermicompost on the soil was quantified. Application of vermicompost resulted in a 33%, 40%, and 67% increase in the soil nitrogen, phosphorous and potassium content respectively. Furthermore, Zinc, copper, manganese and iron indicated a 91%, 67%, 56% and 10% increase in nutrient composition. The peas showed vigor and vitality during the period of growth. Vermicompost can be used for sustainable agriculture practices easing food shortages hence improved food security.

Keywords: bio-fertilizer, peas, soil properties, vermicompost, food demand

INTRODUCTION

Vermicomposting of organic waste is widely being used as a solid waste management technology [Lazcano & Dominguez, 2011; Manyuchi *et al.,* 2012)]. During vermicomposting, epigeic earthworms ingest the organic wastes and are expelled as vermicasts after a bioconversion process in the earthworms gut [3-5]. These vermicasts are termed vermicompost and are rich with the fertilizer macro and micronutrients [2; 5]. Vermicompost also contain living microorganisms and have a high content of humus like material [2; 5]. This vermicompost can be utilized as a bio-fertilizer which is environmentally friendly [6-9]. Vermicompost has been used in sustainable agriculture and was found to stimulate plant growth [1]. Vermicompost has been applied to several plants including strawberries, tomato, rice, lettuce and maize [1; 3; 5; 8; 10-12]. The objective of this study focused on quantifying the impact of vermicompost on peas cultivated's soil physicochemical properties. Peas (*Pisum Sativum)* are a leguminous vegetable crop which can be grown in 2-3 months. Peas thrive best in silt loam, sandy loams or clay loam soils [13]. Ideal temperature conditions of 13-18◦C and pH of 6.0-7.0 is recommended [13].

MATERIALS AND METHODS

Materials

Waste corn pulp blended with cow dung manure and office paper was vermicomposted for 30 days using *Eisenia*fetida earthworms. The organic waste and earthworms were covered with grass to create ideal conditions for vermicomposting (Fig 1). The nutrient composition of the vermicompost is indicated in Table 1.

Fig 1: Vermicomposting being done in bins

Table I: Vermicompost from Waste Corn Pulp Composition

Nutrient	Vermicompost composition
N (%)	4.19
P (%)	1.15
K (%)	6.18
Na (ppm)	4.85
Mg (ppm)	6.58
Cu (ppm)	0.57
Zn (ppm)	1.35
Fe (ppm)	162.30
Mn (ppm)	1.62

Methods

The clay loam soil pH and electrical conductivity were determined by a Hanna HI 9810 Instrument. 5g of the soil was dissolved in 10ml of water and allowed to settle before taking measurements. The nitrogen and phosphorous content were determined by a Shimadzu *uv-vis* spectrophotometer. The potassium content in the soil was determined by a Cary Model AAS spectrophotometer. The raw soil had a pH of 6.0 and moisture content of 54%.Green Arrow peas seeds were planted 25mm deep in loam-clay soils and the seeds were 50mm apart from each other and 150mm between rows. The peas beds were regularly watered to maintained adequate moisture content. The peas seeds were 98% germinated at day 4-5. The lettuce was allowed to grow for 2 months and vermicompost was applied upon planting and after every 4 weeks.

RESULTS AND DISCUSSION

The peas planted using the vermicompost is indicated in Fig 2. The peas shows vigor and vitality due to the bio-fertilizer addition as well as the action of the microbial inoculants present in the vermicompost to the soil.

Fig 2: Peas grown using vermicompost as bio-fertilizer

IMPACT ON SOIL NITROGEN, PHOSPHOROUS AND POTASSIUM CONTENT

Nitrogen exists as ammonium nitrate ions, NH_4^+ and NO_3^- in the soil for ready uptake by plants. Addition of vermicompost increased the nitrogen available in the soil by 33% in the peas cultivated soil compared to the virgin soil (see Fig 3). This was because of addition of extra ammonium nitrates from the vermicompost due to mineralization [10-11]. Furthermore, peas as a leguminous crop have a tendency of fixing nitrogen from the soil to the plant [13]. In addition, *Rhizobium leguminosarum* can be inoculated to the pea seeds before planting to promote nitrogen fixation to the soil [13]. Phosphorous exists as phosphates $H_2PO_4^-$ and HPO_4^{2-} in the soil. Addition of vermicompost in the peas cultivated soil resulted in increased phosphorous content by 40% (see Fig 3). This was because of addition of extra slow release phosphates from the vermicompost hence the increase [1; 10; 12]. Potassium exists as K^+ in the soil. Addition of vermicompost in the peas cultivated soil, resulted in 67% increase of the potassium content (see Fig 3). This was possibly because the potassium available from the vermicompost was high thereby increasing the composition in the soil (see Table 1).

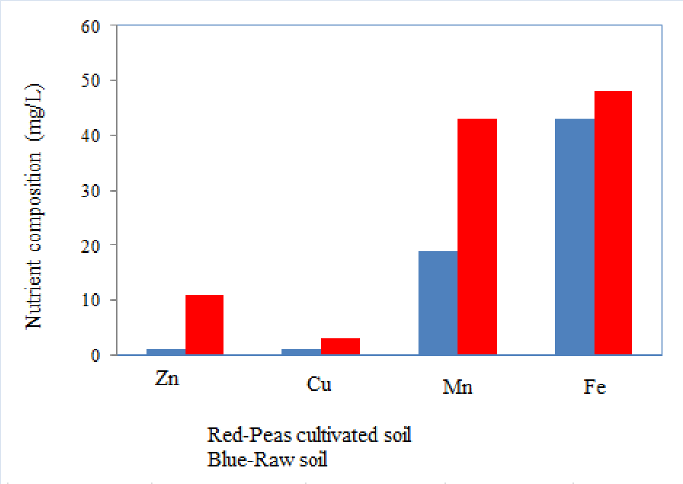

Fig 3: Comparison of soil NPK in raw soil and peas cultivated soil

IMPACT ON SOIL Zn, CU, Mn AND Fe CONTENT

Zinc, copper, manganese and iron exist in the soil as Zn^{2+}, Cu^{2+},Mn_2O_3 and Fe^{2+} and Fe^{3+} respectively.Addition of vermicompost on peas cultivated soil significantly altered the bio-fertilizer micronutrients content (see Fig 4). The Zn, Cu, Mn and Fe content increased significantly by 91%, 67%, 56% and 10% respectively upon addition of the vermicompost. Vermicompost has a tendency of increasing the micronutrients composition in the soil since it contains trace elements from the bio-conversion process [6, 8-9].

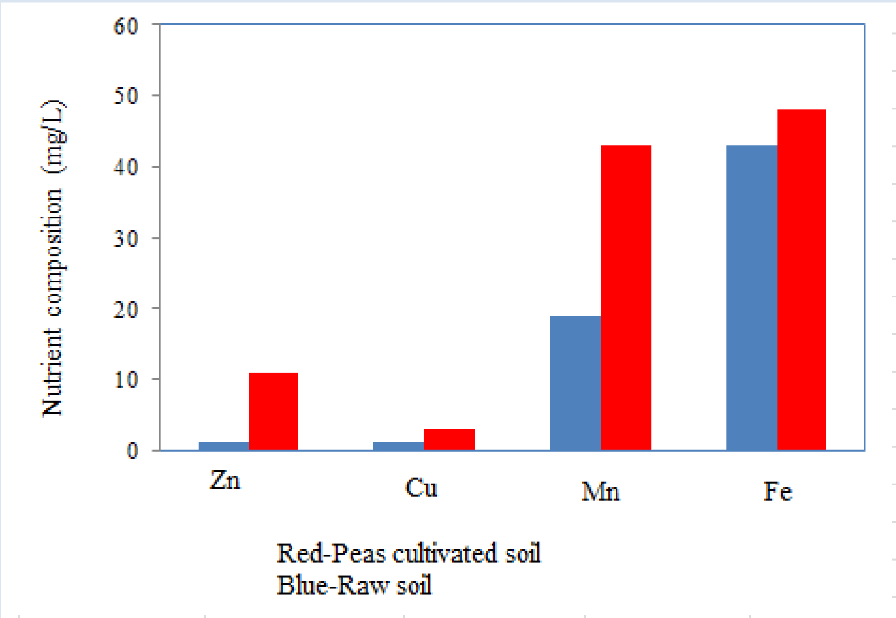

Fig 4: Comparison of soil micronutrients in raw soil and peas cultivated soil

CONCLUSION

Vermicompost can be successfully used as a bio-fertilizer for the growth of peas. The vermicompost impacts positively on the nutrient available for uptake by the peas due to the presence of living organisms in the vermicompost thereby stimulating growth. Vermicomposting technology can be used for sustainable agriculture practices.

ACKNOWLEDGEMENT

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REFERENCES

[1] C. Lazcano, and J. Dominguez (2011). The use of vermicompost in sustainable agriculture: Impact on plant growth and soil fertility. *Soil Nutrients*. 2011, 1-23.

[2] M. M. Manyuchi, A. Phiri, N. Chirinda, P. Muredzi, J. Govha and T. Sengudzwa. Vermicomposting of Waste Corn Pulp Blended with Cow Dung Manure using *Eisenia Fetida*. *World Academy of Science, Engineering and Technology*. 2012, **68**, 1306-1309.

[3] G. K. Chanda, G. Bhunia and S. K. Chakraborty. The effect of vermicompost and other fertilizers on cultivation of tomato plants. *Journal of Horticulture and Forestry*, 2011, **3** (2), 42-45.

[4] M. M. Manyuchi, T. Chitambwe, P, Muredzi and Kanhukamwe, Q. Continuous flow-through vermireactor for medium scale vermicomposting. *Asian Journal of Engineering and Technology*. 2013, **1** (1), 44-48.

[5] P. K. Ramasamy, K. Baskar and S. Ignacimuthu. Influence of vermicompost on kernel yield of maize (*Zea Mays* L.). *Elixir Agriculture*, 2011, **36**, 3119-3121.

[6] Manyuchi, M. M., A. Phiri, P. Muredzi and T. Chitambwe. Comparison of vermicompost and vermiwash bio-fertilizers from vermicomposting waste corn pulp. *World Academy of Science, Engineering and Technology*. **78**, 365-368. 2013.

[7] M. M. Manyuchi, T. Chitambwe, A. Phiri, P, Muredzi and Q, Kanhukamwe. Effect of vermicompost, vermiwash and application time on soil physicochemical properties. *International Journal of Chemical and Environmental Engineering*, 2013, article in press.

[8] M. M. Manyuchi, L. Kadzungura, A. Phiri, P, Muredzi and Q, Kanhukamwe. Effect of vermicompost, vermiwash and application time on soil micronutrients. *International Journal of Engineering and Advanced Technology*, 2013, **2** (5), 215-218.

[9] M. M. Manyuchi, T. Chitambwe, A. Phiri, P, Muredzi and Q, Kanhukamwe. Effect of vermicompost, vermiwash and application time on Zea Mays growth. *International Journal of Scientific Engineering and Technology*. 2013, **2** (7), 638-641.

[10] N. Q. Arancon, C. A. Edwards, and P. Bierman. Influences of vermicomposts on field strawberries: Part 2. Effect on soil microbiological and chemical properties. *Bioresource Technology*. 2006, **97**, 831-840.

[11] R. Azarmi, M. T. Giglou and R. D.Taleshmikail. Influence of vermicompost on soil chemical and physical properties in tomato (*Lycopersicumesculentum*) field. *African Journal of Biotechnology*. 2008, **7** (14), 2397-2401.

[12] K. Tharmaraj, P. Ganesh, K. Kolanjinathan, K. R. Suresh and A. Anandan. Influence of vermicompost and vermiwash on physicochemical properties of rice cultivated soil. *Current Botany*. 2011, **2** (3), 18-21.

[13] C. A. Miles and M. Sonde, Peas shoots, Farming West of the Cascades, PNW 567.

Soil Microorganisms and Climate Change

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ABSTRACT

Climate change has both direct and indirect effects on the activities of soil microbes that feedback gases to the atmosphere and contribute to global warming. This paper examines the potential negative and positive contributions of soil microbes to global warming. Examples of important soil microbes include: Azospirillum*, Azotobacter, Nostoc, Anaebaena, Nitrosomonas, Nitrobacter, Pseudomonas, Corynebacterium, Bacillus, Nocardia, Streptomyces, Aspergillus and Achromobacter*. Increased temperatures accelerate rates of microbial decomposition, thereby increasing Co_2 emitted by soil respiration and producing a positive feedback to global warming. Microbial methanogenesis is responsible for both natural and human-induced CH_4 emissions since methanogenic archaea reduces carbon into methane in anaerobic, carbon-rich environments such as ruminant livestock, rice paddies, landfills and wetlands. Soil microorganisms mediate N_2 cycle making nitrogen available for living organisms before returning it back to the atmosphere .In the process of nitrification, microbes release NO and N_2O, two critical greenhouse gases, into the atmosphere as intermediates.As we attempt to mitigate greenhouse gas emissions and adapt to predict climate change effects, turning towards microscopic life that lies below the surface can help us to better equip for future changes at the microscopic and even global scale.

INTRODUCTION

Climate change is being demonstrated globally by the melting of the polar ice sheets and locally by the milder winters we are having, coupled with more extreme weather such as heavy rain and flooding. The earth is surrounded by a thick layer of gases which keep the plant warm and allows plants, animals and microbes to live. These gases work like a blanket. Without this blanket the earth would be 20-30^{o}C colder and much less suitable for life. Climate change is happening because there has been an increase in temperature across the world. This is causing the earth to heat up, which is called global warming. Microorganisms found in the soil are vital to many of the ecological processes that sustain life such as nutrient cycling, decay of plant matter, consumption and production of trace gases, and transformation of metals (Panikov, 1999). Soil microorganisms contribute significantly to the production and consumption of greenhouse gases, including carbon dioxide (Co_2), methane (CH_4), nitrous oxide (N_2O) and nitric oxide (NO), and human activities such as waste disposal and agriculture have stimulated the production of greenhouse gases by microbes. As concentration of these gases continue to rise, soil microbes may have various feedback responses that accelerate or slow down global warming, but the extent of these effects are unknown.

CONTRIBUTIONS OF SOIL MICROBES TO GLOBAL WARMING

All living organisms participate in biogeochemical cycling of materials, but microorganisms because of their ubiquity, diverse metabolic capabilities, and high enzymatic activity rates, play a major role in biogeochemical cycling (Jorgensen, 1989). Biogeochemical cycling is driven directly or indirectly by radiant energy of the sun (Woodwell, 1970).Energy is absorbed, converted, temporarily stored and eventually dissipated, which is to say that energy flows through ecosystems. This flow of energy is fundamental to ecosystem function. Whereas energy flows through the ecosystem, materials undergo cyclic conversions that tend to retain materials within the ecosystem.

Soil microorganisms are a major component of biogeochemical nutrient cycling and global fluxes of Co_2, CH_4 and N. Global soils are estimated to contain twice as much carbon as the atmosphere, making them one of the largest sinks for atmospheric CO_2 and organic carbon (Willey et al., 2009). Soil respiration refers to the overall process by which bacteria and fungi in the soil decompose carbon fixed by plants and other photosynthetic organisms and release it into the atmosphere as CO_2.Soil respiration accounts for 25% of naturally emitted CO_2, which is the most abundant greenhouse gas in the atmosphere and the target of many climate change mitigation efforts.

Methane, another important greenhouse gas is 25 times more effective thanCO_2 at trapping heat radiated from the earth (Schlesinger and Andrews,2000).Microbial methanogenesis is responsible for both natural and human-induced CH_4 emissions since methanogenic archaea reduce carbon-rich environments such as ruminant livestock, rice paddies, landfills and wetlands.Soil microorganisms mediate N_2 cycle making nitrogen available for living organisms before returning it back to the atmosphere. In this process of nitrification, microbes release NO and N_2O, two critical greenhouse gases into the atmosphere as intermediates.

MICROBIAL RESPONSES TO CLIMATE CHANGE

Microbial responses to increased temperature change was predicted by current models of global climate that warmer temperatures will increase the rate that bacteria and other microbes decompose soil organic matter, scenario that pumps even more heat trapping carbon into the atmosphere. A new study shows that while the rate of decomposition increases for a brief period in response to warmer temperatures, elevated levels of decomposition do not persist. Other scientists have noted that the respiration of soil microbes returns to normal after a number of years under heated conditions, but offered competing explanations. First, it is possible temperatures cause microbes to undergo physiological changes that result in reduced carbon-use efficiency (Allison et al., 2010).Soil microbes may also acclimate to higher soil temperatures by adapting their metabolism and eventually return to normal decomposition rates. Lastly, it can be interpreted as an above ground effect if changes in growing season lengthen as a result of climate change affect primary productivity, and thus carbon inputs to the soil (Davidson and Janssens, 2008).

Moreover, increased temperatures accelerate rates of microbial decomposition thereby increasing CO_2 emitted by soil respiration and producing a positive feedback to global warming.

RESPONSE TO INCREASED CO_2

It is generally accepted that increased levels of CO_2 quantitatively and qualitatively alter the release of labile sugars, organic acids and amino acid from plant roots (Bardgett et al., 2009)and this can stimulate microbial growth and activity. This can change the CO_2 flux depending on the availability of nutrients such as nitrogen (Drigo et al., 2008).In long term, it is argued that the increase in microbial biomass as a result of increase Carbon release by the roots can lead to immobilization of soil nitrogen, thereby limiting the Nitrogen available for plants and creating negative feedback that constrains future increases in plant growth (Diaz et al., 1993).Several studies have shown that increased levels of atmospheric CO_2 can lead to substantial increases in soil respiration (Norby et al.,2004;Jackson et al.,2009) and that, in general,below ground responses in the same ecosystems (Jackson et al.,2009).Conversely,in some cases, because soil microorganism preferentially use labile Carbon over supplied by plants can also influence the feedback response by directly affecting the physiology and structure of the soil microbial community.

MICROORGANISMS INVOLVED IN CLIMATE CHANGE

Bacteria and archaea are involved in climate change.For example, in the Carbon cycle, methanogens convert CO_2 to CH_4 in a process called methanogenesis.In the nitrogen cycle, nitrogen-fixing bacteria such as Rhizobium fix Nitrogen, which means they convert Nitrogen in the atmosphere into biological nitrogen that can be used by plants to build plant proteins. Photosynthetic algae and cyanobacteria form a major component of marine plankton. Fungi and soil bacteria (decomposers) play a major role in the Carbon cycle as they breakdown organic matter and release CO_2 back into the atmosphere. Other examples of microbes involved in climate change are methanogenic bacteria-*Methanospirillium hungatii*, Alga-*Spirogyra* sp., Nitogen fixing bacteria- *Rhizobium leguminosarum*. Also involved are: *Azospirillum, Azotobacter, Nostoc, Anaebaena, Nitosomonas, Nitrobacter, Pseudomonas, Corynebacterium, Bacillus*, *Nocardia, Streptomyces, Aspergillus and Achromobacter.*.

CONCLUSION

There is consensus among scientists that global climate change is happening and that increases in global average temperatures since 1900 can be largely attributed to human activities. The complexity of microbial communities living below ground and the various ways they associate with their surroundings made it difficult to pinpoint the various feedback responses that soil microbes may have to global warming. Whether a positive feedback response results in which microbial process further contribute to climate change, or whether a negative feedback response slows its effects, it is clear that microbes can have a huge impact on future climate scenarios and ecosystem-level responses to climate change. As we attempt to mitigate greenhouse gas emissions and adapt to predicted climate change effects, turning towards microscopic life that lies below the surface can perhaps help us to become better equipped for future changes at the microscopic and even, global scale. Microorganisms may be out of sight, but we cannot afford for them to be out of mind.

REFERENCES

Allison, S.D., Wallenstein, M.D.,&Bradford, M.A. (2010).Soil-carbon response to warming dependent on microbial physiology. *Nature Geoscience* 3, 336-340.

Bardgett, R. D., De Deyn, G. B. &Ostle, N. (2009).Plant–soil interactions and the carbon cycle. *J. Ecol.*97, 838–839.

Davidson, E. A. &Janssens, I. A. 2006.Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. *Nature* 440, 165–173.

Diaz, S., Grime, J. P., Harris, J. & Mcpherson, E.(1993).Evidence of a feedback mechanism limiting plant response to elevated carbon-dioxide*. Nature* 364, 616–617 .

Drigo, B., Kowalchuk, G. A. & van Veen, J. A. 2008.Climate change goes underground: effects of elevated atmospheric CO2 on microbial community structure and activities in the rhizosphere. *Biol. Fertil. Soils* 44 ,667–679 .

Jackson, R., Cook, C., Pippen, J. & Palmer, S. 2009.Increased belowground biomass and soil CO_2 fluxesafter a decade of carbon dioxide enrichment in a warm-temperate forest. *Ecology* 90, 3352–3366.

Jorgensen,B.B.1989.Biogeochemistry of chemoautotrophic bacteria. In H.G.Schlegel and B.Bowien (eds.).Autotrophic bacteria.Springer-Verlag.pp.117-146.

Norby, R. J., Ledford, J., Reilly, C. D., Miller, N. E. & O'Neill, E. G.2004. Fine-root production dominates response of a deciduous forest to atmospheric CO_2 enrichment. *Proc.Natl Acad. Sci. USA* 101, 9689–9693.

Panikov, N.S. 1999. Understanding and prediction of soil microbial community dynamics under global change.*Applied Soil Ecology* 11**,** 161-176.

Willey, J.M., Sherwood, L.M., Woolverton, C.J. Prescott's Principles of Microbiology. McGraw-Hill, New York, NY: 2009.

Woodwell, G.M.1970. The energy cycle of the biosphere. Scientific American 223 (3)64-74.

Schlesinger, W. H. and Andrews, J. A. 2000.Soil respiration and the global carbon cycle.*Biogeochemistry* 48, 7–20.

THEME 2: CLIMATE CHANGE AND EDUCATION

'Hot Air': A Phenomenon Demanding Pedagogy in Nigeria

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ABSTRACT

The anthropogenic components of the causes and consequences of climate change (hot air) may need to be addressed with the kind of education that could promote the understanding of the subject matter of climate change and consequently make people to develop desirable attitude towards sustainable environmental management. However, while it is evident that developed countries contribute more to the problem, both the developed and the developing are mutually bearing the brunt of environmental degradation. Although the developed nations are making drastic and pronounced efforts at stemming the tide of unsustainable environmental exploitations, the developing nations (e.g. Nigeria) appear not to be taking it as seriously. The hunch that is expressed here is that developing nations do not have adequate direct classroom interventions to address the problem of climate change and its attendant consequences, in spite of the availability of various geographic and science-oriented subjects available in the school curriculum. However, methods of teaching used may not be appropriate for the teaching of its learning content, hence people would not acquire the appropriate knowledge, let alone developing desirable attitude required against climate-change inducing activities. This paper thus explores the art and science (pedagogy) of how to impart the learning content of climate change including the scientific background, diagnosis of climate change and impacts of climate change on environment and society. It also explores the applicability of the socio-critical teaching strategy for the inculcation of appropriate knowledge and development of desirable values in people, especially students towards the environment.

Key words: climate change; pedagogy; knowledge and values

INTRODUCTION

Education is a key strategy identified under Agenda 21 in the efforts to achieve a more sustainable society. This educational agenda is supported by the United Nations Decade for Education for Sustainable Development (2005-2014), which was established to encourage the behavioural change necessary for a more sustainable future through the integration of the principles, values and practices of sustainable development throughout all aspects of education and learning. The Education for Sustainable Development agenda is gaining increasing profile within the higher education sector which has acknowledged its potential role to contribute to a more sustainable society through both 'the skills and knowledge that its graduates put into practice' and 'its research and exchange of knowledge through business, community and public policy engagement' and its own 'strategies and operations' (HEFCE, 2009).

Global climate change is a challenging topic to teach and to learn. As climate change science rapidly advances, it is essential for educators to have up-to-date, relevant teaching materials that present the basic concepts in ways that stimulate the interests of students. At the same time, it is important to recognize that students as well as teachers often have misconceptions about global warming that can negatively impact the construction of new knowledge (Chinyerem & Ohia, 2010). By clarifying these misconceptions, teachers are in a better position to devise strategies for successfully addressing them in the classroom. Although challenging to teach, the complexity of global climate change offers an opportunity to engage students in higher order thinking skills and in an interdisciplinary and multidisciplinary analysis of the issues (Chalkley, 2002).

Moreover, climate change is a topic about which everybody has an opinion, often based largely on incomplete knowledge and major misconceptions (McCaffrey & Buhr, 2008). Effective climate change education therefore requires the learners to construct new knowledge and understanding within existing, often well-established and deeply personal frameworks of existing beliefs, incomplete knowledge, and conceptions. This implies that, climate change educators must work to deconstruct existing partial or incorrect knowledge as part of the educational process in order to achieve effective climate change education (Rebich & Gautier, 2005; Harrington Jr., 2008).

Objectives of the study

Premised on the fact that there could be misconceptions or the lack of knowledge of climate change among Nigerians, especially the in-school youth and children, it is expedient that teacher training institutions should provide an opportunity for pre-service teachers to have an understanding of what to teach and the right type of method to use in teaching.. This paper therefore seeks to provide a scheme of work for climate change education and present a concise note that can be used to promote the understanding of its subject matter: by way of synthesizing the scientific explanation on climate change, its diagnosis; and impacts on environment and society. All these were with the view of providing the pedagogy for the content of climate change in the Nigerian institutions of learning.

A SCHEME OF WORK FOR CLIMATE CHANGE EDUCATION

In the teaching profession, a scheme of work is the detailed breakdown of a subject's curriculum and syllabus into teachable units, so that the teacher could have a convenient room to develop a lesson plan and a lesson note (Akinlaye, Mansaray & Ajiboye, 1996). The emergence of climate change as a concept with interdisciplinary posture would require some degree of creativity on the part of whoever wants to teach it. In the purview of these authors as Social Studies educationist, the scheme of work for climate change education is expected to be one that seeks to help the teacher imparts knowledge and assist learners to cultivate good attitudes and values toward the environment, the consequence of which is to stem tide of global warming-inducing activities and indeed climate change. A typical scheme of work for climate change education through Social Studies could look like this:

Theme/sub-theme to be studied	Climate Change
Topic/sub-topic to be discussed	Meaning of Climate Change
Objectives to be achieved	Students should be able to: 1. Define Climate Change 2.Define Climate Change in scientific perspectives 3.Identify the anthropogenic causes of climate change 4. Enumerate the effects of climate change 5. Identify industries that are affected by climate change 6. Explain why it is good to develop positive attitudes towards effective environmental management
Concept to be developed	Climate Change as a geographic concept
Generalizations to be developed	Climate change is a global environmental problem that must be urgently attended to, if the world will not experience a global disaster.
Knowledge to be imparted	1. Climate presents the physical properties of a place based on analysis of its weather conditions, usually the events that occur in the troposphere. 2. The indicators of weather are rainfall, temperature, humidity, air pressure, wind pressure and sunshine. 3. The climate of a place is determined based on weather statistics over a long period of time 4. The climate of a place is said to have changed if elements of weather are not occurring at their conventional periods and can be diagnosed by occurrence of some unforeseen events 5. Climate change is more often than not induced by human development activities 6. The effect of activity of people of an area can be felt in far away distances 7. The effects of climate change include increased heat wave, ice-melt causing ocean overflow and coastal flooding, shortage of rainfall in some places(drought) and excess of rainfall in other places, loss of biodiversity, severe compromise of agricultural production which cause loss of access to food. 8. The Industries that are sensitive to climate change include agriculture, fisheries, forestry, energy, construction, insurance, financial services, tourism, and recreation 9. People have to develop attitudes that will not cause climate change. Such attitudes include sustainable use and management of the forest; reduction of Green House Gas emission; use alternative technologies and sources of energy such as solar.
Attitude and values to be instilled	A shift from activities that are capable of depleting the quality of elements of climate and weather

Skills and competencies to be developed	Ability to measure the occurrence of elements of climate and weather. Ability to oppose and educate others about activities that can cause climate damage.
Method(s)/strategy (ies) to be used	Eclectic Approaches: 1.Exposition 2.Discussion 3.Field trip and outdoor activities 4. Focused Group Discussion
Resources to be employed;	Measuring instruments in geographic gardens Maps, Globe and Atlases Use of resource persons
Evaluation strategy (ies)	Eclectic Approaches: Oral tests and paper pencil test

THE SCIENTIFIC BACKGROUND OF CLIMATE CHANGE

From the scheme of work provided above, the learning content/subject-matter or knowledge of climate change to be imparted has been spelt out. All these suggest what its scientific explanations revolve around. By way of introduction, climate change is a concept with two different words, climate and change. Without much ado about 'change', which the Hyper Dictionary (2000-2009: online) has defined as the alteration of the state of an object, following the introduction of certain conditions, climate in the perspectives of Social Studies experts is a geographic concept. It is the physical properties of the troposphere of an area based on analysis of its weather records over a long period of time. As a none-example (in Social Studies perspective), weather entails the short term changes in the temperature, barometric pressure, humidity, precipitation, sunshine, cloud cover, wind direction and speed, and other conditions in the troposphere at a given place and time (Miller Jr. &Spoolman,2008). The difference between weather and climate is the time lag. This is because the weather is determined for any given time, usually brief.

In the opinion of Jeje and Adesina (2012), 'we can speak of today's weather or last week weather'. According to Jeje and colleague, weather is variable; and in some places, different weather conditions can be observed. For instance, significant changes in weather condition in the winter can produce complete cloud cover, drizzle or storms in a matter of minutes or hours. Moreover, since there are different elements of weather which are used to determine the status (strength and weakness) of any weather condition (mentioned above); it is worthwhile to understand how their occurrences are being measured - in order to facilitate the understanding of the issue of climate change. By and large, since average temperature and average precipitation are the two main factors determining the climate of an area (Miller Jr. & Spoolman, 2008), attention is thus focused on measurement of temperature and rainfall.

The thermometer is the instrument used to measure temperature of a given place. This thermometer contains mercury in a glass bulb which expands as it gets hotter and rises up the scale to show the temperature of the air. The temperature is measured in degrees Fahrenheit or degree Celsius. The Rain Gauge, a metal instrument, measures amount of rainfall or any other form of precipitation (snow, sleet and hail) of a given area at a particular period of time. The rain gauge contains a tiny-holed metal funnel 13cm or 20cm in diameter which leads into a small copper container or a glass bottle. It is usually at least one-foot above the ground level. It is usually sited well away from tall buildings, high trees and other objects that will not allow raindrops to fall into the funnel. When rain has fallen, the funnel is removed and the water content is emptied into a graduated cylinder with a 3.8cm diameter. The extent to which water has percolated the soil, other things being equal (lack of evaporation or drain off) is measured in millimeter; hence there are expressions like 25mm, 20mm rainfall etc (Areola, Ahmed, Irueghe, Adeleke & Leong, 2009). The daily, monthly, yearly and periodic recordings of these weather elements are then kept for references and further use.

Climate, unlike weather, is however determined by measures that use statistics of considerable length of time: although the same elements of weather are used. In the opinion of Areola *et al* (2009), the average climate of any given place is usually determined for a period not less than 35 years; and the records of weather conditions kept overtime are averaged to draw a conclusion on the overall climatic conditions of a particular place. A reference to what obtains at a long period of time, in comparison with the present usually guide geographers and scientists to conclude whether there is change in climate or not.

The United Nations Framework Convention on Climate Change (UNFCC) defined climate change in Article 1 as “a change of climate which is attributed directly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods’’ (IPCC, 2007:30). This usage differs from the IPCC usage of climate change where it is referred to as “a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity’’ (IPCC, 2007:30).

Climate change, according to Eden (2009) is one of the global environmental problems that are constructed over time. According to Eden, climate change was constructed in 1970s as ‘global cooling’, raising the prospect of the next ice age. It was constructed as ‘nuclear winter’ that would have resulted if the cold war had turned into a nuclear war in the 1980s, and as ‘global warming’ in the 1990s. After protracted arguments on environmental problems, Eden provided what somewhat appears the scientific explanation about climate change viz:

> *…in climate change, radiation (sunlight and heat) from the sun is partly reflected but mostly absorbed by the Earth, which then re-radiates it. Certain gases in atmosphere absorb this heat and stop it escaping to space, making lower atmosphere (troposphere) about 32^{0}C warmer than it would be without the(se) ‘greenhouse gases’. The environmental problem that was identified was that emissions of greenhouse gases were increasing the amount of heat being retained- ‘radiative forcing’ – and thus causing ‘global warming’ or the ‘enhanced’ or anthropogenic ‘greenhouse effect’*

Eden identified four types of (the big four) greenhouse gases as carbon dioxide, chlorofluorocarbons (CFCs), methane and nitrous oxides; and ozone (in the troposphere) and water vapour.

Miller Jr. and Spoolman (2008) also hold similar views as Eden. They explain that human actions from the industrial revolution have led to significant increases in the concentration of earth-warming carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) released from agriculture, deforestation, and burning of fossil fuels (and coal), which are responsible for global warming. But from all indication, the emission of CO_2 carries more of the blames. The other gases however minute are also increasing the strength of the CO_2. This may suggest why scientists are predicting that over the next half-century, the global temperature will double; and one of the ways by which they do the estimation and predictions is to make assumptions about how much each type of gas is likely to be released into the atmosphere, and feeding the information into the computers that can model the atmosphere's behaviour. These approaches might have been responsible for the current prediction that the greenhouse effect will amount to 1.5 and 4.5 ^{0}C by the year 2030 (Otiende, Ezaza & Boisvert, 2010). The Institute of Environmental Management and Assessment (IEMA, 2013) also reports an envisage that the global and regional warming could quadruple after 2100, because temperature could rise from 1.5 ^{0}C to as much as 15^{0}C as a result of the current level of fossil fuel consumption. But it could about four times by the year 2100 if the current trends increase. Whereas, the European Union is saying that global annual mean surface temperature increase should not exceed 2 ^{0}C above pre-industrial levels. All these suggest that that some phenomena may be suffering from the impact of climate change.

The summary of the scientific explanation is that which is provided by the IPCC (2007). According to the IPCC, climate change is a product of global warming which are caused by human activities that release greenhouse gases into the troposphere, and which has increased the average global surface temperature by about 0.74^{0}C (1.3 ^{0}F); produced five hottest years (2005, 1998, 2002, 2003, and 2006) since 1861; raised arctic temperature as fast as twice the temperature of the rest of the world for about 55 years ago; caused glaciers and floating sea ice to melt, and shrink at increasing rates; changed rainfall patterns and increased severe drought; and caused sea levels to rise by 10-20 centimeters induced by run-off of ice-melt and increased temperature of the ocean.

EFFECTS OF CLIMATE CHANGE

There is a general consensus of opinion when it comes to the effect of global warming and climate change. Usually they are about predictions of what will happen if global temperature rise continues unabated. Otiende *et al* (ibid) provide some explanations on this. According tothe authors, in temperate zones, winters would tend to be shorter and warmer, and summers hotter and longer. The overall rainfall would rise by an estimated 7-11 percent a year when evaporation rates increase. Temperate winters might be wetter and summers drier. The tropics would also become wetter, but subtropics that are already dry could become drier still. The European Union also buttresses this.

The EU specifically identifies the very vulnerable to climate change. According to EU, melting ice and rising seas will threaten low-lying land areas and islands. Extreme weather, shifting rainfall will cause significant changes in the quality and availability of water resources. Mediterranean area which is becoming drier will be more vulnerable to drought and wildfires. Northern Europe which is getting significantly wetter will experience winter floods. The very young, the elderly, the disabled and low-income households would experience direct risk to the health and safety of people. Society and the economy will incur heavy cost due to damage to property and infrastructure. Sectors that rely strongly on certain temperatures and precipitation levels, such as agriculture, forestry, energy and tourism, will be particularly affected. Plant and animal species will struggle to cope with further temperature increase that could mistakenly increase by 1.5^{0}C-2.5^{0}C; hence they are at increased risk of extinction (Climate Action, 2102).

Every other opinion agrees with the Climate Action account above. For example, UNESCO (2013), Osumanu (2010) and UNICEF (2012). As a synthesis of the opinions of these authorities, the effects of climate change are as those that could not be viewed in isolation - because they are all connected. For example, as the water cycle intensifies both drought and flooding increase. This affects agriculture, increases the likelihood of waterborne disease, and can negatively affect what was once a fertile land rich with resources. The citizens most vulnerable to climate change and its many connections are children. Since children have been developing immune systems and rely on proper nutrition and clean water to progress into adulthood, they are less likely than adults to weather the effects of climate change. The environmental consequences of global warming are thus to be seen to be impacting negatively on livelihoods, employment and sustainable economies of the local peoples.

Moreover, agriculture is seen as a major victim of climate change impacts. The situation becomes more critical because agriculture contributes significantly to employment, livelihoods sustenance and poverty reduction in developing countries, including Nigeria (UNICEF, 2011). At the economy-wide level, the effects of climate change could manifest in declining agricultural productivity and competitiveness, greater risks to human health, stymied prospects of increased employment, worsened poverty, diminished food security and conflicts of resource use (Odingo, 2010; Osumanu, 2010). The present pattern of rainfall in Nigeria, where the outset is staggered, when there is prolonged break in the rainy season and resumed rainfall is causing flooding in one area and there is undue drought in certain regions suggest that Nigeria is a country that is negatively affected by climate change.

HOW TO ADDRESS THE PROBLEM OF CLIMATE CHANGE?

People often say, ‘a problem that is revealed is already solved’. It is already known that CO_2 emissions, in association with other gases are responsible for global warming that in turn causes climate change. Blyth (2010) opines that methods to reduce carbon and GHG emissions such as energy management and reduction on site, improvement to buildings and premises, staff engagement and awareness campaign would be a good framework for action against climate change. The account given by Oyeshola (2008) on the international environmental law could checkmate climate change inducing activities seem to wrap it all. Oyeshola mentioned the three principles of environmental law as:

- sustainable development, which emphasizes conservation of natural resources for the future generation, exploitation of natural resources in a manner which is sustainable or prudent, equitable use of natural resources and integration of environmental considerations into economic and other development plans, programmes and projects
- taking preventive measures, which require the prohibition of what will cause environmental damage, such as environmental auditing and environmental impact assessment; and precautionary measures, which prevent a potential polluter that its activity would not cause pollution before the activity is embarked upon
- polluter must pay, which provides that the cost of environmental pollution should be borne by those whose activities were responsible for the pollution.

THE PEDAGOGY OF CLIMATE CHANGE EDUCATION

Given the account of climate change, its impacts and effects, and bearing in mind the fact that climate change is greatly caused by human actions, there is therefore the need to educate today's youth to be proactive and prepare citizens empowered to adapt and respond to rapidly changing environments. An education, which will prompt young citizens to question and modify existing conditions and structures moving toward enhanced development objectives and disaster risk reduction and preparedness activities, is germane.

The theoretical basis for this explanation can be hinged on the environmental literacy theory which Chinyerem and Ohia (2010) explained assumes that knowledge is necessary to comprehend relatedness, and attitudes of care of stewardship. In other words, an environmentally literate individual should have the practical competence that is required to act, on the basis of knowledge and feeling. From this notion, environmental literacy is primarily concerned with knowing, caring and practical competence which encompass the understanding of how people and societies relate to each other and natural systems, including how they might do so sustainably. An adaptation to climate change and an assurance for the overall sustainable development in Nigeria therefore hinge on effective climate change education.

As earlier said, the pedagogy of climate change education is about what to teach and with what method would it be taught. Having made some expositions on the likely learning content (what to teach), the next is about how to teach the learning content so that the learners could acquire the right knowledge, cultivate the right attitude and values and develop appropriate skills towards environmental sustainability - bearing in mind the impacts that climate change could bring on humanity and all the life supporting elements.

First of all, it is necessary to mention that there is a general paradigm shift from the teacher-centred method of teaching to more learner-centred methods. Practitioners of education for sustainability have over the decades advocated the engagement of the socio-critical oriented teaching strategies; and Fien (1993) and Paulo Fiere (a Brazilian philosopher), are the protagonist of the approach. The approach suggests the social roles of the school, the desired student's outcomes, broad curriculum organisation, classroom organisation, the teacher's role, student's roles, teacher-student relationship and class control. Others are the type of knowledge, the learning theory, teaching spaces and resources and assessment techniques.

By and large, since a scheme of work has been provided above, there may not be the need to expose each of the components of the approach into detail. But from the authors' perspectives, these twelve headings could be classified into just three main headlines. These are settings, communication strategies and the timing for teaching. These headlines thus guide the discussion below.

<u>Settings for Climate Change Education</u>
The socio-critical teaching strategy explains that the school and society reflect each other. The school is seen to be helping the society to overcome her justifiable conflict situations. That is why climate change education activities and learning tasks can take place in both the school and the community: because the boundaries between the school and the society are blurred. This allows for informal classroom arrangements. This thus suggests that teaching strategies such as educational field trip and discovery method, discussion, service learning instructional strategy and focus group discussion are relevant to the teaching of climate change education content.

<u>Communication Strategies Climate Change Education</u>
In the socio-critical classrooms, teaching and learning are critical, constructive and co-participatory. Such activities seek to transform the society and the participants are also transformed by it. In order to have effective exchange of ideas, the teacher is an organiser as well as resource person who negotiates how to go about the learning activities with the students, who also see other people as co-learners. The relationship of the teacher and the students are also cordial, as the teacher and the students see the problem as a mutual issue of concern. In the process the knowledge to be shared is dialectal. They therefore jointly give a name to whatever social problem they want to solve. They also reconstruct a social reality, bearing in mind that they would share the gains of their actions whichever way it results.

<u>The timing for teaching Climate Change Education</u>
The curriculum of the social critical approach is broad. The community, the teacher and the learners are involved in the learning tasks; hence they agree on when to embark on it.
Let us take a look at two of the strategies that fall within the above explanations.

SERVICE LEARNING INSTRUCTIONAL STRATEGY

Service learning instructional strategy has been defined in many ways but the core of its definition lies in connecting learning with community service. The National Community Service Act of 1990 defined service learning as a process whereby students learn and develop through active participation in organized service experiences that actually meet community needs. Service learning provides students opportunities to use their acquired skills and knowledge in real life situations in their communities. This enhances teaching by extending student learning into the community and helps foster a sense of caring for others (Burns, 1998). The primary goal of service learning, as expressed by Covitt (2002) is to make learning relevant for the children.

A more comprehensive definition of services learning was provided by Anderson (1998) as both a philosophy of education and an instructional method. As philosophy of education, service learning reflects the belief that education should develop social responsibility and prepare students to be involved citizens in democratic life. As an instructional method, service learning involves a blending of service activities with the academic curriculum in order to address real community needs, while students learn through active engagement (Anderson, 1998). Anderson further defines Service Learning as an instructional strategy that combines service to the community with classroom curriculum. It is a hands-on approach to mastering subjects matter while fostering civic responsibilities. Service learning provides a context for talking about learning in terms of not only what students know but also what they are able to do. Critical to this type of learning is building in time for students to reflect their experience. It also builds stronger academic skills because students take an active role in determining how the projects are identified and accomplished, creating interest and excitement for learning. Definition given by Anderson can be subsumed into two: service learning accommodates many different learning styles and it is a growing pedagogy that integrates community service into an organized curriculum that includes regular opportunities for personal reflection. Kuh, Kinzie, Schuh, and Whitt (2005) are of the view that service learning invites students to work together with adults to serve within their own school (or another school). This is achieved throughtutoring or peer-mentoring, or in the broader community by working in environmental settings., It offers the opportunity to serve, giving students the sense that they can make a difference by using what they have learnt (Ajitoni & Gbadamosi, 2012; Fares, 2006).

Steps involved in the use of Service Learning Instructional Strategy

Phase 1: Preparation

Step I: The teacher guides students to link the concept with environmental issue in the school/ community used.

Step II: Theteacher guides the students to mention the areas experiencing environmental issues for the study.

Step III: Students discuss the causes of the environmental problems such as causes of pollution in the school compound.

Step VI: The teacher guides students to discover the importance of solving the identified environmental problems in the school/community.

Step VII: **S**tudents decide on what they would do to solve the problem (services to perform).

Phase 2: Action

Step1: The Teacher assists the students to organize the project themselves and develop a work plan. Work plan will involve initial action steps to begin the work; set a realistic timeline for getting the work done, set goals for the project and how to do it**.**

Step II: The Facilitator guides students to develop pre-reflection activities whereby students will think about what to gain in solving the problem before they engage in it.

Step III: The students carry out the service such as making of sand bag and planting of trees to control erosion.

Phase 3: Reflection

The Facilitators provide structured time for students to think, talk and write about

what they did and observed during the service activity.

Phase 4: Demonstration/ Celebration

The students organize presentations on what they have learnt and how the project has positively affected them.

Limitation of Service Learning Instructional Strategy

Yanesh (2002) in a study on the effect of service-learning in the curriculum discovered that service-learning was often not integrated into the curriculum as expected, teachers often did not require students to reflect on their experiences, and teachers did not spend adequate time preparing for service projects. However, service-learning pedagogy requires each of these characteristics in their absence, the practice of service-learning seemed to have less positive effect on the students.

Educational Trips Instructional Strategy

Educational trips instructional strategy are learning experiences that involve taking learners out of school to places where students can observe first hand information and study in a real life setting (Mezieobi, Fubara & Mezieobi, 2008). With the availability of learning materials on the Internet, some teachers and students may question why educational trips are needed anymore. Educational trips can be troublesome and difficult to organize and supervise. But they do provide learning opportunities that cannot be experienced in the classroom as discovered by some researchers. Studies shown that educational trips give opportunity for real first hand experiences and brings welcome change to monotonous presence of teachers. Studies that examined the effects of outdoor environmental programmes found statistically significant changes in campers' knowledge of environmental issues (Gbadamosi, 2011; Olatundun, 2008; Chowdbury, 2008). It is thus expected that when learners are taken out 'on tour' of facilities of company generating greenhouse gases, to the bar-beach to see the ocean movements, agricultural and livestock farms they would learn first-hand about global warming and climate change .

Steps involved in the use of Educational Trips Instructional Strategy

Phase 1: Preliminary phase (Before the educational trip)
Teacher's activities
Step I: The Teacher chooses and visits environmental problem site to study.
Step II: The Teacher takes attendance of the students.
Step III: The Teacher discusses the topic with the students.
Step IV: The teacher presents the purpose of the trip to the students.
Step V: The Teacher gives background information by describing specific features to be observed on the trip.
Step VI: the Teacher informs students to jot down information received during the trip.

Phase 2: Teacher's and Students' activities (Educational trip)
Step I: The Teacher and the students visit the study sites such as illegal dump sites, erosion site and so on.
Step II: The students observed and study causes, effects and solutions to the environmental issues.
Step III: Each student writes down what he/she has observed.
Step III: The students ask questions from the teacher and or community members.

Phase 3: Follow up/ Evaluation
Teacher's / Students' activities
Step I: The students present and discuss their observations from the environmental problems sites visited.
Step II: The Teacher evaluates the students by asking questions.

Challenges Teachers Face When Supervising Students on a Educational Trips

Supervising students on an educational trip can be tough for teachers. Educational trips are an essential part of the learning process for students in all grades and across all subjects. Not only does the out-of-class experience provide another way in which to learn about a topic, but also removal from the classroom excites and energizes students as they can learn in a less-structured environment. However, teachers do have a few challenges they must overcome when supervising students on an educational trip. Among them as stated by Lynda (2006) are keeping up with individual student; discipline: teachers may have to continuously remind students to behave and impose harsher penalties than usual for misbehaving, since students are expected to behave better in public; resolving conflict between students; ensuring a learning experience for all.

CONCLUSION AND RECOMMENDATION

This paper has taken a look at the problem of climate change as a phenomenon that requires urgent attention into which the school could also contribute. It has seen climate change as a concept requiring greater understanding by the pre-service teachers and the learners in the school. Its learning content also requires a better approach to teaching, usually the outdoor learner-centred methods. The paper observes that only effective communication of the content in the right time and setting could foster the understanding of the learning content and assist the learners to acquire relevant knowledge, cultivate the right attitude and develop the right type of values and skills to promote activities that will check-mate climate change inducing activities.

REFERENCES

Ajitoni, S. O. & Gbadamosi, T. V. (2012). Effects of service learning and educational trips in Social Studies on primary school pupils' environmental knowledge for sustainable development, *Academic Research International.* 2 (2) pp. 342-348.

Akinlaye, F., Mansaray, A. & Ajiboye, A. (1996). *Fundamentals of teaching Social Studies, Lagos: Purmark* Nigeria Ltd.

Anderson, J. (1998). *Service learning and* teacher education. ERIC Clearing house on Teaching and Teacher Education, Washinton, D.C.

Areola, O., Ahmed, K., Iruegbe, O.I., Adeleke, B.O. & Leong, G.C.(2009). *Certificate Human Geography for Senior Secondary School Schools*, Ibadan: University Press.

Blyth,N.(2010). IEMA special report, GHG management and reporting – A view from the front. *The Environmentalist*. October 4, 2010. P.14.

Burns, L. (1998). Make sure it's service learning, not just community service. *Education Digest*, 64(2), 38 41.

Chalkley, B. (2002) Setting the sustainability scene. *Planet Special Edition*, 4, pp. 3.

Chinyerem, U.M & Ohia, A.N (2010). Human resources availability for environment literacy and adoptation to climate change. *Nigerian Journal of Educational Administration and Planning.* 10(2) 181-190.

Climate Action (2102).What are the consequences of climate change? Retrieved Wednesday 14 August 2013 from *http://ec.europa.eu/clima/policies/brief/consequences/index_en.htm*

Chowdbury, M. H. (2008). *Community based environmental education for sustainable development: the case of Bangladesh*. Comila Bangladesh: Bangladesh Academy for Rural Development (BARD).

Eden, S. (2009). Global and local environmental problems. In Cloke, P., Crang, P. and Goodwin, M. *Introduction to human geography*. U.K: Hodder Education.

Fares, H. (2006). Environmental Service Learning Programs in the United Arab Emirates: Impacts on Environmental Awareness and Civic Engagement. Retrieved 4th august, 2010 from *http://gwbweb.wustl.edu/csd/gsi.*

Federal Ministry of Environment of Nigeria (2013). Climate change. Retrieved from *http://environmentgov.ng/issues/climate-chnage/y on 30*, July, 2013.

Gautier, C., Deitsch, K. and Rebich, S. (2006) Misconceptions about the greenhouse effect. *Journal of Geoscience Education*, 54 (3), pp. 386-395.

Gbadamosi, T. V. & Ajagbe, C. A. (2012). Teachers' educational qualification as determinants of teachers' understanding of climate change. *Books of Reading, School of Arts and Social Sciences.* Emmanuel Alayande College of Education, Oyo .

Gbadamosi, T. V. (2011). Effects of gender and educational trips instructional strategy on pupils' environmental attitude in Social Studies, *Journal of Pedagogical Thought.* 2 pp. 69-77.

FCCC. (2007). Climate change: Impacts, vulnerabilities and adaptation in developing countries. United Nations Framework Convention on Climate Change (UNFCCC).

Fien, J. (1993). Major characteristics of the vocational/neoclassical, liberal/progressive, and socially critical orientation in education. In Fien, J. *Teaching for a sustainable world.* Australia: Griffith University. Pp. 2-3.

IPCC (2007). *Climate change 2007*. Fourth Assessment Report (AR4).

Jeje, L.K. & Adesina, F.A. (2012). *Man and environment: An introductory note. Ile-Ife*:Department of Geography, Obafemi Awolowo University.

Johnson, R.M., Johnson, R.M., Henderson, S., Gardiner, L., Russell, R., Ward, D., Foster, S., Meymaris, K., Hatheway, B., Carbone, L. and Eastburn, T. (2008) Lessons learned through our climate change professional development program for Middle and High School teachers. *Physical Geography*, 29 (6), pp. 500-511.

Kuh, D., Kinzie, J., Schuh, J. H., & Whitt, E. J. (2005). *Student success in college: Creating conditions that matter.* San Francisco, CA: Jossey-Bass.

Lynda, M. B. (2006). What are some challenges teachers face when supervising students on a field trip? Retrieved 29 march, 2013 from *http://www.ehow.com/info_8322853_challenges-supervising-students-field-trip.html#ixzz1hBP1cE9v*

Madumere-Obike, C.U., Kaegon, L.E.S & Kpee G.E (2010) Climate literacy and teachers on secondary schools in South-East Secritorial Zone of Rivers State Nigeria. *Nigerian Journal of Educational Administration and Planning*. 10(2) Pp. 43-56.

Madumere-Obike, C.U & Nwabueze, A.I (2010). *Quality Education: A panacea to managing the Effects of climate change in South-East States of Nigeria*. A Paper Presented at 2010 International Conference on Educational Management, Environmental Literacy and Climate Change by Nigeria Association for Educational Administration and Planning, held at The Atrium, Port Harcourt.

McCaffrey, M.S. and Buhr, S.M. (2008) Clarifying climate confusion: Addressing systemic holes, cognitive gaps and misconceptions through climate literacy. *Physical Geography*, 29 (6), pp. 512-528.

Miller Jr. G.T. & Spoolman, S. (2008*). Environmental science: problems, concepts and solutions,* USA: Thomson Books/Cole.

Odjng O, P.A.O (2010). General overview of climate change impacts in Nigeria *J. Hum Eco,* 29(1) 47-55.

Ogbo, A, Lauretta, N.E. & Ukpere, W. (2013) Risk Management and challenges of climate change in Nigeria *Journal of Human Ecology* 41 (3) pp. 221-235

Ogboudu, A. I. (1988). Resource person in the teaching of social studies in Akinlaye, F.A; Kupolati, C.O; Opawale, D.A (Mrs.) and Oshungbohun, T (Mrs.) Eds. *Concept and scope of Social Studies education for schools and colleges.* Ibadan: Onibonje publishers Nigeria Limited.

Olatundun, A. O. (2008). Impact of Outdoor Educational Activities on Pupils' Knowledge and Attitude in Selected Primary Schools in Ibadan, Nigeria. *Unpublished Ph.D.Thesis.* Department of Teacher Education, University of Ibadan, Ibadan.

Onuoha, C.M. (2008). Understanding climate change in African Economies. *The Green Economist-International Journal of the Green Economics Institute*, UK; Vol. 3 Issue 2, Autumn (www.greeneconomics.org.uk).

Osumanu, K.O (2010). *Propagation and management of environmental change in West Africa*. A Lead Paper Presented at 2010 International Conference on Educational Management, Environmental Literacy and Climate change by Nigeria Association for Educational Administration and Planning, held at The Atrium, Port Harcourt.

Otiende, J.E., Ezaza, W.P. & Boisvert, R. (2010). *An introduction to environmental* *education.* Nairobi: University of Nairobi Press.

Oyeshola, D.O. (2008). *Sustainable Development : Issues and challenges for Nigeria*. Ibadan, Daily Graphics.

Yanez, N. D. (2002). Empowering students through community action. Retrieved from *http://www.colorado.edu/journals/cye/16_1/16_1_01_NatureAndLifeCourse.pdf* (Volume 3).

Adolescents' Reactions to Climatic Changes and Environmental Issues in Lagos, Nigeria

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ABSTRACT

The purpose of the study was to clarify a number of widely held misconceptions about climatic changes and environment management in schools. It was also aimed at integrating climatic changes and environmental management topics into curriculum of secondary schools. Methodology of the study comprised random sampling techniques without replacement of one hundred and eighteen secondary school students from Lagos West Senatorial District. The instrument consisted of a questionnaire, which was analysed by appropriate statistical method like SPSS (Statistical Package for Social Sciences), Simple percentage, and Face and Content validity. The results indicated that more than half of the participants were females falling within the age bracket of 14-16 years. Science students tended to have more awareness of climate and environmental issues than Arts and Commercial students. They claimed that their source of awareness was mainly Television and Radio but not schools and homes. About 67% of the respondents had some knowledge of climate change while about 59.5% claimed to have some knowledge about environmental management. Majority of the students had little or no knowledge of Greenhouse gases and impacts of using fossil fuels but they had some knowledge of Global warming, Ozone layer, floods, and pollutions, industrial and medical wastes. It is recommended that climatic and environmental management issues should be included in general subjects like Mathematics, English, Biology, Geography, Agricultural Science, Economics, and Government at the secondary school level. Teachers and even the general public should be more oriented in climate and environmental issues from the grassroots and students should be included in climatic and environmental development projects in the community.

Keywords: Climate changes, Environmental Management

INTRODUCTION

The growing awareness of the impact of the environment on social, economic and health wellness of the population explains the reason for the more attention now being paid to environmental issues. It was established that air pollution is caused by the excessive concentration of one or more contaminants such as dust, smoke, fumes, gases, etc in the air which adversely affects human health, plants, animals or even damage to properties, which on the long run leads to global warming, depletion of ozone layers, acid rain etc.

In humankind's pursuit of well-being, we both influence and respond to climate. Anthropogenic emissions of greenhouse gases affect the heat balance of the Earth, and the resulting changes in precipitation patterns, temperature extremes and rising sea levels affect how society develops. The dynamic interaction between humans and climate is not new, but the scale of the interaction has reached unprecedented proportions. While climate scientists study the effects of increased temperatures and atmospheric carbon dioxide on the world's oceans and weather patterns, engineers are seeking ways to produce cleaner energy and provide steady supplies of fresh water. Social scientists, policy experts and lawyers are studying human behaviour in the face of change as a way to improve how we make decisions, and the policy and legal tools we can use to implement measures that address the climate challenge. The educationists try to create awareness and possibly look at integrating climatic issues into school curricula.

To fully appreciate the urgency of climate change and environmental issues, it's important to understand the ways it affects society and the natural environment. Sea levels are rising and glaciers are shrinking; record high temperatures and severe rainstorms and droughts are becoming increasingly common. Changes in temperatures and rainfall patterns alter plant and animal behaviour and have significant implications for humans. There are a number of widely held misconceptions about climatic changes and environmental management in schools. Unfortunately, these misconceptions are reflected in some of the educational materials available on the subject. Thus, to clarify the misconceptions and enable students get a clear perception of the subject, this research is necessary.

Also, climatic change and environmental management is a great topic for students to study because it integrates so many subjects: Energy, Environment, Geography, Politics, Chemistry, Biology, Economics and more. It requires students to use analytical tools and mathematical skills to exercise their abilities to research, think and understand complex issues. In Nigeria, secondary education is the ante-chamber to higher education hence; secondary schools serve as the major source of recruitment into higher institutions of learning. Therefore, the Joint Matriculation Examination (which is the qualifying examination for entrance into the University, Polytechnics, Mono-technics and Colleges of Education) in Nigeria and School Certificate Examination have been the instruments and criteria by which performance of students or output quality of students are measured.

Nevertheless, the main objectives of the secondary education in Nigeria as contained in the National Policy of Education (FRN, 2004) are as follows:

i. To develop the personal capacity of individuals

ii. To prepare pupils for the world of work and

iii. To prepare pupils for the next stage of education.

This response has been that the concept of life-long loaming and the idea that there is not just one transition from education to work; instead the two systems are seen as parallel entities and individuals can expect to interact with both through the course of their work life. It was remarked that secondary school supplies the person who with one or more years training institution or on the job becomes the labour force of a nation. Another significance of the study is the controversial nature of issues on climatic changes and environmental education. With such strong scientific consensus that climate change is real and is largely due to human activities, why is there so much controversy in. the press and among the public? Why do some people keep insisting it is just an unproven theory? Some reasons involve communication breakdowns, but even more important is the deliberate campaign by special interests, including some in the fossil fuel industry to undermine or cast doubt on the science.

Climate science can be confusing and is not easily explained in sound bites or brief newspapers articles. Many well-intentioned reporters are ill equipped to get the story right and their mistakes are often perpetuated as other reporters use previous articles as source material for new ones. For example, partly as a result of such problems, many people erroneously believe that global warming is caused by increased heat entering the atmosphere due to ozone depletion caused by chlorofluorocarbons. In addition, most scientists discuss their research in terms that the public cannot easily understand, especially secondary school students. They also use some words that mean different things to the young minds of these students than they do to scientists. For example, when scientists speak of "aerosols", they are referring to tiny atmospheric particles, whereas "aerosols" to a secondary student is a spray can.

But the most significant reason for the controversy is that some special interests have mounted an active campaign to raise doubts and create confusion about this issue. For legitimate and other reasons, a very small number of scientists raise questions about whether global warming has or will occur. When they do, special interests work hard to amplify and distribute the views of these "Contrarians" in order to create confusion among the press, policy makers and public and give the impression that there is still a major scientific debate about the reality and causes of climate change. (Note: not all fossil fuel companies are implicated in this disinformation campaign). Some, in fact, have acknowledged the scientific realities and are taking steps to reduce their greenhouse gas emissions. Given all these confusion and controversy, it is particularly important that teachers and students have access to reliable information about climate change. (Teachers 'guide to high quality educational materials on climate change and global warming, 2002).

This study is also significant because the consciousness of adolescents' students to environmental issues is so crucial to maintaining sufficient knowledge on global warming of the students, thus leaving the future world as livable as possible to the following generations by turning the knowledge into attitude, not only are global warming-induced changes currently underway, but scientists also expect additional effects on human society and natural environments around the world. Some further warming is already unavoidable due to past heat-trapping emissions; unless we aggressively reduce today's emissions, scientists' project extra warming and thus additional impacts.

In the light of this background, this paper presents the analysis of adolescents' reactions to the climatic changes and environmental issues with the aim to achieving the role of science for combat. Therefore, the following research questions guided this study.

1. What is the quantitative analysis of students' reaction to climatic changes?
2. What are the quantitative reactions of students to environmental management?
3. What is the qualitative analysis of students' reaction to climatic changes and environmental management?

METHODOLOGY

This is a survey research designed purposely to analyse Adolescents' reactions to Climatic changes and Environmental management in schools. It was considered appropriate because secondary school students constitute a reasonable percentage of a nation's population. And it is secondary school students that translate into undergraduates. Therefore, their environmental awareness can go a long way to save our planet earth. Also, this design would permit the description of the relationship between the independent (predictor) variables and the dependent variables, thereby answering the research questions and development of generalizations. In order to obtain an adequate representation of the population, random sampling techniques were used without replacement. The research designed the instrument to analyse adolescents' reactions to global environmental issues. The researchers personally administered the instrument (questionnaire) to each student in the selected schools. The data collected were coded for the purpose of computer analysis. The instruments were subjected to face and content validity. Reliability of the instruments were obtained using Cronbach's Alpha at 0.65 and 0.62 respectively using 30 adolescents and with this, the instruments' consistency was ensured.

RESULTS AND DISCUSSION

<u>Research Question One</u>

What is the quantitative analysis of students' reactions to Climatic changes?

Table 1 Climate Change Issues

Climatic Change Issues	Very adequate	Adequate	Not sure
I know what the concept of Climatic change is	(89.8) 106	(5.1) 6	(5.1) 6
I know what the concept of Global Warning is	(45.8) 54	(41.5) 49	(12.7) 15
I know what the concept of Greenhouse gases	(30.5) 36	(57.6) 68	(11.9) 14
I know what the concept of and heard of Ozone layer	(75.4) 89	(14.4) 17	(16.2) 12
I know what the concept of and know the causes of floods	(89) 105	(3.4) 4	(7.6) 9
I know what the concept of and know the causes of acid rain	(69.5) 82	(14.4) 17	(10.1) 19
Total	(66.7) 472	(22.7) 161	(63.6) 75

In order to answer research question one, there is need to refer to Table 1. The results on the table show that there is great awareness of the students to climatic changes since more than 90% of the respondents responded positively to item one. For Global Warning, the awareness level is about half (80 %), while more (80 %) have knowledge of Greenhouse gases. The quantitative awareness for Ozone layer, causes of floods and acid rain put together are more than 80% respectively too. The quantitative analysis of students' reactions or awareness to climatic changes is about 89 %.

Research Question Two

In order to answer Research question Two, reference has to be made to Table 2. From the Table 2, it can be shown that Adolescents' quantitative reactions or awareness to Environmental Pollution and effects of Environmental pollution are relatively high (89 % and 85% respectively) while for the effects of indiscriminate bush burning effects of deforestation, and impact of improper waste disposal on the environment are little above average i.e 85%, 84 % and 81% respectively. The results of items 7-14 put together showed 83 % quantitative reactions of adolescents to environment management. Whereas, the reactions are shown towards the impact of using fossil fuels on the environment, impact of Industrial Effluents on the environment and impact of Medical wastes on the environment , i.e 80%, 80 %, and 78 % respectively.
What are the quantitative reactions of Adolescents to Environmental Management?

Table 2: Knowledge on Environmental Management

Knowledge of Environmental Management	Very adequate	Adequate	Not sure
I know the causes of Environmental Pollution	(87.3) 103	(1.7) 2	(11.0) 13
I do know the effects of Environmental Pollution	(79.7) 94	(5.1) 6	(15.3) 18
I do know the effects of indiscriminate bush burning	(60.2) 71	(23.7) 28	(16.1) 19
I do know the effects of deforestation	(50.8) 60	(30.5) 36	(18.6) 22
I do know the impact of using fossil fuels (petrol, kerosene, diesel, etc) on the environment	(46.6) 55	(35.6) 42	(17.8) 21
I do know the impact of improper waste disposal on the environment	(68.6) 81	(11.9) 14	(19.1) 23
I do know the impact of Industrial Effluents on the environment	(46.6) 55	(33.1) 39	(20.3) 24
I do know the impact of Medical Wastes on the environment	(36.4) 43	(42.4) 50	(21.2) 25
Total	(59.5) 562	(23.0) 217	(17.5) 165

Research Question Three:

What are sources of Adolescents knowledge of climatic changes and environmental issues? This section treats the sources of adolescents' reaction or awareness to Climate changes and Environmental management. To analyse the source, reference has to be made to tables 3 and 4.

Table 3: Knowledge of climatic change

Knowledge of climatic change	Home	School	Magazine	TV Radio	Friend
Knowledge of climatic change	(0.8) 1	(15.2) 18	(1.7) 2	(72.9) 86	11 (9.3)
Knowledge of global warming.	1(0.8)	75(63.5)	5(4.2)	32 (27.1)	5 (4.2)
Knowledge of greenhouse effects	(0.8) 1	(69.5) 82	(5.1) 6	(22.0) 26	3 (25)
Knowledge of ozone layer	(4.2) 5	(29.6) 35	(5.9) 7	(54.2) 64	
Knowledge of causes of flood	(6.8) 8	(17.8) 21	(3.4) 4	(61.0) 72	13 (11.0)
Knowledge of acid rain	(5.9) 7	(39.0) 46	(4.2) 5	(44.9) 53	(5.9) 7

The major source of knowledge of Climatic change Adolescents students is through TV/Radio (72.9%). The same goes for the knowledge of Ozone layer (54.2%), causes flood (61.0%) and causes of acid rains (44.9%). Whereas, the major sources of awareness of the knowledge of Global Warming (63.5%) is other sources not included in the options of home; school; magazine; Tv/Radio and friends. The same goes for the knowledge of Greenhouse gases (69.5%).

Table 4: **Adolescents' knowledge of environmental issues**

Knowledge of environmental issues	Home	School	Magazine	TV Radio	Friend
Knowledge of causes of environmental pollution	(5.1) 6	(17.8) 21	(3.4) 4	(66.1) 78	(7.6) 9
Knowledge of effects of environmental pollution	(5.1) 6	(24.6) 29	(4.2) 5	(57.6) 68	(8.5) 10
Knowledge of indiscriminate bush burning	(4.2) 5	(37.2) 44	(1.7) 19	(49.2) 58	(7.6) 9
knowledge of deforestation	(4.2) 5	(47.5) 56	(1.7) 2	(45.8) 54	(0.8) 1
Knowledge of the impact of using fossil fuels	(4.2) 5	(52.5) 62	(3.4) 4	(32.2) 38	(7.6) 9
Knowledge of improper waste disposal	(9.3) 11	(43.5) 49	(3.4) 4	(38.1) 45	(7.6) 9
Knowledge of the impact of Industrial Effluents on the environment	(46.6) 55	(50.6) 60	(4.2) 5	41 (34.7)	(5.1) 6
Knowledge of the impact of Medical Wastes on the environment	(5.9) 7	(62.7) 74	(4.2) 5	(20.3) 24	(6.8) 8
Total	(59.5) 562	(23.0) 217	(17.5) 165	944	0

The major source of knowledge of causes of Environmental pollution is TV/Radio with 66.1%, likewise the knowledge of the effects of Environmental pollution which is 57.6% and knowledge of indiscriminate bush burning effects with 49.2%. The knowledge of effects of deforestation shows a bracket of 45.8% between TV/Radio sources and other sources. For the knowledge of impact of using fossil fuels on the environment, the major sources are others with 52.5%. 43.5% is a percentage for the knowledge of improper waste disposal from Tv/Radio since other sources is 3 7.3% for the same knowledge. The most prominent sources of knowledge of impact of Industrial effluent on the environment and impact of Medical wastes are others not stipulated which are 50.6% and 62.7% respectively.

DISCUSSION

The high level of awareness for climatic change and environmental issues were discussed in this paper. The adolescents' awareness of the concepts of ozone layer, causes of floods, acid rains, environmental pollution, waste disposal and effect of indiscriminate bush burning among science students could be our indication of the inclusion of these issues in the Social Subjects, Geography, Chemistry and other Science subjects curriculum. Whereas, the low awareness levels of Greenhouse gases, impact of fossil fuel usage on the environment, impacts of industrial effluents on the environment and even the impact of disposal of Medical wastes into the environment could be attributed to the unfamiliarity or low campaign levels of these issues on the mass media.

Most of the respondents claimed that their source of awareness to climate changes and Environmental management issues are the Television and Radio and few from other sources were stipulated. School source was lower than Radio/TV but higher than Home. This could be an indication that even the general public is less familiar with environmental issues. It translates to the fact that what parents do not, have they cannot give to their children. Jekayinfa and Yusuf (2005) noted this that the ordinary citizen and youths living in rural are unaware of the simple steps they might take within their means to manage and control their environment.

RECOMMENDATIONS

There should be a review of the secondary schools curriculum to include climatic change and Environmental management issues in general subjects like English, Mathematics, Biology, Government, Economics, Commerce etc and not just sciences alone. It should even be increased in science curriculum to accommodate more environmental issues.

Also, due to the fact that the majority of the respondents did not trace the source of their knowledge to school and home, it is recommended at this juncture that, first; teachers themselves should be given proper orientation about climatic and environmental issues so that they can effectively teach these issues as they ought to. Secondly, environmental awareness campaign should be taken to the grass root so as to enable parents and guardians including communities to orientate or create environmental consciousness in every member of the community which in effect, breeds a healthy global environment.

Again, it is recommended that students especially in the secondary schools who are majorly adolescents should be included in environmental development projects such as climate changes summit, tree planting and beautification project so as to build in them a sense of environmental responsibilities.

CONCLUSION

Adolescents are more environmentally and climatically conscious and getting their knowledge majorly from Mass Media such as TV/Radio and other sources but not fully from school or home. It is also concluded that some of them have some idea of climatic changes and environmental management but their knowledge is not really sufficient. Aside, the general public should be more oriented in climate and environmental issues from the grassroots and students should be included in climatic and environmental development projects in the community

REFERENCES

Akinwunmi, F.S and Odunsi, A. O. (2008), Impact of Environmental Management on students' quality output in Nigerian Secondary Schools, The Journal of International Social Research Volume 1(5)

Adelakan, I.O (2000). A survey of Rainstorm as weather Hazards in Southern Nigeria. Environmentalist, 20 (1): 33 – 39

Awake, August 2008. Volume 8, Published by Watch Tower Bible and tract Society of Pennsylvania.

Ayoade, J.O (2004), Climate Change, Ibadan, Vantage Publishers, pp. 45 – 66.

Buadi, P.v and Ahmed, A. N. (2006), The Impacts of Wind Related Hazards in Southern Cameroon, Journal of Physical sciences, 3 (2) : 82 – 88.

Clerk, C. R. (2002), Climate Change or Climate Fluctuations?, Journal of Arid Environment, 1(1): 18 – 33

Ejembi, R (2008), Five Hundred Rendered Homeless in Benue Rainstorm Disaster, Sun Newspaper, Monday, april 28, 2008, pp. 1 – 5

Fatih, A. (2010) Secondary School Students' Perceptions' towards global warming: A Phenomenographic analysis, Scientific Research and Essays Volume 5(12), pp 1566 – 1570.

Intergovernmental Panel on Climate (IPCC) 2005. The Climate System. An overview of Climate Change, Contribution of Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change.

Jekayinfa, A. A. and Yusuf, A. (2005), An Investigation into Students Teachers Views on the Introduction of Environmental Education into the Nigerian Social Studies Curriculum.

Mabo CB 2006. Temperature Variation in Northern Nigeria between 1970 and 2000. Journal of Energy and Environment, 19(1): 80 – 88.

Nigeria Environmental Study/Action Team (NEST) 2003. Climate change in Nigeria. A communication Guide for Reporters and Educators. Ibadan: NEST, pp. 5 – 16.

Nyelong PN 2004. Global Warming and Global Waters. Journal of Energy and Environment, ACD: 99 – 90.

Odjugo, P. A. (2009), Quantifying the Cost of Climate Change Impact in Nigeria Emphasis on Wind and Rainstorms.

Sunday Tribune 2008. When rainstorm wreaked havoc in Ibadan city. Tribune, March 9, 2008, pp. 1 – 4.

Teachers' Guide to High Quality Educational Materials on Climate Change and Global Warming, (2002).

Karl, T.R., J.M. Melillo, and T.C. Peterson, eds. 2009. Global climate change impacts in the United States. Cambridge University Press.

Lemke, P., J. Ren, R.B. Alley, I. Allison, J. Carrasco, G. Flato, Y. Fujii, G. Kaser, P. Mote, R.H. Thomas, and T. Zhang. 2007. Observations: Changes in snow, ice and frozen ground. In: Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the

Intergovernmental Panel on Climate Change. Edited by S. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller. Cambridge University Press.

Miller J., E. Muller, C. Rogers, R. Waara, A. Atkinson, K.R.T. Whelan, M. Patterson, and B. Witcher. 2009. Coral disease following massive bleaching in 2005 causes 60% decline in coral cover on reefs in the US Virgin Islands. Coral Reefs 28:925-937.

Parry, M.L., O.F. Canziani, J.P. Palutikof, and co-authors. 2007. Technical summary. In: Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson. Cambridge University Press, pp. 23-78.

Serreze, M.C., A.P. Barrett, J.C. Stroeve, D.N. Kindig, and M.M. Holland. 2009. The emergence of surface-based Arctic amplification. The Cryosphere 3:11-19. doi:10.5194/tc-3-11-2009.

Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. aga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood, and D. Wratt. 2007. Technical summary. In: Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by S. Solomon, D. Qin, M. Manning. Z. Chen, M. Marquis, K.B. Averyt, M. Tignorm, and H.L. Miller. Cambridge University Press.

Trenberth, K.E., P.D. Jones, P. Ambenje, R. Bojariu, D. Easterling, A. Klein Tank, D. Parker, F. Rahimzadeh, J.A. Renwick, M. Rusticucci, B. Soden, and P. Zhai. 2007. Observations: Surface and atmospheric climate change. In: Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by S. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller. Cambridge University Press.

Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (German Advisory Council on Global Change). 2006. The future oceans: Warming up, rising high, turning sour. Online at **http://www.wbgu.de**.

Level of Information, Communication and Technology Awareness and Use by Science Educators in Integrating Climate Change into the Curricula of Universities

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ABSTRACT

This study examined level of Information, Communication and Technology (ICT) awareness and use by science educators in integrating climate change into the curricula of universities. The inferential survey design was adopted. A total of 35 lecturers (20 females and 15 males) out of the total number of 146 lecturers in the faculty of education, Imo State University were sampled purposively for the study during the 2011/2012 academic session. Instrument titled "the level of ICT awareness, access and usage questionnaire (LIANUQ) was used. A reliability index of 0.83 obtained by use of Cronbach Alpha statistic was ascertained. The research questions were answered using mean while the hypothesis was tested with chi-square statistic. Findings show that majority of the lecturers had low level of computer literacy in integrating climate change into the curricula, low availability of ICT facilities for climate change integration and incompetency of some lecturers to infuse climate change topics into the curricula. It is recommended that training workshops on pedagogy and content knowledge be organized frequently to enhance the teachers knowledge on integrating climate change issues.

Keywords: climate change, availability, facilities, competency, usage

INTRODUCTION

Today's students are the future guardians of the earth, and for those reason science educators must work together to inspire and educate the students in the science of climate change using technology (Ibe, 2013). The goal is to help science educators expand students' understanding of the scientific concepts of climate change, and teach the students how to use sophisticated, sensor-based data collection technology to do real scientific investigations. In essence, the students need to experience the power of sensor-based data collecting tools, just like climate scientists do.

New information and communication technologies are changing the world we live in. ICT is changing the teaching-learning process through its potentials as a source of knowledge, a medium of transmission and a means of interaction and dialogue (Ajayi, 2009). It involves electronic base system of information, transmission, reception, processing and retrieval which has drastically changed the way we think, the way we live and the environment we live. ICT is defined as the use of computer and telecommunication system in the collection, analysis, processing forms of data which may include audio, visual and audio-visual format (Jegede, 2007). It can be used to access global knowledge. The input of the ICT has significantly changed the speed of production, use and distribution of knowledge. ICT is the cause of the change and a means of achieving it. Time was when the principal teaching resources available for the lecturer were textbooks and chalkboard (Okebukola, 1997) in Ajayi, and Ekundayo (2009). The global adoption of ICT has been a landmark of educational scene for the last two decades thus, resulting in information age. In developing countries in particular, the metaphor of information age has generated a whole set of wide speculations about the necessity of educational reforms that will accommodate the new tools (Pelgrum, 2001).

Science educators constitute the facilitators and entrepreneurs in ICT learning environment and use in integrating climate change issues into the curricula. Science educators' level of ICT awareness and usage depends upon Science educators' related factors such as perception, competence, and efficiency and each of these ICT related behaviour will impact its use and integration of climate change into the university curricula (Jegede, 2008). It is therefore mandatory for Science educators' to acquire the necessary ICT skills to enhance ICT usage in the integration of climate change in the science curricula. Climate change is a critical environmental issue, (Nwajiuba, 2011) .There is a real need to get climate change science into curricula; but, unfortunately, most science educators are not prepared to infuse these new activities into their teaching or redirect some of their presently used activities. Some science educators are also unfamiliar with using technology-based data collection and analysis tools; although many research studies show that using digital tools in science can significantly enhance students' learning experience. The goal is to sensitize science educators expand their understanding of the scientific concepts behind climate change, and then challenge the students to create their own investigations using digital tools that model the ones real scientists use in integrating climate change. The students through this would acquire knowledge and ability to collect, manipulate and analyze information using real world tools that are used by today's scientists in integrating climate change. Science's main role is the teaching and learning about climate change and the impact on the environment.Information gained in Science will inform the common student task. In Science, students will undertake research in the field, and from other sources that will beused in the completion of the design project. By participating in this cross curriculum unit of work, students will be working towards the achievement of the following outcomes:

- Understand, develop, and communicate ideas and information.
- Access, analyse, evaluate, and use information from a variety of sources.
- Work collaboratively with others to achieve individual and collective goals.
- Be productive, creative and confident in the use of technology.

Tucker (2010) uses PASCO's Xplorer GLX graphic data logger, MyWorld GIS, a geographical information system designed for students; EcoZone, a system designed to help students model and understand the complex interactions within different ecosystems; and a wide range of PASPORT digital sensors. In addition, Tucker helps teachers align climate change topics with Washington state science standards and infuse activities into their curriculum. Last summer, he gathered 26 teachers at the Puget Sound Energy (PSE) Retreat Center of Baker Lake for a workshop called "Science to Action," funded by PSE, PASCO and Northwest Air Pollution Authority.

Education planners in most of the developing countries have responded to the change by initiating national programmes to integrate the new technologies. In Nigeria, such programmes are the 1988 National Policy on Computer Education (FRN, 1988) and the 2001 National Policy on Information Technology tagged ("Use IT") (Jegede, 2007). The headlong drive to incorporate ICT in universities have taken precedence over end-user factors such as lecturers' awareness, level of usage in the classroom as well as use of technology to integrate climate change into science education curricula.

Jegede, Beetheng & ChiaHaw (2008) have identified inadequate knowledge to evaluate the role of ICT in integrating climate change, lack of skills in the use of ICT equipment and software in integrating climate change result in lack of confidence in using ICT tools. Previous studies (Becta, Cugasi & Piccarozzi, 2009) have revealed that, students who learn in a technology - rich environment experience positive effects on their performance as their teachers are able to integrate climate change into the curricula in all subject areas. In a related study, Becta (2009) pointed out that, ICT provides fast and accurate feedback to student in integrating climate change and speed of competition and graphing thus freeing student to focus on strategies and interpretations. Despite these benefits, many students in Nigerian universities are deprived of the ICT potentials in integrating climate change because it is being suspected that majority of the lecturers who should teach the students' are still not computer literate, do not use technology driven lectures and may not be able to integrate climate change issues into the curricula using technology. Kotecha and Ozor (2010) asserted that, there is still a long way to go before university lecturers in developing countries like Nigeria will be able to take advantage of the opportunity provided by the 2I century technology in integrating climate change

Jegede (2007) in a study on teachers' level of ICT usage observed that, only 8% of 500 teacher-educators who participated in the study use ICT to teach what more to integrate climate change. In another survey, Atan, Azil, Raimen & Doris (2002) found that in developing countries, majority of teachers are aware of the presence of ICT tools, there is a marked difference between the level of awareness and the level of usage in integrating climate change. This implies that, the level of awareness of ICT is high while there is a corresponding low level of usage in the classroom in integrating climate change

Some science educators in the tertiary institutions in Nigeria such as the universities lack the required skills and knowledge to utilize the ICT facilities for effective classroom communication with their students as well as infusing climate change into the curricula.

This research is carried out to ascertain level of ICT awareness and use by science educators' in the integration of climate change into the curricula. Specifically, the study did the following:

- Identified the technology literacy level of the science educators' in the integration of climate change into science education curricula;
- Determined the availability of ICT facilities for the integration of climate change;
- Ascertained the competency level of the science educators' to integrate climate change into the science curricula by the use of technology.

  The following three research questions were raised and one hypothesis formulated.

  - What is the level of technology literacy of the science educators' in the integration of climate change into science education curricula?
  - To what extent are ICT facilities available for the integration of climate change?
  - How competent are the science educators' to integrate climate change into the science curricula by the use of technology?

There is no significant relationship between science educators' awareness and usage of ICT in the integration of climate change into the curricula.

METHOD

The study employed an inferential survey design. This design obtains accurate and meaningful description of a phenomenon as it exists in the natural environment. The researcher used checklists and questionnaire to obtain data on science educators' about the awareness and usage of ICT in the integration of climate change into the curricula in the areas of technology literacy, availability of ICT facilities and competency of the science educators' in the integration of climate change into the curricula.

The sample consists of 128 science educators' in the various faculties of Education from four institutions in the south east zone of Nigeria for integrating climate change into the science education curricula. Twenty-five percent (25%) of each of the population of the institution was randomly drawn The researcher developed a questionnaire titled The Level of ICT Awareness, Access and Usage Questionnaire (LAAUQ).The instrument contains three sections. Section A sought for theavailability of ICT tools for use in integrating climate change on a four point scale of strongly agree, agree, disagree and strongly disagree. Section B sought lecturers' frequency of use in integrating climate change on a scale of daily, weekly, monthly and occasionally. Section C soughtcompetency of the Science Educators to Integrate Climate Change into the Science curricular by the use of technology on a four point scale of strongly agree, agree, disagree and strongly disagree.The instrument was validated by two experts from the Department of Measurement and Evaluation and one from the Department of Environmental Studies. The experts made their inputs as regarding wordings and appropriateness of the items as relates to the purpose of the study. The reliability of the instrument was ascertained using Cronbach Alpha Statistics and the coefficient ascertained at 0.78.

RESULTS

Table 1: Mean responses on availability of ICT facilities for use and lecturers' frequency of usein integrating climate change into the curricula.

Section A: Availability of ICT facilities for use	Mean	Remark
i) Computer	2.58	Moderately available
ii) E-mail	2.02	Sparingly available
iii)Internet	2.20	Sparingly available
iv)Electronic notice board	0.00	Not available
v)Film Projector	2.12	Sparingly available
vi)Video equipment	2.02	Sparingly available
Section B		
Lecturers' use of ICT facilities		
i) Daily	2.02	Sparingly available
ii) Weekly	2.20	Sparingly available
iii) Monthly	2.12	Sparingly available
iv) Occasionally	2.02	Sparingly used

Data on Table I (Section A) showthat of the six items that sought responses on availability of ICT facilities, only computer had mean of 2.58 above the cut-off mean of 2.50 indicating that computers are moderately available for integrating climate change into the science education curricula. The rest five items had means below the cut-off mean of 2.50.This implies that the items were sparingly available. Also data on Table I (Section B) show that of the four items that sought responses on frequency of use of lecturers' ICT facilities none had mean score up to the cut-off mean of 2.50.

Table 2: Mean and standard deviation responses on Competency of the Science Educators to Integrate Climate Change into the Science Curricular by the Use of Technology

	Items	Mean	Standard deviation	Remark
1	I am computer literate	2.54	0.78	Accepted
2	I can adequately use Microsoft word	2.29	1.14	Not accepted
3	I cannot access the internet unaided	1.98	1.04	Not accepted
4	I can only access the internet when assisted	2.98	1.34	Accepted
5	I can adequately use the presentations tools	2.18	1.12	Not accepted
6	I can adequately send and receive E-mails	2.25	1.14	Not accepted
7	I am competent in using statistical tools	1.48	0.94	Not accepted

Data on 2 shows that of the seven items that sought information on the competency level of the lecturers in the use of ICT facilities in integrating climate change, only items 1 and 4 had mean scores above the cut-off mean of 2.50.

Table 3: X^2 table of lecturers' ICT Awareness and Use in integrating climate change in the Science Education curricula

Variable	Observed/Expected	Total	X2cal	X2tab	df
Computer	84/(74.7)	84	263.4	5.99	5
E-mail	14/(33.00)	14			
Internet	16/(38.00)	16			
Electronic Notice board	6/(26.00)	6			
Film projector	4/(9.48)	4			
Video Equipment	4/(9.48)	4			

Figures in parentheses represent the expected frequencies. Data on Table 3 shows that the calculated chi (x2cal) is greater than X2tab, this implies that there is significant relationship between lecturers' awareness and use of ICT in the integration of climate change into the curricular.

DISCUSSION

This study showed that ICT facilities such as computer, projectors, E-mail, electronic notice board, internet, and video equipment are not adequately provided in the universities to the accessibility of the lecturers' in integrating climate change into the science education curricula. The implication is that lecturers' are still fond of the old method of teaching. This setback has grave consequences on the resourcefulness of the lecturers in integrating climate change topics and issues into the science education curricula. The above findings is in line with the findings of Ajayi and Ekundago (2009) who asserted d that ICT facilities such as computer, projectors, electronic notice board, internet, film strips were not available in tertiary institutions that could help lecturers' in integrating climate change in the zone investigated.

The study revealed that the frequency of lecturers' use of ICT facilities in integrating climate change is occasionally. This might be connected to the fact that, current education programmes in Nigerian Universities do not provide adequate computer training for the student-teachers who later became lecturers to be able to use ICT facilities in integrating climate change and other issues confidently in teaching their subjects (Okwor 2000, Agolabi 2001 and Usman 2002). This hinders ICT use in integrating climate change in the universities.

The study shows that the competency level of the lecturers in integrating climate change into the science education curricula is far below expectation as the cut-off mean of all the items that evoked responses were below the cut-off mean. This means that majority of the science educators are unable to integrate climate change into the curricula of science education. This is due to the fact these lecturers lack the basic skills to integrating climate change ICT facilities into teaching, what more integrating climate change into the curricula by use of technology. Integrating the climate change curricula into science education by means of ICT facilities means more than teaching basic computer skills and software programmes in a separate computer class.

Findings from the study also show that there is significant relationship between lecturers' ICT awareness and use in integrating climate change in the Science Education curricula. The implication is that since majority of the lecturers have low level of ICT competencies and the frequency of use occasionally, the possibility of integrating climate change into the curricula of science education remains a far cry.

CONCLUSION

Based on the findings and discussion of this study, the following conclusions were made:

- This study established level of ICT awareness and use by science educators in integrating climate change into the curricula of universities.
- This study determined that ICT facilities such as computer, projectors, E-mail, electronic notice board, internet, and video equipment are not adequately provided in the universities to the accessibility of the lecturers' in integrating climate change into the science education curricula.
- The study revealed that the frequency of lecturers' use of ICT facilities in integrating climate change into the science education is occasionally.
- The study shows that the competency level of the lecturers in integrating climate change into the science education curricula is far below expectation as the cut-off mean of all the items that evoked responses were below the cut-off mean.
- The study shows that there is significant relationship between lecturers' awareness and use of ICT in integrating climate change into the science education curricula.

RECOMMENDATIONS

The following recommendations are made based on the results of the findings.

1. Every university should own a well-equipped and functional computer Centre managed by ICT experts for lecturers and students to regularly practice with the facilities;
2. Arrangements should be made by the university with computer firms so that all lecturers be able to procure a laptop for a start so as to be able to engage in practice of the use of computer and all the applications;
3. Regular seminars and conferences should be organized for lecturers to improve their ICT knowledge and skills;
4. It should be a requirement for all serving lecturers to acquire the basic skills and knowledge in ICT for their regular promotion;

REFERENCES

Ajayi, I. A. and Ekundayo, H. T. (2009).The Application of Information arid Communication Technology in Nigerian universities.*International NGO Journal* Vol. 4(5) pp. 28 1-286.

Atan, H., Azil, N. Rairnen, Z. and Doris, H. (2002).Computer in distance education, Gender difference in self perceived computer competence.*Journal of Education Media* 27(3) pp. 123-136.

Becta, C.V (2009). What the researcher says about ICT and reducing teacher workload. ConventryBecta www.becta.orgumesearchijctrn.

Beetheng, L and ChiaHaw, S. (2008). Exploring the extent of ICT adoption among tertiary lecturers in Malaysia.

Cugusi, B. and Piccarozzi, M (2009). Environmental change and human mobility: A thematic literature and organizational review. Prepared for the international conference towards the G8 Summit on "Climate Change and Human Mobility in Africa" *Dialogue for a Strategic Cooperation between Italy and Afric*a: Rome, April 21; pp 1- 57.

Ibe, H.N (2013). Integrating climate change curriculum and adaptation into the science education curriculum of Faculties of Education.*Journal of the Curriculum Organization of Nigeria* , Vol. 6, No. 9, pp16-26.

Intergovernmental Panel on Climate Change (IPCC) (2007). Climate change : Synthesis Report . Contribution of the Working Groups 1, 2 and 3 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.Pachauri, R. and Reisinger, A (eds.). IPCC, Geneva,Switzerland.http://wwwipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.Accessed on 14th June, 2011.

Jegede, P. (2007). Relationship between ICT competence and attitude among Nigerian tertiary institutions, *Lectures educational research and review* 2(7) pp. 172-177, July (2007).

Jegede, P. (2008). Attitudinal characteristics and teachers ICT use level, issues in informing science and informing technology, Ile-Ife, Nigeria Pojegede@oaufeedu.org.

Kotecha, P. (2010). Climate change, adaptation and higher education: securing our future.*Southern African Regional Universities Association (SARUA) leadership dialogue series,* volume 2, no. 4.

Nwajiuba, C (2011). The extreme weather (rainfall) event in Lagos: a dimension to climate change. An unpublished paper presented at the Building Nigeria's Response to Climate Change workshop at the University of Nigeria, July.

Ozor N (2010). Implications of Climate Change for National Development: The Way Forward. In:Enugu Forum Policy Paper 10-Implications of Climate Change for Economic Growth and Sustainable Development in Nigeria. African Institute for Applied Economics.

Okwor, F. A. (2002) Science and technology issues for education in the information age. *Interdisciplinary Education Journal (INTEJ)*.

Pelgram, W. J. (2001) Obstacles to the integration of ICT in education result from a worldwide educational assessment, *Computer and education* (37) pp. 163-178.

Climate Change and Children's Health: Implication for Basic Science Curriculum Reform in Nigeria

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ABSTRACT

Tackling the effects of environmental and climate change is one of the biggest challenges this generation is facing. Nigeria among other African countries is particularly vulnerable to climate and environmental change. There is a broad consensus that the global climate is warming, the process is accelerating, and human activities are the main cause. This warming has adverse effect on the ecosystem and human health. In Nigeria, this has been attributed to a departure from the traditional values and way of life to the adoption of Western lifestyle without commensurate precautions being taken to counteract the effects. This paper discusses the impact of environmental changes in contemporary Nigeria on children's health and the need to revisit the Basic science curriculum which serves as the children's entry to the world of Science in Nigeria. The paper recommended the need for an effective and efficient climate change education in Nigeria and advocates that climate change education be incorporated into the basic science curriculum to provide effective and efficient awareness of the dangers of climate change. This will make it possible to start early to make students acquire a life style that will lead to a sustainable environment. The incorporation of climate change education into the Basic Science curriculum should be through an integrated approach. Teachers of Basic Science should be provided with professional development programmes to enhance their competence and disposition towards the new inclusions to the curriculum. Environment Protection Clubs should also be set up in schools and students should be encouraged to join the clubs. Finally it is recommended that government and non-governmental organisation should map out strategies to mitigate the impacts of climate change on children, who are more vulnerable to climate change.

Key words: Climate Change, Children's Health, Basic Science Curriculum Reform in Nigeria

INTRODUCTION

Climate change is an adverse environmental phenomenon that is causing enormous concern all over the world. It refers to some anomalies in the climate that occurs as a result of human activities and natural activities. These anomalies include increase in the concentration of Greenhouse Gas (GHGs), Hydro fluorocarbons (HFCs) and chlorofluorocarbons (CFCs) in earth's atmosphere, which ultimately lead to global warming. Climate change according to Whoterforth (2011) is the change in the average weather conditions in the atmosphere over a considerable length of time. It is attributed to natural events and anthropogenic activities on the lithosphere and hydrosphere that alter the atmospheric composition and variability in comparatively recent time periods (Efe, 2008). Climate change, or global weather patterns, or global warming can be described as the biggest environmental issue of our time. It is global in its causes but its consequences are far more reaching in developing countries, particularly Nigeria. It is a topical issue worldwide because of its attendant problems that are threatening the sustenance of man and his environment. These are particularly becoming more severe in the under-developed and developing countries (Onyekakeyah, 2012). Climate change has become the new reality of our time. It brings with it changes in weather patterns that have serious effect on human beings, upsetting seasonal cycles, harming ecosystems and water supply, affecting agriculture and food production and causing sea-levels to rise. Climate change has a cumulative effect on natural resources and the balance of nature.

Communities across the globe are already experiencing the impacts of more extreme weather events, temperature changes and disease outbreaks. The types of climate risks confronting children are diverse, ranging from direct physical impacts, such as cyclones, storm surges and extreme temperatures, to impacts on their education, psychological stress and nutritional challenges. Some of the leading killers of children worldwide are highly sensitive to climate changes (Chan, 2008). Higher temperatures have been linked to increased rates of malnutrition, cholera, diarrhoeal disease and vector-borne diseases like dengue and malaria. Children's underdeveloped immune systems put them at far greater risk of contracting these diseases and succumbing to their complications. Even moderate climate change impacts could have profound long-term consequences on children's overall development, threatening the achievement of the Millennium Development Goals (MDG).

Nigeria, as a developing nation is particularly sensitive to the effects of climate change. A large part of the economy of the country depends on natural resources, which are particularly vulnerable to climate change. When those resources are affected, communities are implicated. Disease, loss of livelihoods and settlements can force entire communities into relocation or complete extinction and even refugee status. The most devastating adverse impacts of climate change in Nigeria and other subtropical countries according to Anyadike (2009) includes frequent drought, increased environmental damage, increased infestation of crop by pests and diseases, depletion of household assets, increased rural urban migration, increased biodiversity loss, depletion of wildlife and other natural resource base, changes in the vegetation type, decline in forest resources, decline in soil conditions (soil moisture and nutrients), increased health risks and the spread of infectious diseases and changing livelihood systems.

Each day, the sun emits rays of light onto the earth's surface. The earth absorbs part of the heat, reflects another share into the atmosphere and sends out a third share in the form of infra-red rays. These rays are cushioned by the clouds and water vapour, which stabilizes the earth's temperature under normal circumstances. These leads to some of the problem we are facing today which is the concentration of Green House Gasses produced by human activity that has increased significantly. The gases absorb the terrestrial radiations from the earth and reradiate the heat back to earth, thereby leading to a general increase in temperature known as global warming.

CAUSES OF CLIMATE CHANGE

Climate change is caused by two basic factors, which include natural processes (bio-geographical) and human activities (anthropogenic). The natural processes are the astronomical and the extraterrestrial factors. The astronomical factors include the changes in the eccentricity of the earth's orbit, changes in the obliquity of the plane of ecliptic and changes in orbital procession while the extra-terrestrial factors are solar radiation quantity and quality among others. On the other hand, the anthropogenic factor in climate change involves human activities that either emit large amount of greenhouse gases into the atmosphere that depletes the ozone layer or activities that reduce the amount of carbon absorbed from the atmosphere. The human factors that emit large amounts of greenhouse gases include industrialization, burning of fossil fuel, gas flaring, urbanization and agriculture. On the other hand, human activities that reduce the amount of carbon sinks are deforestation, alterations in land use, water pollution and agricultural practices. The human factors have been proven to be responsible for the ongoing unequivocal climate change or global warming (IPCC 2007).

The emitted greenhouse gases are carbon dioxide (CO_2), chlorofluorocarbons (CFCs), Methane (CH_4) and nitrous oxide (N_20). CO_2 currently contributes the highest rate of the greenhouse gases followed by CH_4, CFCs N_2O and others like halons, tropospheric ozone, sulphuric hexafluoride (SF6) among others. Although CO_2 has the highest contribution to greenhouse gases, its potency is far lower. For instance, a gram of CH_4 is about 23 times higher than the effects of the same volume of CO_2 and a gram of sulphuric hexafluoride (SF6) released into the atmosphere is about 22,000 times that of CO_2 with respect to tropospheric zone depletion . The life time of CO_2 in the atmosphere varies, but obviously less than ten years, while that of CH_4, N_2O, CFCs and SF6 are 12.2, 120, 50-1700 and 3200 years respectively (Ayuba, 2007). While a molecule of CO_2 could cause damage to stratospheric ozone just for a few years, other greenhouse gases could cause ozone layer damage for between decades to thousands of years. Although the potency of CO_2 released into the atmosphere through human activities may be significantly lower than many other greenhouse gases, the much greater volume of its emissions still makes it the most important influence in humans' enhancement of the natural greenhouse effect.

Available evidences show that climate change will be global, likewise its impacts, but the biting effects will be felt more by the developing countries, especially those in Africa, due to their low level of coping capabilities (Nwafor, 2007). Nigeria is one of such developing countries. Researchers have shown that Nigeria is already being plagued with diverse ecological problems, which have been directly linked to the on-going climate change (Odjugo and Ikhuoria, 2003; Ayuba, 2007; Abaje and Giwa, 2007). While Odjugo (2001a) observes erratic pattern of weather elements in Nigeria, Odjugo and Ikhuoria (2003) show that climate change has started impacting on desertification. Ayuba (2007) showed that climate change is impacting negatively on plant species composition in North-eastern Nigeria. These may not be the only impacts of climate change in Nigeria.

In densely populated rural regions, there is greater competition for natural resources including agricultural and grazing lands, water and mineral resources, land tenure/fragmentation and shorter lengths of fallow period. In turn, these enhance deforestation for fuel wood collection and construction, accelerate soil erosion and expose fragile arable land to desertification. In the urban centres, management of generated wastes most of which are of non-biodegradable, road traffic effects and industrial activities are the main contributors to climate change. They result in hazards especially floods and increased concentration of GHGs. Other main causes of Climate Change through population concentration are: agricultural practices; oil and gas production; air quality degradation air quality degradation (Agulu, 2009).

IMPACT OF CLIMATE CHANGE ON CHILDREN

Children are very sensitive to changes in the climate because they are physiologically and metabolically less able than adults at adapting to heat and other climate-related exposure. This makes them disproportionately vulnerable to the impacts of climate change. The septic nature of their vulnerability is multidimensional, shaped largely by the physical, social, and emotional changes that take place over the course of childhood. These changes are intensified by children's heightened sensitivity to negative or high-impact events during the early stages of development and by their general lack of agency and voice. In the case of Nigeria, the impacts of climate change on children need to be considered in relation to wider development pressures affecting the country. Challenges such as international economic shocks and stresses, high levels of poverty and inequality, population changes, effects of HIV and AIDS, management of scarce natural resources and rapid urbanisation will each interact with climate change. The results of those interactions will affect how far the effects of climate change are transmitted to children and households at the local level. With this in mind, an effective response to changing climate and development pressures requires efforts from all stakeholders as well as good coordination across multiple levels of governance, from household and community, through a municipal and provincial, to national and international levels (Udenyi, 2010).

An important international legal framework underpins the need to focus on how children's well-being can be affected by climate change. It particularly points out the duty of the State to enable children's rights to be met. The UN Convention on the Rights of the Child (UNCRC) commits all signatory states to protecting the right of every child to a safe, healthy environment in which to develop and grow. The African Charter on the Rights and Welfare of the Child (ACRWC) recognises that the development of a child requires particular care with regard to health, physical, mental, moral and social development (Chan, 2008). It recognises that the child's development also requires legal protection in conditions of freedom, dignity and security. In particular, it recognises the role of the State in protecting and reuniting children who have been displaced as a result of natural disasters. The World Fit for Children declaration, which is a consensus outcome from the UN General Assembly Special Session on Children held in 1992, articulates the commitment of states to protect children and to minimise the impact on them of natural disasters and environmental degradation.

Nigeria has already taken steps to understand, recognise and address the challenges that climate change poses. This is evident in its National Climate Change Response strategies and other examples of environmental and developmental policy response actions. Yet, within these strategies, the ability to recognise and address the needs of the country's children is not well established. Despite the particular vulnerability of children, few studies have investigated how climate change will affect child development and well-being across Nigeria, in the short, medium and long term. This study seeks to redress this deficiency by exploring the impact of climate change on children's health: implication for basic science curriculum.

The analysis of the impacts of climate change on child well-being is divided into primary and secondary impacts. Substantial changes in Nigeria climate are likely to be caused by such variables as rising temperatures, changing patterns of precipitation and differences in the frequency and intensity of extreme events. Each of these changes has a significantly direct, physical impact on children. Examples of direct, primary impacts may include injury suffered during unusually heavy rainfall events or increases in infectious, vector and water-borne diseases in areas subject to higher annual average temperatures and rainfall intensity. These impacts can also be felt indirectly when climate change interacts with other development pressures. This results in challenges such as rising food prices or issues of local conflict over scarce natural resources where children and households are forced to cope accordingly. Secondary impacts on children are associated with the coping and adaptation strategies adopted in response to climate change. At the local level, examples of adaptation strategies would be: changing lifestyle and behaviour; seeking other forms of temporary employment to supplement income; permanently migrating to exploit new opportunities; or adopting a new livelihood practice (Msumba, 2006). Though these strategies might be undertaken over longer timescales, they have significant and profound implications for child development and well-being.

However, children may have some degree of agency and, when living on their own or in child-headed households, children will often influences the nature of adaptation strategies themselves. The ability to carry out these adaptation strategies is known as the adaptive capacity (Nzeh & Eboh, 2010). Levels of adaptive capacity vary tremendously from person to person, based on a range of socio-economic characteristics; those from poor households and marginalised groups (including children, women and girls) are generally considered to have lower adaptive capacity. This study seeks to give value by complementing the analysis of the impacts with an exploration of how household coping and adaptation strategies will affect children over the short and long term and its implication to basic science curriculum.

HEALTH IMPACT OF CLIMATE CHANGE ON CHILDREN

Environmental health comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social, and psychological factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations (WHO, 2000).

A changing climate impacts on our health and wellbeing. Climate change is a critical public health problem. Climate change makes many existing diseases and conditions worse and it may also help introduce new pests and pathogens into new regions or communities. As the planet warms, oceans expand and the sea level rises, floods and droughts become more frequent and intense, and heat waves and hurricanes become more severe. The most vulnerable people, children are at increased risk of health effects from climate change. Climate change also stresses human health care infrastructure and delivery systems. Weather and climate play a significant role in people's health. Changes in climate affect the average weather conditions that we are accustomed to. Warmer average temperatures will likely lead to hotter days, increase the concentrations of unhealthy air and water pollutants. This could increase the number of heat-related illnesses and deaths. Increases in the frequency or severity of extreme weather events such as storms could increase the risk of dangerous flooding, high winds, and other direct threats to people and property. Changes in temperature, precipitation patterns, and extreme events could enhance the spread of some diseases.

Human-caused climate change leads to the deaths of at least 150,000 people around the world every year, a figure which is likely to increase as global warming continues to exacerbate existing environmental health threats around the world (McMichael, 2004). In the 2012 Nigeria floods, 363 people were killed and over 2,100,000 people were displaced (Inyama, Muanya & Adepetun, 2012). The Areas affected were mostly; Adamawa, Taraba, Plateu, and Benue states of Nigeria. The flooding was caused by seasonal flash floods which were sometimes lethal, especially in the rural areas or overcrowded slums, where drainage is poor or does not exist at all. Many Nigerian coastal and inland cities experienced heavy rains, and residents of Lagos were "gasping for breath" due to the flooding. In addition, there was a gridlock on major roads, causing people to cancel or postpone appointments they may have had. In late July 2012, at least 39 people were killed due to flooding in the central Nigerian Plateau state (Ogaji, 2013). Heavy rainfall caused the Lamingo dam to overflow near Jos, sweeping across a number of neighborhoods in Jos, and approximately 200 homes were submerged. In addition, at least 35 people were missing. The floods left 3,000 people homeless, many of whom are taking refuge in government buildings in Jos. The mid-August flooding killed at least 33 people in central Nigeria's Plateau state, and co-ordinator of the National Emergency Management Agency in central stated that homes were destroyed while roads and bridges were washed away; obstructing relief efforts and over 12,000 people were affected by the flooding in six districts of the state, while hundreds were rendered homeless (Nnaji, 2012). During this period, children were most vulnerable to the exacerbations because they are more sensitive than adults to harm from environmental hazards and climate change increases these hazards by worsening air quality, stimulating more extreme weather events, creating conditions that favour increases in food, water and vector-borne infections, and enhancing their heat stress conditions.

The following expected health impacts of global climate change can be separated into direct and indirect effects. Direct impacts stem from extreme events such as heat waves, floods, droughts, windstorms, and wildfires, while the indirect effects may arise from the disruption of natural systems, causing infectious disease, malnutrition, food and water-borne illness, and increased air pollution. Below are some of the direct and indirect effects of climate change on human health in Nigeria.

Heat waves and UV Radiation

Heat already accounts for the greatest number of weather-related deaths in Nigeria. There has been an increase in the number of unusually warm nights, which deprives the body of breaks from the heat. Young children are most susceptible to the effects of heat stress. Most heat related deaths occur in cities, where what is known as the urban heat island effect can potentially amplify temperatures as much as 10° C. Low-income families are especially vulnerable to heat because they may have less access to adaptive features such as thorough insulation or air-conditioning (Ogaji, 2013). The stratospheric ozone layer absorbs most of the harmful UV radiation emitted from the sun, but that amount of absorption has decreased since ozone-depleting substances, which are also powerful greenhouse gases, caused the thinning of the ozone layer. Children burn from sun exposure easily, putting them at increased risk of skin damage from UV radiation. A study showed that children sunburned between the ages of 10 and 15 years have a threefold increase in the risk of later developing skin cancer (Nwafor, 2007).

Floods, Droughts and Wildfires

Sea level rise is already putting low-lying coastal populations at risk, and intense rainfall events are projected to increase with climate change. This increases the risk of flooding, which introduces chemicals, pesticides, and heavy metals into water systems and increase the risk of water-borne disease outbreak. Droughts, which are expected to become more common in Nigeria, destroys crops and grazing land, reduces the quantity and quality of water resources, and increase risk of fire. Furthermore, the increase in the frequency and intensity of wildfires that has occurred over the past few decades is very likely to continue. In addition to destroying homes and property, these wildfires causes eye and respiratory diseases. Strong tropical storms are also likely to become more common with climate change; the trauma of which can lead to post-traumatic stress disorder, grief, depression, anxiety disorders, somatoform disorders, and drug and alcohol. These abuses affect children greatly due to their high level of vulnerability.

Air Pollution and Aeroallergens

Climate change is projected to cause more respiratory disease. Higher temperatures cause ground-level ozone to increase, and short term exposure to ozone increases the rate and severity of asthma attacks, causes nasal and eye irritation, coughs, bronchitis, and respiratory infections. In addition, long-term exposure may lead to the development of asthma. Children are more vulnerable to these effects because they take in more air per body weight than adults and have narrower airways. The severity of asthma is also affected by aeroallergens, concentrations of which are projected to increase with increasing temperature. For example, ragweed is a particularly important risk to human health: it has highly allergic pollen and is spreading in several parts of the world. Allergic reactions to poison ivy may also increase because these plants grow faster and become more potent when carbon dioxide levels are higher. Furthermore, algal blooms, which may cause respiratory irritation, are increasing on a global scale.

Vector-borne Diseases

Climate change may cause vector-borne diseases to shift in geographic distribution as well as changes in vector development, reproduction, behaviour, and population dynamics.

Spread of Malaria: By 2080, an estimated 260-320 million more people around the world will be affected by malaria as a result of climate change (World Health Organization, 2008). Children are most at risk: 75% of malaria deaths occur in children under five. In Nigeria, malaria is the cause of one in four deaths recorded in infants and young children and, worse still, for every 10 women that die around childbirth, one is caused by malaria. About half of Nigerian adults have at least one episode of malaria each year, while in younger children malaria occurs up to 3–4 times a year. Malaria is also the reason for hospital attendance in 7 out of every 10 patients seen in Nigerian hospitals (Nwafor, 2007). Malaria is caused by four distinct species of the *Plasmodium* parasite, transmitted by mosquitoes of the genus *Anopheles,* which are most abundant in tropical and subtropical regions, although they are also found in limited numbers in temperate climates (WHO, 2008). Transmission of malaria is associated with the changes in temperature, rainfall, humidity as well as the level of immunity in humans. The IPCC Special Report on Regional Impacts of Climate Change (IPCC, 2007) acknowledges that climate has a great impact on malaria.

Food and Water-borne Diseases

Outbreaks of infectious diarrhoea, *Cryptosporidium, Giardia, Salmonella, E. coli,* and rotavirus are projected to increase. These diseases occur as a result of the contamination of water supplies through the disruption of water and sanitation systems, which can be caused by toxic runoff from increased rainfall and flooding. Food contamination can result from lack of air-conditioning or refrigeration; for example, higher temperatures in Nigeria were found to contribute to an estimated increase of 30% in cases of *Salmonella* (Jonathan, 2005). Children are especially vulnerable to food and water borne-diseases because they are more likely to die from dehydration from diarrhoea and vomiting. Minority children and children of lower socioeconomic status in areas that lack adequate capacity to provide food and water supplies are at the greatest risk.

Malnutrition and Resource Scarcity

Globally, approximately 800 million people are currently undernourished. Climate change is likely to further affect food production, distribution, and storage. In Nigeria, higher food prices are more likely to lead to food-insecurity than an actual shortage. Water availability is also projected to decrease with climate change. According to the Millennium Ecosystem Assessment of 2005, 60% of global resources are already in decline or are being used in unsustainable ways (Epstein, 2005). Climate change is perhaps the most serious environmental threat to the fight against hunger, malnutrition, disease and poverty in Nigeria, mainly through its impact on agricultural productivity. Resource scarcity coupled with population growth in Nigeria has led to war, political instability, poverty, substance abuse, crop or catch failure, rising consumer prices, and the disruption of social structure (Udenyi, 2010).

IMPLICATION OF CLIMATE CHANGE TO BASIC SCIENCE CURRICULUM PLANNERS AND IMPLEMENTERS

The effects of climate ranges from drought events to flooding events, sea level rise, drying of rivers and streams, decrease in water quality, melting of glaciers, loss of biodiversity, changes in rainfall pattern and amounts, increases in temperature, among others. These effects have negative and far-reaching impact on the economy, food security, agricultural production, health of many nations, including Nigeria. This calls for integrated approach on efforts to reduce these effects. One way to achieve this is through education and capacity building. To realize this, the curriculum of educational institutions has to be modified to accommodate the current issues of climate change. For sustainability, these issues have to be early so that a child goes through school with the understanding that he/ she about climate change.

Climate change issues should therefore, be infused into the curricula of schools right from the elementary to the university level as a matter of urgency. This will enable young people (students) gain knowledge and understanding about climate change. Such knowledge and understanding will enable them to respond effectively to the global challenges posed by climate change, as they grow older. Educating those currently at school about climate change will help to shape and sustain future policy-making and take actions geared towards mitigating its harmful effect on child's health.

The Listed Topics are suggested to be infused into the Basic Science Curriculum (upper Basic)

- Introduction to climate change: The content and context of climate change; Implications of climate change to people's livelihood, children's health and the world economy.
- Global warming: Causes of global warming
- Climate change and society: Adaptation and mitigation Strategies to climate change; the vulnerable groups to climate change; Scientific activities that affects climate change; Indigenous and modern innovations for adaptation to climate change by different groups of people; Local contributions to greenhouse gas emissions and/or local impacts and hazards arising from climate change
- Importance of Environment Protection Club in schools

- Development of prevention strategies to harmful effects of climate change on children.

CONCLUSION AND RECOMMENDATIONS

Since the impact of climate change affects not only human settlements and health but also, water resources, wetlands, industry, commerce, financial services, food security, land degradation, forestry and biodiversity, it is recommended that climate change awareness be created starting from primary school. In this respect, efforts should be made to sensitize the young ones on what climate change is all about; how they can be affected by it and how their action and activities contribute to climate change. To realize this, the curriculum of educational institutions has to be revised to accommodate the current issues of climate change. Such revision will ensure that children gain detailed knowledge and awareness of the danger associated with the disequilibrium in the natural arrangements and working of the environment.

The recommendations for a powerful and efficient climate change education in Nigeria can be summed up as follows: i) Climate change education should be incorporated into the basic science curriculum in Nigeria to provide effective and efficient awareness of the dangers of climate change: ii) The incorporation of the climate change education into the basic science curriculum should be through integrated approach (infusion approach), the teachers who will implement the basic science curriculum should be provided with professional development programmes (training) to enhance their competence in integrating these suggested topics into their lesson: iii)Finally,government and non-governmental organisation should map out strategies to mitigate the adverse impacts of climate change on children, who are more vulnerable to changes in the environment.

REFERENCES

Abaje, I. B and Giwa, P.N. (2007). Urban flooding and environmental safety: a case study of kafanchan town in Kaduna State. http://www.naijaproperties.com/guide71.php

Anyadike, R.N.C. (2009). Climate change and sustainable development in Nigeria: conceptual and empirical issues. Debating Policy Options for National Development; *Enugu Forum Policy Paper 10*. http://www.aiaenigeria.org/Publications/Policypaper10.pdf

Ajayi, O. (2012). Nigeria flood sacks Ibadan residents. http://www.infed.org/biblio/b-explrn.htm

Ayuba, H. K. (2007). Climate change impact on plant species composition in six semi-arid rangelands of Northern Nigeria. *Nigerian Geographical Journal* 5(1): 35-42.

Chan, M. (2008). The impact of climate change on human health. http://www.who.int/mediacentre/news/statements/2008/s05/en/index.html

Efe, S. I. (2008). Spatial distribution of particulate air pollution in Nigerian cities: Implications for human health, *Journal of Environmental Health Research*, 7 (2). 124-129.

Epstein, R. P. (2005). *Climate Change Futures: Health, Ecological and Economic Dimensions.* Boston, MA: Center of Health and the Global Environment, Harvard Medical School. www.climatechangefutures.org/pdf/CCFReportFinal10.27.pdf

IPCC, (2001). Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, UK.

IPCC, (2007). Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contributions of working group II to the third assessment report of the intergovernmental panel on climate change http://www.punchng.com/news/senate-to-limit-presidencys-power-on-ecological-fund.

Ishaya, S.1 and Abaje, I. B (2008). Indigenous people‟s perception on climate change and adaptation strategies in Jema'a local government area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning.* 1(8): 138-143

Inyama, N.; Muanya, C.; Adepetun, A. (2012). Lagosians gasp for breath as flood ravages the city. *The Guardian Nigeria.*

McMichael, A. J. (2006) Climate change and human health: present and future risks. *Lancet. 367* (19): *859* – 869.

Nnaji, M. O. (2013). Nigeria: Deadly flooding in Jos in Plateau state. doi:10.1016/j.lindif.2012.10.009

Msumba A. G. (2006). Climate change and sustainable human development. *Journal of Arid Environment* http://www.euro.who.int/Document/EEHC/25th_EEHC_Milan_edoc15.pdf

Nwafor, C.M (2007) Climate change and sustainable development in Nigeria: The mitigating role of green wall Sahara Nigeria programme. *Africa institute for Applied Economics 10 (33):199-205*.

Nzeh, E. C and Eboh, O. R. (2010). Technological challenges of climate change adaptation in Nigeria: Insights from Enugu. *African technology policy studies Network. 5 (4)315-310*.

Odjugo, P. A. O and Ikhuoria, A. I. (2003). Impact of climate change and anthropogenic factors on desertification in the semi-arid region of Nigeria. *Global Journal of Environmental Science*, 2(2): 118-126.

Odjugo, P. A. O. (2001). The impacts of global warming on climate change and extreme weather conditions: Global and regional evidences. *Asia Pacific Journal on Environment and Development*, 7(3): 53-70

Ogali, K. I. (2012). Nigeria Plateau State floods kill 33. doi:10.1111/j.1539-6053.2009.01038.x

Olorunfemi, F. (2010). Risk communication in climate change and adaptation: Policy issues and challenges for Nigeria. http://iopscience.iop.org/1755-1315/6/41/412036/pdf/ees9_6_412036.pdf

Ozor, N. (2009). UNN Talks climate change: influencing curriculum development and knowledge of climate change issues at the University of Nigeria Nsukka and Environs. Paper presented at the *Workshop on Influencing Curriculum Development and Knowledge of Climate Change Issues at the University of* Nigeria, Nsukka.

Soneye, A. S. O. (2011). Disaster Relief Operations and Environmental Protection for Sustainable Development in Nigeria" in *Environment and Community Security for Sustainable Development: Innovative Perspectives and Approaches*. 8 (5)123 – 143.

Soneye, A.S.O (2012). Concentrations of GHGs around Tankfarms and Petroleum Tankers Depots, Lagos, Nigeria". *Journal of Geography and Regional Planning.* 5(4), 108-114.

Udenyi, O.G. (2010). Impacts of Climate Change. Nigeria Social Network UNEP (2008) Scoping Paper for Expert Group Meeting on Climate Change Adaptation, African Minister Conference on the Environment 12th Meeting of the Expert Group TBC http://www.unep.org/roa/About_AMCEN/default.asp

UNDP (2010). Adaptation Policy Frameworks for Climate Change. *Developing Strategies, Policies and Measures.* Cambridge, UK. Cambridge University Press.

Whoterfort, C. (2011). Gender Matters: implications for climate variability and climate change and for disaster management in the Pacific Islands, *Inter coast* Newsletter, University of Rhode Island's Coastal Resource Center.

World Health Organization (2008). World Health Organization's Children's Environmental Health http://odili.net/news/source/2011/sep/20/8.html

World Health Organization (2000). *Gender, Climate Change and Health*. WHO: Geneva.

THEME 3: CLIMATE CHANGE AND ENERGY

Effective Biogas Production through Co-digestion of Cow Dung and Food Waste

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ABSTRACT

Biogas is increasingly becoming popular as a renewable source of energy. Due to its increased use, there is the need to find possible optimal biogas production conditions. Biogas was therefore produced alone. Furthermore, the co-digested slurry had a 7% higher methane concentration as compared to cow dung alone. In addition, the biogas obtained from the co-digested slurry had insignificant nitrates and H_2S composition indicating a high quality biogas. Co-digestion of food wastes and cow dung improved the biogas concentration and quality.

Keywords: Biogas production, co-digestion, cow dung, food wastes, physicochemical properties

INTRODUCTION

Biogas is produced when organic matter is decomposed anaerobically by the use of methanogens, which are methane producing bacteria [1-8]. Biogas mainly composes of methane which can be used for power generation, heating and cooking purposes [1-8]. Biogas also contains carbon dioxide, nitrates and hydrogen sulphide [1-8].Biogas has successfully been produced from several sources such manure, sewage and municipal waste among others. In this study, cow dung and food wastes were blended to investigate the potential of optimum biogas production from the co-digestion these two organic wastes.

MATERIALS AND METHODS

Materials

Cow dung and food waste were used as the organic material. Cow dung was obtained from the Institute vermicomposting project whilst the food wastes which mainly composed of corn pulp and vegetables were obtained from the Institute canteen.

Methods

Analysis of physicochemical properties of the cow dung and food wastes

The organic materials samples were dried in a Memmert Germany brand oven drier at 105◦C for 20 minutes for total removal of any moisture. Moisture content was measured by heating 5g at 105◦C for 15 minutes, using an AND Moisture analyser. Ash content was determined by incineration, using a burner and porcelain crucibles. Volatile matter was measured by heating 5g at 160◦C for 5 min using the AND moisture analyser. Fixed carbon was calculated as follows = 100% - (Moisture% + Ash% + Volatile matter %). The total mass was blended to 500g either with cow dung or food wastes using an AND analytical balance as the weight measuring instrument. The feedstock temperature was varied between 38 and 55◦C.

Biogas generation and quantification from cow dung, food waste and their mixture

The cow dung and food waste were mixed thoroughly to homogenize in a 2 Litre beaker at the required ratio. 0.5L of water was added till the mixture was in slurry form. The slurry samples were put into a 3×500 ml glass volumetric flask. A starter culture of methane producing bacteria was added to initiate the organic waste decomposition. The slurry was allowed to ferment for 48hours with a balloon attached to the top end of the volumetric flask for collection of biogas. The slurry temperature was maintained at 50°C using a Memmert oven. The pH of the slurry ranged between 6.8-7.0. This pH was ideal for methanogens to thrive in. The biogas composition was analysed using an Agilent Micro gas Chromatography analyser. The gas was analysed for the methane (CH_4), carbon dioxide (CO_2), nitrogen (N_2), Ammonium (NH_3) and hydrogen sulphide (H_2S).

RESULTS AND DISCUSSION

Analysis of the organic waste

The cow dung and food waste's physicochemical properties were analysed to ascertain the behaviour in the biogas production from the individual digested organic waste as well as the co-digested slurry. The cow dung and food waste physicochemical properties that were obtained are indicated in Table 1. High organic matter ash content has a tendency of lowering biogas production and the same applies to high fixed carbon content. On the other hand, presence of high volatile matter enhances biogas production. The ash content, fixed carbon and volatile are in varying proportions for the two cow dung and food waste and co-digestion can actually promote factors that enhance biogas production

Table 1: Cow dung and food waste physicochemical characteristics

Parameter	% Content in cow dung	% Content in food waste
Moisture content	80	65
Ash content	5	21
Volatile matter	10	12
Fixed carbon	5	2

Biogas composition for the various organic wastes

Biogas generated from the cow dung and food waste blend indicated higher methane content as compared to cow dung and food waste alone (see Table 2). The biogas produced from the cow dung blended with food waste was 14% richer in methane compared to the one from food waste only and 7% richer in methane compared to the one from cow dung alone (see Table 2). The biogas also from the co-digested slurry had minimum traces of other gases.

Table 2: Characteristics of biogas generated from cow dung, food waste and blended cow dung and food waste

Gas characteristic	Food waste	Cow dung	Cow dung- Food waste mixture
CH_4	60%	65%	70%
CO_2	40%	35%	30%
N_2 and other inert gases	≤3	≤2	≤1
NH_3	40-180 ppm	30-100	Traces
H_2S	200-600 ppm	Traces	Traces

The quality of biogas produced is attributed to the physicochemical properties of the organic waste produced (see Table 1). Food waste had a higher ash content of 21% which counteracted the other parameters hence the slightly lower biogas quantity. Furthermore, the N_2 produced in the mixture was less than 1ppm and the NH_3 and H_2S were only available in traces (see Table 2). This showed that the biogas produced from the mixture was of high quality as there is no need to remove H_2S or the nitrous gases which have a negative effect on the environment. However, co-digestion had a tendency of balancing the organic waste physicochemical properties which may negatively lower biogas production, hence it’s a necessity.

CONCLUSION

Biogas is an attractive renewable energy source. Co-digestion of cow dung manure and food wastes improves biogas production which is rich in methane.

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REFERENCES

[1] G. O. Agiril, O. Akaranta, Adsorption of metal ions by dye treated cassava Mesocarp, Scientific Research and Essay, 4 (5), pp 526-530, 2009.

[2] C. Roati, S. Fiore,

[3] B. Ruffino, F. Marchese, D. Novarino, M.C. Zanetti, Preliminary evaluation of the potential biogas production of food-processing industrial wastes, American Journal of Environmental Sciences, 8 (3), pp. 291-296, 2012.

[4] P. L. Koh, V. Pomarico, V. P. Tadepalli, L. Rojas-Solorzano, Pre-feasibility study of a biogas plant for Peyrelevade Community, International Renewable Energy Congress, November 5-7, pp. 141-146, 2010.

[5] A.Peterson, M. H. Thomsen, H. Hauggard-Nielsen, A. Thomsen, Potential bioethanol and biogas production using lignocellulosic biomass from winter rye, oilseed rape and faba bean, Biomass and Bioenergy, 31, pp. 812-819, 2007.
[6] P. Kaparaju, M. Serrano, A. B. Thomsen, P. Kongjan, I. Angellidaki, Bioethanol, biohydrogen and biogas production from wheat straw in a biorefinery concept, Bioresource Technology, 100, pp. 2562-2568, 2009.
[7] R. Zhang, H. M. El-Mashad, K. Hartma, F. Wang, G. Liu, C. Choate, P. Gamble, Characterisation of foodwaste as feedstock for anaerobic digestion, Bioresource Technology, 98, pp. 929-935, 2007.
[8] F. Patania, A. Gagliano, F. Nocera, A. Galesi, Feasibility study of biogas in CHP plant for a pig farm, International Conference on Renewable Energies and Power Quality, 28-30 March, 2012.
[9] G. A. Osman, A. H. Eltinay, E. F. Mohamed, Biogas production from agricultural wastes, Journal of Food Technology, 4 (1), pp. 37-39, 2006.

Effects of the Use of Starter Culture and Different Concentrations of 'Kuuru' on the Nutritional Quality of Fermented *Parkia Biglobosa*

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ABSTRACT

The effect(s) of different concentrations of 'kuuru' on the nutritional quality of fermented African locust beans (*Parkia biglobosa*) seeds was studied. The dried seeds were processed into 'iru-pete', either by boiling the cotyledons with varying concentrations (1:300 to 1:50 w/w) of 'kuuru' or use of starter culture (*Bacillus subtilis* strain BC4333). The fermentation was carried out in an incubator at 35^{o}C for 36h. Commercial sample of 'iru-pete' was used as control. The unfermented sample (UF), naturally fermented product (FOK), 'iru' produced with varying concentration of 'kuuru' 1:300 (F1K), 1:150 (F2K), 1:100 (F3K), 1:75 (F4K), 1:60 (F5K) and 1:50 (F6K) respectively, starter culture fermented 'iru' product (F14) and commercial 'iru-pete'(CIP) were analyzed for concentrations of anti-nutritional factors (phytic acid and trypsin inhibitor), anti-oxidants level, (phenol, total flavonoids and free radical scavengers), concentration of vitamins (A, B, C, D and E) and protein digestibility. The concentrations of phytic acid and trypsin inhibitor in 'iru-pete' produced using 1:300 to 1:50 (w/w) of 'kuuru', increased from 6.99 to 10.43mg/ml and 45.51 to 60.44mg/ml, respectively. As the concentration of 'kuuru' increased, there were significant decrease in the concentrations of phenol, total flavonoids and free radical scavengers, vitamins A, B, C, D and E and protein digestibility

of the fermented products. However, the use of starter culture led to significant decrease in the concentrations of phytic acid (from 9.39mg/ml to 5.76 mg/ml) and trypsin inhibitor (from 64.36mg/ml to 41.18mg/ml), when compared to the anti-nutritional levels in the unfermented substrate. Starter-culture fermentation also led to significant increase in the anti-oxidant levels, vitamins and protein digestibility of the product. This research paper confirms that 'iru-pete' can be produced, using *Bacillus subtilis* strain BC4333, where the nutritional contents are not compromised.

Key words: *Hibiscus sabdariffa,* Fermentation, Anti-nutritional factors

Energy and Climate Change

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ABSTRACT

Over the last two centuries, industrial activities, deforestation and the burning of fossil fuels have released high concentrations of heat-trapping agents called greenhouse gases (GHGs) into the atmosphere. While a certain amount of greenhouse gas is important to keep our climate warm and livable, these higher concentrations are warming the Earth's surface to temperatures that threaten life on our planet. Carbon dioxide (CO2) and methane are two GHGs that have increased dramatically due to human activity. As the world's need for energy grows, research focuses on developing clean fuel initiatives to make the most of traditional fossil fuels while investing in cutting edge research to develop sustainable technologies which can be produced from diverse sources, including bio-fuels, wind and solar energy. Developing energy efficient technologies for buildings, homes, transportation, power systems and industry is a key component of reducing our reliance on fossil fuels. Energy technologies can have profound consequences for the environment both over the long term, as evidenced by the global climate change from fossil fuel carbon emissions, and immediately, as was made vividly clear by the historic oil spill in the Gulf of Mexico. Sustainable energy technologies will carry their own environmental impacts that must be understood before widespread implementation. Even the most innovative and effective technologies cannot solve the world's energy and climate problems without commensurate changes in public policy. Understanding the

potential social and economic impacts of sustainable energy technologies will be critical to their success.

Keywords: sustainable energy, climate, green house, carbon dioxide, fossil fuel

INTRODUCTION

Throughout history, mankind's ability to live in harmony with its environment has been dependent upon the availability of energy. In this regard, civilisations can be seen as thermodynamic systems that grow in proportion to their energy access and are subject to decline when they become unable to sustain productivity and quality of life from their available energy. Today the world is an unprecedented period of growth in its human population, made possible by a technology revolution over the past 200 years that has dramatically increased mankind's ability to harness energy from nature. By 2050, this revolution, based primarily on fossil fuels, will have enabled a ten-fold increase in global population since 1800. (Energy and Climate Change World Energy Council 2007).

Demand for energy and associated services, to meet social and economic development and improve human welfare and health, is increasing. All societies require energy services to meet basic human needs (e.g., lighting, cooking, space comfort, mobility and communication) and to serve productive processes. Approximately, since1850, global use of fossil fuels (coal, oil and gas) has increased to dominate energy supply, leading to a rapid growth in carbon dioxide (CO_2) emissions. (Energy and Climate Change World Energy Council 2007). Increasingly frequent extreme weather events, record annual global average temperatures and disruptive seasonal changes in vulnerable countries all point to increasing evidence of anthropogenic climate change. Continued reliance on outdated energy sources, coupled with a growing population and the emergence of a global middle class, put the world on a pathway to experience climate impacts of a dangerous and irreversible magnitude. This fossil fuel-based growth trajectory of the last century is no longer sustainable or economically viable. In order to achieve their economic and development aspirations while also responding to climate risks, the world's nations, businesses and citizens need to fundamentally rethink current energy policies, practices and actions.(www.wri.org/climate). Greenhouse gas (GHG) emissions resulting from the provision of energy services have contributed significantly to the historic increase in atmospheric GHG concentrations. The IPCC Fourth Assessment Report (AR4) concluded that "Most of the observed increase in global average temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations." Recent data confirm that consumption of fossil fuels accounts for the majority of global anthropogenic GHG emissions (Energy and Climate Change World Energy Council 2007).

IMPACTS FROM CLIMATE CHANGE:

- Temperature rise
- sea level rise
- massive biodiversity loss
- increase of extreme events
- Depletion of fresh water resources
- Increase of vector-borne diseases
- economic and social instabilities

SOME RENEWABLE ENERGY SOURCES

Bioenergy

Bioenergy can be produced from a variety of biomass feedstocks, including forest, agricultural and livestock residues; short-rotation forest plantations; energy crops; the organic component of municipal solid waste; and other organic waste streams. Through a variety of processes, these feedstocks can be directly used to produce electricity or heat, or can be used to create gaseous, liquid, or solid fuels. The range of bioenergy technologies is broad and the technical maturity varies substantially. Some examples of commercially available technologies include small- and large-scale boilers, domestic pellet-based heating systems, and ethanol production from sugar and starch. Advanced biomass integrated gasification combined-cycle power plants and lignocellulose-based transport fuels are examples of technologies that are at a pre-commercial stage, while liquid biofuel production from algae and some other biological conversion approaches are at the research and development (R&D) phase.

Solar energy

Direct solar energy technologies harness the energy of solar irradiance to produce electricity using photovoltaics (PV) and concentrating solar power (CSP), to produce thermal energy (heating or cooling, either through passive or active means), to meet direct lighting needs and, potentially, to produce fuels that might be used for transport and other purposes.

Hydropower

Hydropower harnesses the energy of water moving from higher to lower elevations, primarily to generate electricity. Hydropower projects encompass dam projects with reservoirs, run-of-river and in-stream projects and cover a continuum in project scale. This variety gives hydropower the ability to meet large centralized urban needs as well as decentralized rural needs. Hydropower technologies are mature.

Wind Energy

Wind energy harnesses the kinetic energy of moving air. The primary application of relevance to climate change mitigation is to produce electricity from large wind turbines located on land (onshore) or in sea- or freshwater (offshore). Onshore wind energy technologies are already being manufactured and deployed on a large scale. Offshore wind energy technologies have greater potential for continued technical advancement. Wind electricity is both variable and, to some degree, unpredictable, but experience and detailed studies from many regions have shown that the integration of wind energy generally poses no insurmountable technical barriers.

GLOBAL CARBON EMISSION CURVE

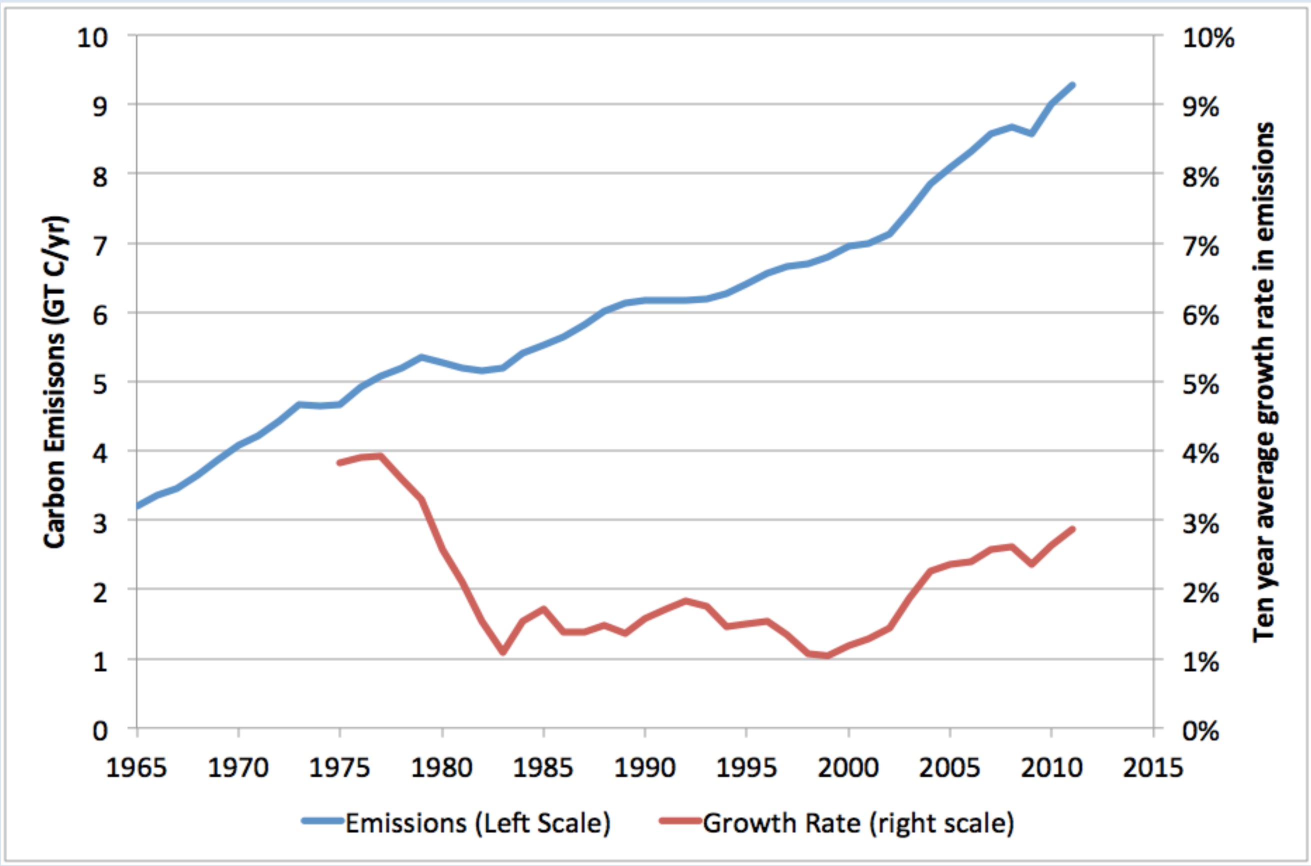

Fig 1: Global Carbon Emission curve

CLIMATE CHANGE IN AFRICA (CO_2 EMISSIONS)

By contrast, Africa has shown a range of different experiences, with many countries experiencing economic problems and slow growth, and some being affected by conflict. There is also a wide variation in industrial and energy structures. It is therefore difficult to provide any clear generalizations except that, by and large, emissions per head are very low, though they have been increasing fast. Emissions roughly doubled between 1971 and 1990, and have grown a further 50% since then. However, this is not true of all countries. For instance emissions in Zambia, Zimbabwe and the DR Congo have fallen since 1990, while emissions in Ghana, Ethiopia and Togo have risen rapidly – more than doubling in each case. Emissions per head are very low overall (0.9t compared with the world average of around 4t and the OECD's 11t). But even on this measure there are large differences. South Africa, for instance, with its healthy economy and large coal reserves, has a figure of over 7t, in line with many OECD (Organization for Economic Co-operation and Development) countries.

The low emissions reflect low energy use in the region arising from the low level of economic development in most countries, lack of industrialization and low living standards (Energy and Climate Change World Energy Council 2007).

THE RENEWABLE ENERGY SOURCES IN GHANA

Ghana, like many other African countries, faces enormous social, economic and environmental challenges that are likely to be exacerbated by the impacts of climate change. Energy Efficiency and Renewable Energy. Only energy saving technologies and the use of renewable energy sources can reduce greenhouse gas emissions and prevent climate change. The renewable energy sources available in Ghana are the following:

Solar

Solar power from photovoltaics involves the conversion of solar energy to electricity in photovoltaic cells. Solar-thermal power exploits solar radiation for hot water production.

Wind

Wind power exploits the kinetic energy of wind in wind turbines to generate electrical power or in wind water pumps for irrigation purposes.

Small Hydro

Hydroelectric power plants convert the potential and kinetic energy of water into electricity.

Biomass

Solid or liquid biomass is defined as any plant matter or organic waste used directly as fuel or converted into other forms (e.g. biofuel, biogas) before combustion.

CONCLUSION

Energy use is the most important source of anthropogenic greenhouse gas emissions; therefore the energy sector is where the greatest reductions will have to be sought. Conserving energy is critical.

RECOMMENDATIONS

Inform and educate policy makers and the public

Create conditions to support innovations

Provide vision, mechanics and funding to deliver solutions

REFERENCES

World Energy Council .Energy and Climate Change, 2007

Energy Commission Ghana, Electricity Sector Overview, 2002

http://www.resilience.org/stories/2013-01-15/co2-concentration-in-panic-and-repent-scenarios,9/10/13

http://www.wri.org/climate,9/30/13,3:10pm

Fungi Isolated from Rotted *Jatropha Curcas* Fruits: Implication for Biodiesel Production

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ABSTRACT

Jatropha curcas is a flowering plant cultivated in tropical and subtropical regions around the world. The seeds contain 27-40% oil that is processed to produce biodiesel that can be used in a standard diesel engine. The use of this biodiesel is being promoted and encouraged as a replacement for the currently used diesels that contain aromatic hydrocarbons which have contributed greatly to climate change by their emissions into the atmosphere. Such a promising plant should be protected from disease pathogens such as fungi. In the light of this, a study to determine the fungi associated with fruit rot of *J. curcas* was undertaken. Small portions (5mm diameter) of rotted *J. curcas* fruits

obtained from the Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Nigeria were cultured on chloramphenicol-containing Potato Dextrose Agar at room temperature (28 $\pm$ 2^oC) for seven days. Isolated fungi were identified following conventional methods. The fungi isolated and their percentage occurrences were *Aspergillus flavus* (61.50), *Fusarium moniliforme* (23.1) and *Candida tropicalis* (15.38). *Aspergillus flavus* had the highest microbial load of 16x10^6). Although *Aspergillus flavus* and *Fusarium moniliforme* are common environmental moulds and the latter has been reported to cause rot of *Jatropha curcas* fruits, this is, however, the first report of the isolation of C*. tropicalis* (an opportunistic human pathogen) from *J. curcas* fruits. The isolated fungi are capable of damaging the fruit (which harbor the seeds) thereby reducing the economic value as well as the germinability of seed. Therefore, there is the need to prevent/control these pathogens so as not to hamper the production of biodiesel from *Jatropha curcas* seeds. Production and use of biodiesel as against petroleum diesel will gradually mitigate climate change resulting from depletion of the ozone layer indirectly caused by use of petroleum diesel emissions.

INTRODUCTION

Jatropha curcas is a species of flowering plant in the spurge family, Euphorbiaceae that is native to the American tropics, most likely Mexico and Central America and contains about 170 known species (Sepidar *et al*., 2009). It is a poisonous, semi-evergreen shrub or small tree, reaching a height of about 5m (Bagani and Henning, 2004). It is resistant to a high degree of aridity, allowing it to be grown even in the desert. The seeds of *J. curcas* contain 27-40% oil (average 34.4%) that can be processed to produce a high-quality biodiesel fuel, usable in a standard diesel engine. The seeds are also a source of the highly poisonous taxalbumin curcin (Juhasz *et al.,* 2009).

Fruits are produced in winter, or there may be several crops during the year if soil moisture is good and temperatures are sufficiently high. Most fruit production is concentrated from midsummer to late fall with variations in production peaks where some plants have two or three harvests and some produce continuously through the season (Pradhan *et al.,* 2009). The seeds are mature when the capsule changes from green to yellow. The seeds contain around 205 saturated fatty acids and 80% unsaturated fatty acids, and they yield 25%-40% oil by weight. In addition, the seeds contain other chemical compounds such as saccharose, raffinose, stachyose, glucose, fructose, galactose and protein. The oil is largely made up of oleic and linoleic acids. Furthermore, the plant also contains curcasin, arachidic, linoleic, myristic, oleic, palmitic and stearic acids and curcin (Yuan *et al.,* 2009).

Yield and Processing

While *J. curcas* starts yielding from 9-12 months, the best yields are obtained only after 2-3 years. Seed extraction is made simple with the use of the Universal Nut sheller, an appropriate technology designed by the Full Belly project. Oil content varies from 28% to 40%. One hectare of plantation will give 400 to 600 litres of oil if the soil is average. The oily seeds are processed into oil, which may be used directly (as vegetable oil) to fuel combustion engine or may be subjected to trans-esterification to produce biodiesel. *Jatropha* oil is not suitable for human consumption as it induces strong vomiting and diarrhea.

Uses of *Jatropha Curcas*

The oil is mainly used as biodiesel for energy. The cake obtained after oil extraction can be used for fish or animal feed (if detoxified), biomass feedstock to power electricity plants, or as biogas or high-quality organic fertilizer. It can also be used as a bio-pesticide and for medicinal purpose (Abdu-Aguye *et al.,* 1986). Glycerin is another by-product from *Jatropha* oil processing that can add value to the crop. Beside the above uses of the plant other uses include: (1) *Jatropha* leaves are pounded and applied near horses eyes to repel flies in undid. (2) Nuts are sometimes roasted and eaten, although they may cause diarrhea. It is commonly reported that *Jatropha* seeds are edible once the embryo has been removed. (3) they can also be burned like candle nuts when strung on grass (4) The nuts and seeds are used as a contraceptive in South Sudan (Devappa *et al.,* 2010; Aquino *et al.,* 2009). (5) *Jatropha* oil has been used for illumination, soap and candle making. It is used in formulating lubricants, softeners, and dying assistants. (6) Ashes of roots are used as a salt substitute but HCN and Rotenone are present. (7) Bark of *Jatropha* is used as a fish poison probably because of HCN present. (8) Latex of the plant strongly inhibits the watermelon mosaic virus. Thus, the *Jatropha* plant is economically important in many ways.

Fruit rot of *Jatropha curcas*

Many fungi have, however, been associated with fruit rot of *Jatropha curcas.* Fungal pathogens have been identified as causing diseases on *Jatropha curcas* seedlings, stem, leaves and fruits. The diseases include leafspots caused by *Thielaviopsis paradoxa, Curvularia* and *Cercospora sp.* seedling blight caused by *Curvularia* and *Choanephora spp.,* anthracnose and fruit rot caused by *Colletotrichum gloeosporioides* and *Fusarium moniliforme*. The use of *Jatropha curcas* seeds in biodiesel production is a promising replacement for the environment-degrading hydrocarbon-based oils being currently used. Therefore it becomes necessary to study the fruit rot. Since the fruit harbours the seeds, rot of the fruits can affect the seed and this may have implications on the quantity and quality of biodiesel produced as alluded to by Akhihiero *et al.,* (2011).

The objective of this paper was to isolate and identify the fungal organisms associated with fruit rot of *J. curcas* in Benin City, Nigeria and determine their implication for biodiesel production from the seeds.

MATERIALS AND METHODS

Source of plant materials: *Jatropha curcas* fruits were obtained from a farmland at the Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Nigeria and stored in a sterile polythene bag.

Culture media: The medium used for isolation of fungi was PDA sterilized by autoclaving at 15psi (121^{o}C) for 15 minutes. Chloramphenicol at 0.02gm per 20ml of medium was introduced at pouring to inhibit the growth of bacteria.

Detection of fruit rot: Fruits of *Jatropha curcas* were examined visually and by the presence of necrotic yellowish spot after which the symptoms were described.

Isolation of Fungi Associated with *Jatropha fruit rot:* small portions 5mm in diameter, of the rotted fruit were cut with a flamed scalpel from the pod surface sterilized in 0.1% mercuric chloride solution for 2 minutes and rinsed in three changes of sterile distilled water, dried with sterile whatman paper and crushed before planting in Petri dishes containing PDA medium. Culture dishes were incubated on a laboratory bench at a temperature of 28 $\pm$ 2^{o}C for 3-7 days. After the period of incubation, different colonies of fungi growing in the plates were aseptically sub-cultured by means of flamed inoculating needle into fresh plates of PDA. The frequencies of occurrence of the various colonies were noted. All stock cultures were maintained on PDA slopes in McCartney bottles at 5^{o}C in the dark and were sub-cultured afresh at intervals for each experiment.

Microbial (fungal) load of the *Jatropha* rotted fruits were determined by serial dilution technique. From 10^{-1} to 10^{-4} dilutions in McCartney bottles, platings were done by transferring 1ml aliquots of tissue washings onto triplicate PDA plates containing chloramphenicol. Plates were incubated at 28$^{o}\pm$2^{o}C.

Morphological identification of Isolates

Each isolate obtained from the cultures was macroscopically and microscopically examined, and identification was done with the aid of a Laboratory Manual of Commonwealth Mycological Institute of Identification of Fungi and Bacteria. Isolate samples were also sent to the Commonwealth Mycological Institute, England for confirmation.

Frequency of occurrence of fungal species in fruits: The frequency of occurrence of fungal species in the isolation plates was determined for each fungus based on its occurrence in culture plates as follows:

$$\text{Frequency} = \frac{\text{No. of colonies of fungus in 3 replicates}}{\text{Total No. of colonies of all fungi in 3 replicates}} \times 100$$

RESULTS

Symptomatology

Jatropha curcas fruit rot generally began with gradual yellowing of the fruits and development of small necrotic patches which gradually spread round the fruits. The development of these symptoms made the fruit pods to become dry and necrotic (cf. Plates 2 and 3) when compared with the healthy fruits (Plate 1).

Fungal isolates obtained

Three pathogens were isolated from the rotted fruits (Plates 4, 5 and 6). *Candida tropicalis, Aspergillus flavus* and *Fusarium moniliforme* with percentage occurrences of 15.3%, 61.54% and 23.08% respectively (Fig 1). The microbial load of the three fungi was 4 x$10^{6,}$ 16x10^6 and 6x10^6 respectively (Table 1). Thus *A .flavus* had the highest occurrence while *C. tropicalis was* least frequent. Plate 7 shows yeast –like elongate cells of *C. tropicalis* that forms pseudomycelium (Plate 4).

Plate 1: Healthy *Jatropha curcas* fruits

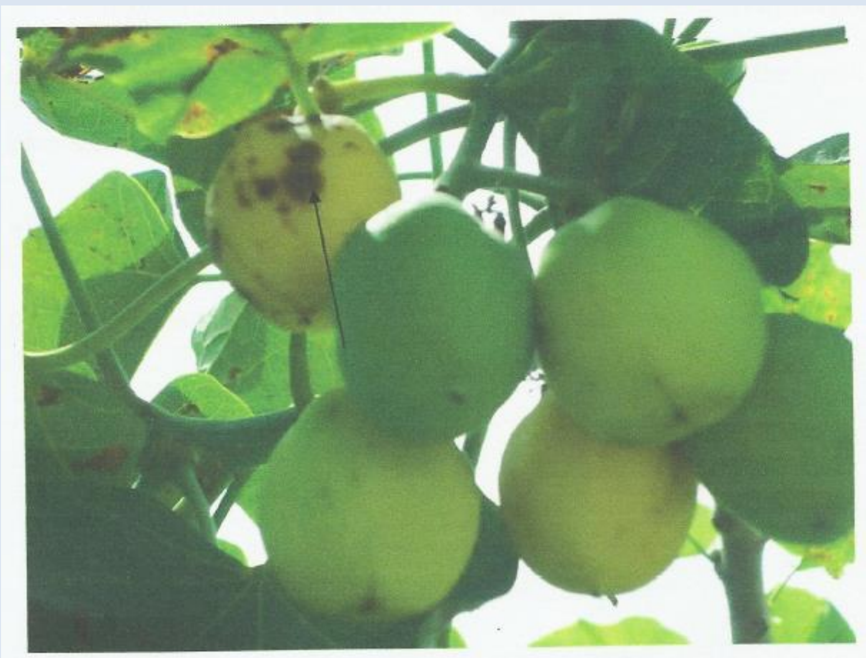

Plate 2: Chlorosis and necrotic patches on *Jatropha curcas* fruits

Plate 3: Rotted Pods of *Jatropha curcas* fruits

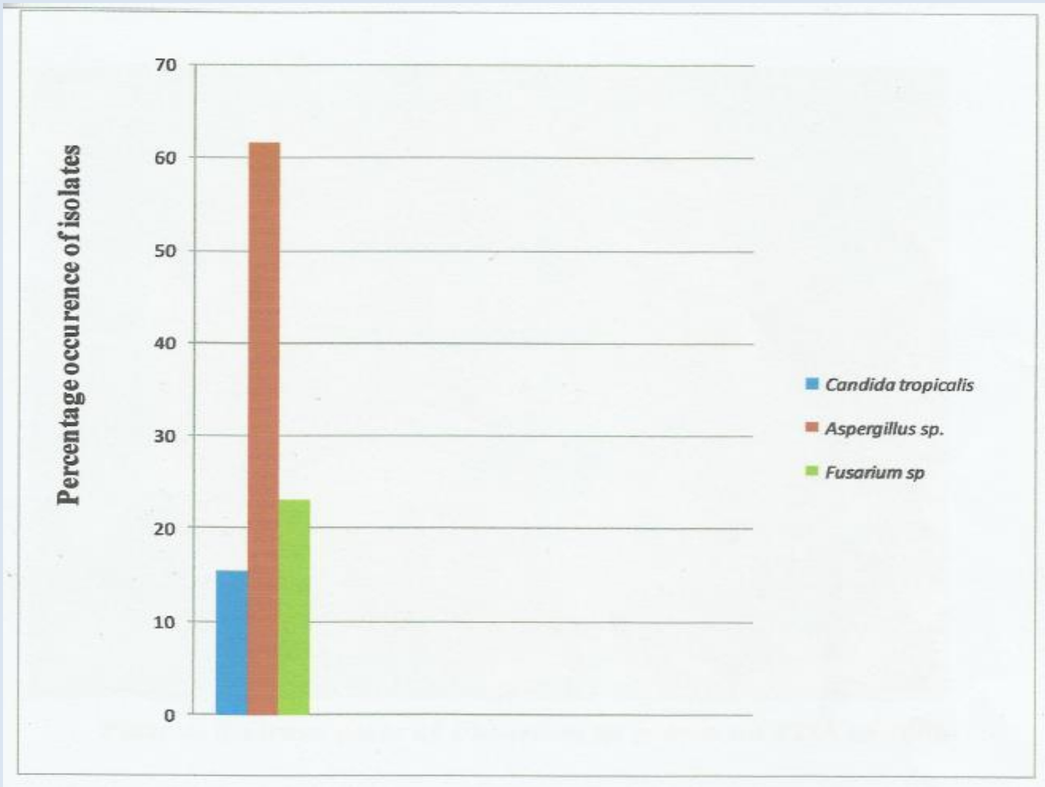

Figure 1: Percentage occurrences of the fungi isolated on PDA from rotted fruits of *Jatropha curcas* at 28 ± 2°C.

Table 1: Microbial Load of Fungal isolates from rotted *Jatropha* fruits

Fungus	Microbial load
Candida tropicalis	4×10^6
Aspergillus flavus	16×10^6
Fusarium moniliforme	$6x10^6$

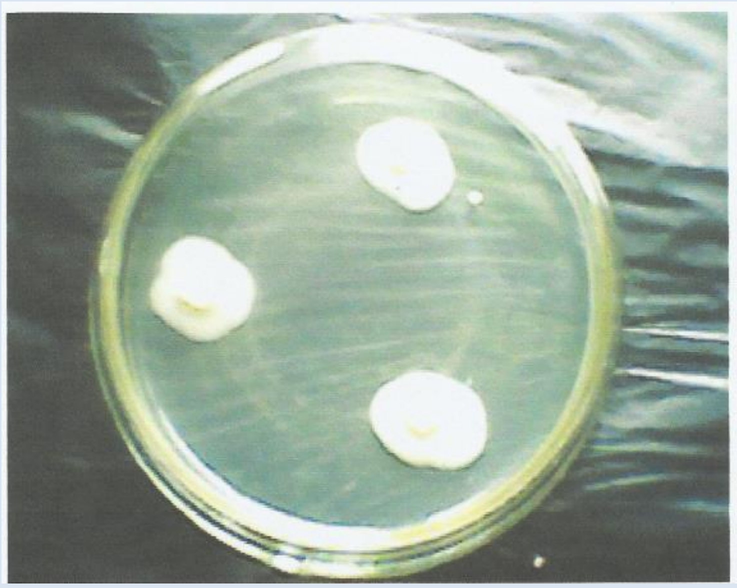

Plate 4: Culture plate of *Candida tropicalis* grown on PDA at room temperature for 4days

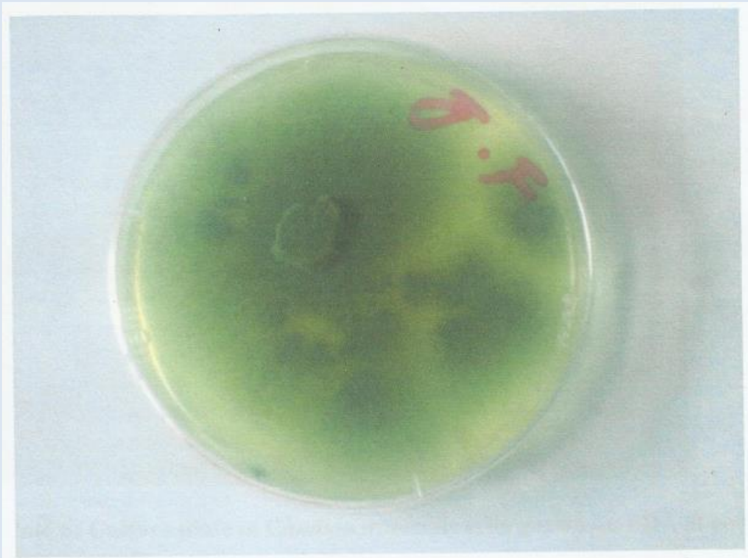

Plate 5: Culture plate of *Aspergillus flavus* grown on PDA at room temperature for 4 days

Plate 6: Culture plate of *Fusarium moniliforme* grown on PDA at room temperature for 4 days

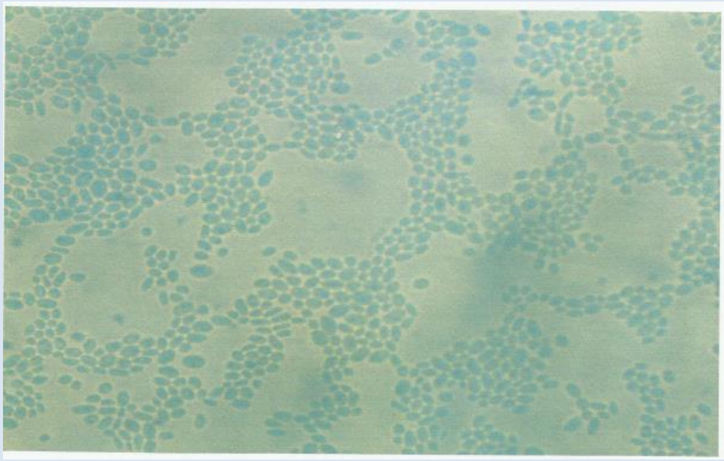

Plate 7: Photomicrograph of spores of *Candida tropicalis* grown on PDA at room temperature for 4 days

DISCUSSION

The determination of the fungi associated with fruit rot of *J. curcas* is of great importance in order to provide information for the protection of this economically useful plant and its fruits. This study has shown that three fungal species isolated from the rotted fruits were *Candida tropicalis,* a deuteromycetous yeast, *Aspergillus flavus* and *Fusarium moniliforme* the percentage occurrences of which were 15.38, 61.54 and 23.08 respectively. *Aspergillus flavus* and *Fusarium moniliforme* are common environmental moulds that have been reported to cause rot of *J. carcas* fruits as well as in numerous other crops like peach (Molina and Giannuzzi, 2002), Muskmelon (Carter, 1981). *C. tropicalis* is being reported for the first time from fruits of *J. curcas* in Nigeria and is noteworthy. *C. tropicalis* is an opportunistic human pathogen (Chai *et al.,* 2010). Okungbowa *et al.,* (2003) while reporting on infections of human genitourinary tracts in Nigeria showed that *C. tropicalis* is taxonomically close to *Candida albicans,* which causes candidiasis. Whether or not *C. tropicalis* is a true and persistent pathogen of *J. curcas* would have to be further investigated through the means of pathogenicity tests.

Aspergillus flavus has been known to produce aflatoxins that are carsinogens (Singh and Prashar, 1989). *J. curcas* fruits and seeds are not typically produced for food, so one may worry less but the seeds are getting popular for biodiesel production when specially processed. Increasing interest in biofuels is the environmental friendliness and sustainability. The use of biodiesel as against petroleum diesel will gradually mitigate climate change which has resulted from depletion of the ozone layer caused by emission from aromatic petroleum products.

The colonization of the fruits can affect the seeds and hence affect the production of biodiesel. Akhihiero (2011) alluded to the fact that mouldiness of *J. curcas* seed kernels from which the plant oil was extracted for biodiesel production actually resulted in better quality biodiesel. This may be a case of moulds modifying the seed oil positively. No specific fungus however, was listed in her study. Whether the three fungal species encountered in this study will manifest similar effects on biodiesel production will have to be specially investigated. In any case, fruit rot is not a desirable thing because the plant can loose yield.

Alternatively, attention is here being drawn to the possibility of obtaining seeds from rotted fruits, using them for biodiesel production in comparison with oil produced from seeds of healthy fruits. Another angle to the presence of the fungi on the fruits of *J. curcas* is their effects on germinability of the seeds. If seeds fail to germinate because of fruit/seed infection, expectations are dashed.

CONCLUSION

J. curcas rotted fruits yielded three fungal species including *Candida tropicalis* a human pathogen. Further studies are needed to establish *C. tropicalis* as a consistent pathogen of *J. curcas* fruits. To avoid possible loss of fruit yield the plant must be protected from fungal attack. The exact role of the fungi in biodiesel production from *J. curcas* seeds and germinability of the seeds need be comprehensively investigated.

REFERENCES

Abdul-Aguye, I., Sannusi, A. Nafiya-Tayo, R.A., Bhusanrmath, S.R. (1986). Acute toxicity studies with *Jatropha curcas*. *Human Toxicals* **5(4):** 269-274.

Akhihiero, E.T., Aluyor,E.O. and Audu, T.O.K (2011). Effects of seed degradation on the quality of oil produced from *Jatropha curcas* seeds. Proceedings of the 41st Annual Conference and AGM of the Nigerian Society of Chemical Engineers, Lagos, November 2011.

Aquino, A.L., Guzman, L.E., Villaricencio, M.L. and Viltancio V.T. (2009). Seed quality of physic nut (*Jatropha curcas)* at different stages of fruit maturity. *Phillippine Journal of Crop Science* **34(3):** 82-89.

Bagani, Reinhard K. and Henning Rothkreuz (2004). *Jatropha curcas* in Africa – An evaluation 11, D-88138. Weissenberg, Germany. www.jatropha.org.

Carter W.W. (1981). Re-evaluation of heated water as a postharvest treatment for controlling surface and decay fungi of muskmelon fruits. *Hortsciences* **16:**333-334.

Chai, L.Y., Denning, D.W. and Warn, P. (2010). *Candida tropicalis* in human disease. *Critical Reviews in Microbiology.* **4:** 282-298.

Devappa, R.K., Makkar, M.P. and Becker, K. (2010). Toxicity of *Jatropha curcas* pharbol esters in mice. *Food and Chemical Toxicity.* **48(2):** 626-625.

Juhasz, S., Pimenta, B.O., Soares, D., Rabello, H. (2009). Floral biology and artificial polinization in physic nut in north of Mina Gerais State, Brazil. *Pesquisa Agropecuaria Brasileira* **44(9):** 1073 – 1077.

Molina M. and Giannuzzi (2002). Modeling of aflatoxin production by *Aspergillus parasiticus* in a solid medium at different temperatures, pH and propionic acid concentration *Food Research International* **35:** 583-594.

Okungbowa F.I., Isikhuemhen O.S and Dede A.P.O. (2003) The distribution frequency of *Candida* species in the genitourinary tract among symptomatic individuals in Nigerian cities. *Revista Iberoamericana de Micologia*; **20**:60-63

Pradhan, R.C, Naik S.N., Bhatnagar,N.and Vijay V.K. (2009) Moisture-dependent physical properties of *Jatropha* fruit. *Industrial Crops and Products* **29** (2):341-347.

Sepidar Sayyar, Zurina Zainal Abidin, Robiah Yunus and Azhari Muhammed (2009). Extraction of oil from *Jatropha* seeds, optimization and kinetics. *American Journal of Applied Sciences* **6(7):** 1390-1395

Singh R.S. and Prashar M. (1989). Post harvest spoilage of peach and plum fruits in North India due to *Aspergillus. Journal of Research Punjab Agricultural University* **26:**62-64**.**

Yuan, P., Xiong, X. and Yuan, X. (2009). On physical and chemical properties of seed fatty oil, element content analysis and preliminary study of application value of seed kernel meal of *Jatropha curcas*. *Journal of plant resources and environmental* **18(4):** 88-90

Evaluation of Almond (Prunus amygdalus) Seed Oil as a Viable Feedstock for Biodiesel Fuel

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ABSTRACT

Viability of almond (*Prunus amygdalus*) seed oil as a potential feedstock for biodiesel production was reported. The oil content of the seed was extracted with n-hexane using Soxhlet extraction method. The extracted oil was characterized to determine the key physical and chemical properties that mark the suitability of the oil for biodiesel production. Values obtained for parameters such as density (0.98 g/cm^3), flash point (220 ^{0}C), acid value (40.14 mg/KOH/g) and kinematic viscosity (30 CSt at 40 ^{0}C) for the extracted oil were comparable with values reported for other non-edible oils such as *Jatropha curcas, Pongamina pinnata, Azadirachata indica* and *Simaroubia indica.* The extracted seed oil was transesterified using both homogeneous (NaOH) and heterogeneous (CaO and MgO) catalysts.The yields of the biodiesel obtained with homogeneous catalyst under optimum conditions such as 1500 rpm agitation speed, 60 ^{0}C reaction temperature, 5:1 methanol to oil ratio were relatively higher than the yields obtained with heterogeneous catalyst under these same experimental conditions. Physico-chemical properties of the biodiesel such as acid value (mgKOH/g), saponification value(mg/g), flash point(^{0}C), fire point(^{0}C), specific gravity (gm^{-3}), viscosity (Kgm^{-1}S^{-1}), cloud point(^{0}C) and centane number were determined and found consistent with the standards set for ASTM D6751 and EN 14214. In addition, remarkable variation was noticed in the flash point (298 ^{0}C) and cetane number (62) of the biodiesel compared with those of petroldiesel which were 125 ^{0}C and 49,respectively.Weight percent composition of the biodiesel was diglycol diacetate 0.49, methyl oleate 43.04, methyl palmitate 48.40 and methyl stearate 8.07. The biodiesel profile of the seed-oil is comparable with the high quality biodiesel produced with yellow oleander (Thevetia peruvian) seed oil. Hence, almond seed oil is cheaper, cleaner and suitable feedstock for biodiesel fuel.

Key words: Almond seed-oil, Catalysts, transesterification, biodiesel, petrol diesel

INTRODUCTION

Global warming and other forms of pollution are few of the consequences emanating from over dependence on fossil fuels. Diverse forms of alternative energy are being exploited by researchers on daily basis to provide substitutes that are environmentally friendly. Biodiesel is categorised as one of the options that is very promising by virtue of its remarkable lower carbon and sulfur emissions compared with conventional petroleum-based fuels. Basically, biodiesel fuels are generated from three sources namely; edible sugars and starches, non-edible plant materials, algae and other microbes. Generally, these sources are renewable and generate fuels with lower carbon and sulfur emissions compared with conventional petroleum-based fuels that are characterized by high carbon and sulfur emissions.[EPA,2002]

The general acceptability of biodiesel as a suitable substitute lies in the possibility of being used either as pure or in blends with conventional diesel fuel in unmodified diesel engines, hence eliminating engine exhaust pollutants. However, the relative simplicity of biodiesel production can disguise the importance of maintaining high quality standards for any fuel supplied to a modern diesel engine. Bio-diesel is a promising non-toxic and biodegradable renewable fuel comprised of mono-alkyl esters of long chain fatty acids, which are derived from vegetable oils or animal fat (edible and non-edible) [Hanna,1999; Haq et al,2008; Meher et al,2005;Encinar et al,1999; Noureddin et al, 2005].

The most commonly used oils for the production of biodiesel are soyabean, sunflower, palm kernel, rapeseed, cotton seed and jattropha. However, there are good numbers of seed-oils that are presently under-utilized for biodiesel production among which are almond (*Prunus amygdalus*). Essence of exploiting non-edible seed oils for biodiesel does not limit to conserving the edible counterparts for human consumption but also providing a platform for economical production of biodiesel with such resources that are readily available at no cost.

EXPERIMENTAL

Sample collection

Almond seeds were collected from the premises of Federal University of Technology Akure, Ondo State, Nigeria.

Sample preparation

The seeds collected were manually dehulled and carefully sorted to remove all the mesocarp. The seeds were sundried for two days, oven dried for 2 h at the temperature of 105 ^oC and finely ground into flour using blending machine.

Oil extraction of the seed flour

100g of the prepared sample flour was transferred into the soxhlet thimble which was carefully fixed on a 500 mL capacity round bottom flask. 300 mL n- hexane (b.p 40-60 ^oC) was poured inside the flask and heated on a thermostatically controlled heating mantle to boiling point. The refluxing continued for four hours, until the oil was fully extracted.

Pretreatment of the oil sample

The almond seed oil could not be transesterified directly due to its high Free Fatty Acid (FFA) value, hence the pretreatment.The FFA value of the fat was reduced below 1% using Concentrated Sulphuric acid as catalyst and methanol prior to transesterification.

Procedure

10 mL of the extracted oil was measured into a pre-dried flat bottom flask, then 60 mL of methanol was added and 1% H_2SO_4 by volume were also added. The mixture was agitated at very high speed at 60 ^oC with magnetic stirrer. The reaction time was achieved after 70 min, the mixture was then poured into a 250 mL separating funnel, three layers were formed comprising water at the bottom, oil sample at the middle while the methanol was at the upper layer. The mixture was carefully separated by removing the water first followed by the oil and lastly, the methanol. The pretreated oil was poured into a 250 mL beaker and placed inside the oven set at 105 ^oC until traces of water and methanol were vaporized. Consequent upon which the pretreated oil was apparently suitable for the transesterification process.

TRANSESTERIFICATION OF THE EXTRACTED OIL SAMPLE

Transesterification of the extracted almond oil with methanol were carried out in the presence of homogeneous and heterogeneous catalysts to yield fatty acid methyl ester (biodiesel) .

Homogeneous transesterification

Homogeneous transesterification was achieved using sodium hydroxide (NaOH) as homogeneous catalyst. A 250 mL flat bottom flask was used as laboratory scale reactor vessel and a hot plate assembled with magnetic stirring device used for heating and stirring purposes.

Procedure

10 mL of the oil was weighed inside the reactor vessel, heated on the hot plate to heat the oil adequately. Thereafter 0.03 g of the alkali catalyst (NaOH) was weighed and dissolved in 2 mL of methanol. The mixture of the catalyst and methanol was poured carefully inside the heated oil. The resulting mixture was stirred and heated simultaneously at 60 ^oC for a period of 90 min. The reaction mixture was allowed to cool, transferred to the separating funnel and allowed to stand for 24 h to achieve a good separation. After the set time, two distinct layers appeared; the upper consist of fatty acid methyl ester while the lower was made up of glycerol, excess alcohol and the catalyst. Each of the layers was carefully collected through the tap and the methyl ester (biodiesel) layer was washed with warm water about four times to remove traces of alcohol and catalyst residues. The biodiesel produced was dried in an oven set at 105 ^oC for 2 h to remove water molecules.

Heterogeneous transterification

Transesterification of the pretreated oil of almond seeds was performed with admixture heterogeneous catalyst of Calcium Oxide and Magnesium Oxide. The procedure for homogeneous transesterification was adopted except for the catalyst.

Physico-chemical properties of the derived biodiesel

The physico-chemical properties of the extracted oil were determined and compared with the standard values of oil suitable for biodiesel production. The parameters considered include density, viscosity, flash point, fire point, smoke point, acid value, free fatty acid peroxide value, colour and iodine value, these were determined according to ASTM standard method (D6751).

Biodiesel charaterization using GCMS

Chemical components of the derived biodiesel were characterized with Gas Chromatography Mass Spectrometry, in order to correlate its composition with those of petroleum-based diesel.

RESULTS AND DISCUSSION

Oil yield from the extraction process

The oil yield obtained from the almond seed using soxhlet extraction was 47 %, this showed that the oil content of almond seed is relatively higher than other non-edible seeds such as mangifera indica which contains 14.0% (Nzikou,2010). However, the oil content was comparable with the oil content of Dacryodes edulis which was 59% of its total seed as reported by Ogunsuyi et al, (2013).

Physico-chemical properties of almond seed oil

Table 1 depicts the physico-chemical analysis performed on the extracted oil of the almond seed.

The oil indicated a smoke point of 60 ^oC and a flash point of 110 ^oC which were relatively lower than that of most of the non-edible seed oils commonly used for biodiesel. However, the fire point of the seed oil was comparatively higher than those of the other non-edible oils. The pH value of the oil was 6.68, this implied that the oil was acidic in nature. Refractive index which is related to the average chain length and the degree of unsaturation was found to be as low as 1.46, hence, the oil was semi-solid at room temperature. This observation was quite consistent with the findings of Canakci and Gerpan (2001) who asserted that refractive index increases as double chain increases.The semi-solid nature of the almond oil contributed to its lower iodine values of 12.46mg/g. The iodine value which is an index for assesing the ability of an oil or fat to go rancid indicated that the oil contained appreciable level of saturated bonds, hence, low ability to undergo oxidative deterioration. The acid value of almond seed oil was relatively high (40.4 mgKOH/g) compared to that of castor seed oil which was 0.7 mgKOH/g. This shows that the acid value of the seed oil was very high and may lead to neutralization of part of the catalyst present, thus reducing the formation of the alkoxide and consequently producing soaps within the reaction medium. Soap formation would not only reduce mass transfer during reaction but also increase the problem of phase separation at the stage of product recovery. Almond oil has significantly high viscosity of 302.39 CSt. The high viscosity of the oil reduces the fuel atomization and increases the fuel spray penetration. The bigger fuel spray is considered to be partially responsible for the difficulties with deposits in the engine and thickening of the oil. However, these effects can be removed through transesterification process, which was evident in the drastic reduction in the viscosity of the oil after being transesterified, which gave a value of 31.84 CSt

Table 1: Physico-chemical Properties of the Extracted Oil of Almond seed

PARAMETERS	ALMOND OIL
pH	$6.67^b \pm 0.01$
TEMPERATURE (^oC)	$28.80^e \pm 0.11$
FLASH POINT (^oC)	$110.00^h \pm 1.15$
FIRE POINT (^oC)	$220.00^j \pm 1.15$
SMOKE POINT (^oC)	$60.00^g \pm 0.00$
REFRACTIVE INDEX	$1.46^a \pm 0.00$
DENSITY (g/cm^3)	$0.91^a \pm 0.01$
VISCOSITY (CSt)	$302.39^k \pm 0.01$

ACID VALUE (mg/KOH/g)	40.14^{f} ± 0.01
FREE FATTY ACID (mg/KOH/g)	20.05^{d} ± 0.01
IODINE VALUE (mg/g)	12.46^{c} ± 0.01
PEROXIDE VALUE (mg/KOH/g)	2.25a ± 0.01
COLOUR	Yellow
SAPONIFICATION VALUE	151.55^{i} ± 0.03

Each value is a mean of three replicate samples ± standard error of mean. Values followed by the same letter(s) are not significantly difference (P>0.05) from each other by New Duncan's Multiple Range test.

Oil sample pretreatment

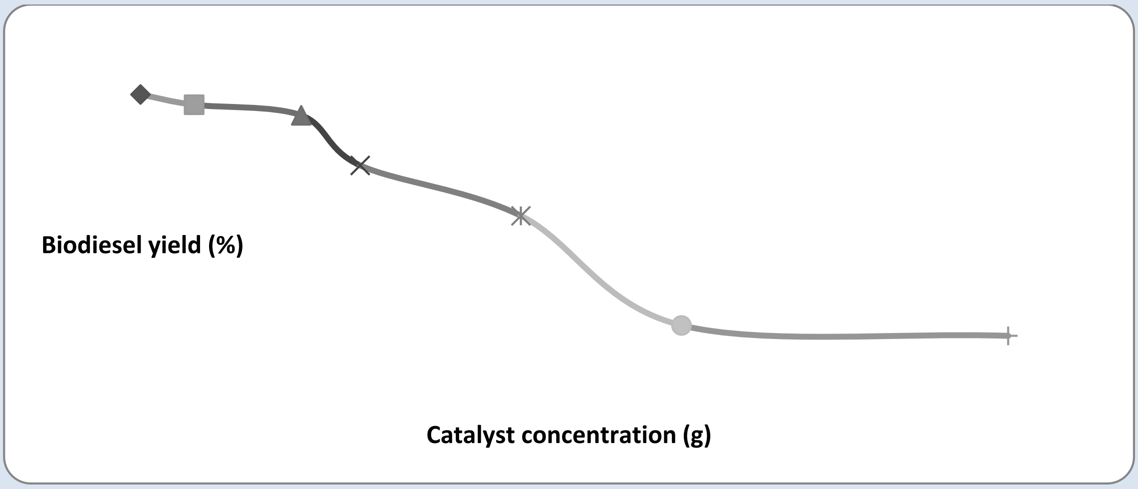
Oil sample pretreatment was carried out on the extracted oil due to its high level of saturation and hence, could not undergo direct transesterification. More also, the pretreatment reduced the free fatty acid contents (FFA) of the extracted oil. The FFA value of the fat was reduced below 1% using Concentrated Sulphuric acid as catalyst and methanol prior the transesterification process. The pretreatment process was noted to be effective, as the free fatty acid of the almond seed oil significantly reduced from 20.05 mg/KOH/g to 5.69 mg/KOH/g. The reduction in FFA content actually made the seed oil suitable for transesterification purpose.

Transesterification of the Oil using Homogeneous Catalyst (NaOH)

Transesterification process was conducted on the plant seed oils to investigate the effects of parameters such as catalyst concentration, methanol to oil ratio, agitation speed and temperature on the yield of the biodiesel produced.

Effect of Catalyst Concentration on Biodiesel Yield

The result of transesterification of the oil samples using homogenous catalyst NaOH, at different catalyst concentrations and their corresponding biodiesel yields is as shown below in Figure 1. As the catalyst concentration increased from 0.020g to 0.182g, the percentage yield decreased from 59.90 to 19.70% which indicated that at low catalyst concentration there was a higher yield of biodiesel. This was attributed to the fact that at higher concentration of the catalyst, saponification reaction was likely to have set in thereby reducing the quantity of the biodiesel. The soap particles formed emulsion with water, which resulted into increased viscosity as reported by Chettri et al.,(2008)



Figs 1: Effect of catalyst concentration on the yield of almond seed oil biodiesel

Effect of Molar Ratio of Methanol to Oil on Biodiesel Yield

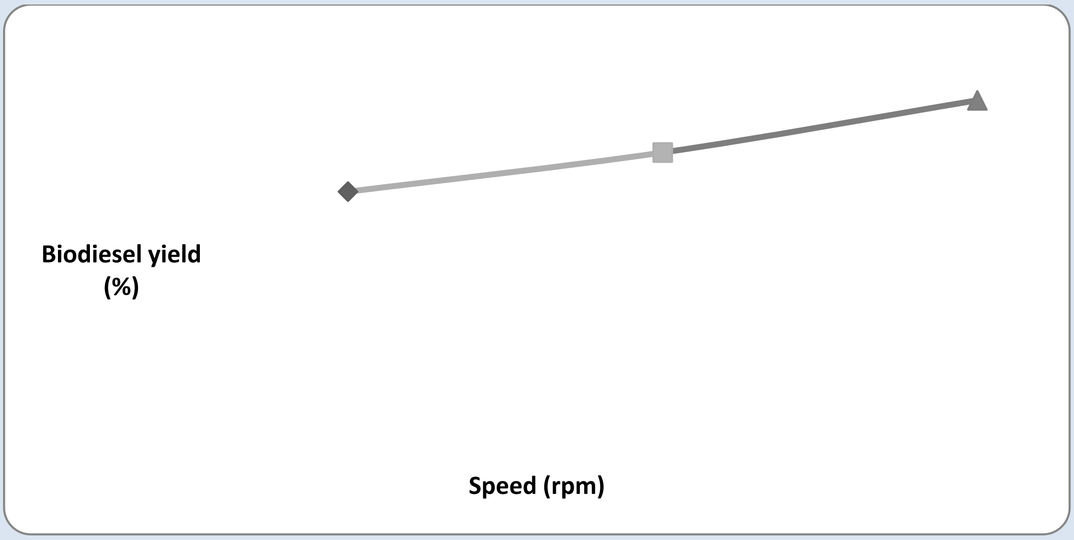
The effect of molar ratio of methanol to oil on the yield of almond seed oil biodiesel is as depicted in Table 2. At 3:1 of methanol to oil ratio, 14.0ml of biodiesel yield was recovered. This increased to an optimum yield at ratio 5:1 of methanol/oil which gave 17.6ml and thereafter dropped below this value to 12.0ml. Hence, the best methanol to oil ratio was attained at 5:1 for the transesterificatio process.

Table 2: Yields of biodiesel at different ratio of methanol to oil.

Vol.of.oil (ml)	Vol.of methanol (ml)	Vol of H_2SO_4 (ml)	Methanol to oil ratio	Yield of biodiesel (ml)
20	60	1	3:1	14.0
20	80	1	4:1	16.0
20	100	1	5:1	17.6
20	120	1	6:1	12.0

Effect of Agitation Speed

Agitation speed is an important factor in transesterification process since the speed affects the equilibrium of the reaction. Figure 2, shows the various biodiesel yields obtained at different speed between 500 rpm and 1500 rpm at a constant standard reaction conditions (reaction time 90 min, weight of catalyst concentration of 0.03 and molar ratio methanol/oil 5:1). It showed the stirring speed increased from 500 rpm to 1500 rpm, the percentage yield also increased from 39.90 % to 51.54 % which was the highest stirring speed. This implies that speed is directly proportional to the yield of the biodiesel i.e high stirring speed favours higher yield of biodiesel. This result was in accordance with the findings of Peterson et al, (1997) which showed that agitation at a high speed during transesterification of vegetable oils enhances the homogenization of the reactants hence leading to higher yields.



Figs 2: Effect of agitation speed on the yield of almond oils

Effect of Temperature

The extracted oils was transesterified within the temperature range of 50 °C and 70 °C under standard reaction conditions such as reaction time 90 min, weight of catalyst concentration of 0.03g, molar ratio methanol/oil 5:1 and speed of 1500 rpm. From Table 3 it was noted that moderately high temperature such as 60 °C was most suitable among the various temperatures considered. At this optimum temperature of 60 °C, the yield of biodiesel produced with almond seed oil was 58.19 %.

Table 3: Effect of temperature on the yield of almond oils biodiesel

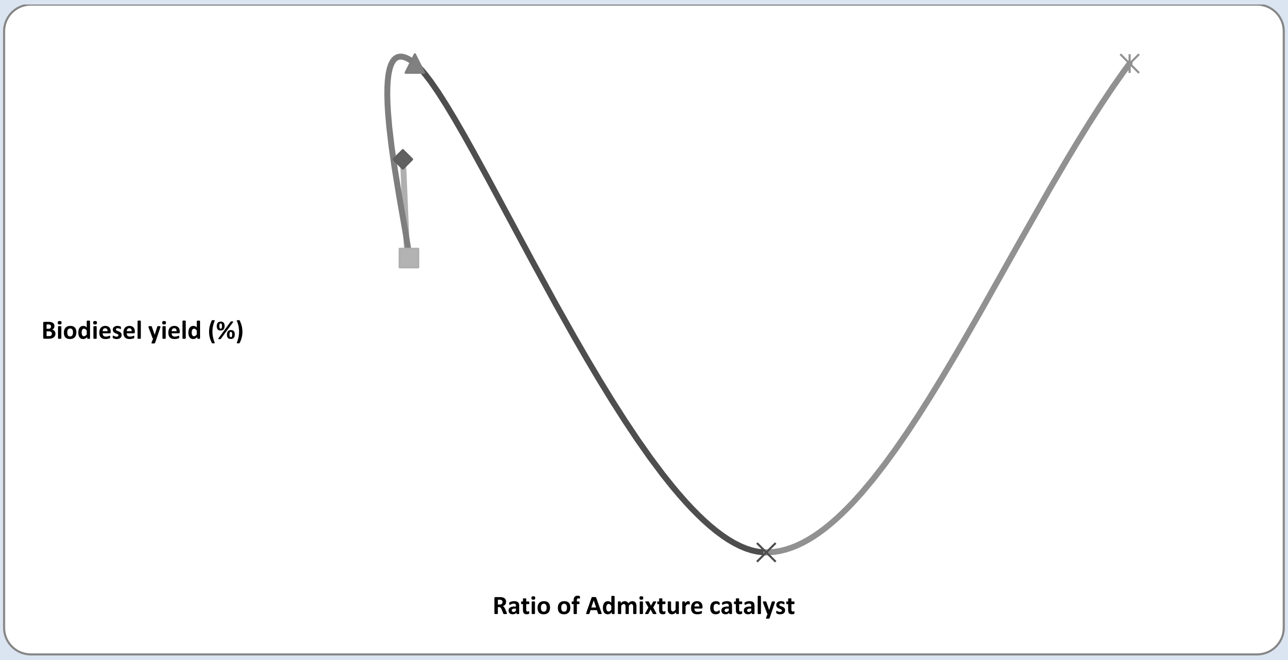
Vol. of oil (ml)	Catalyst conc. (g)	Temperature (°C)	Biodiesel yield (mL)	Biodiesel yield (%)
10	0.17	50	3,8	31.59
10	0.25	55	1.8	14.96
10	0.41	60	7.0	58.19
10	0.50	65	2.6	21.61
10	0.75	70	6.6	54.86

Transesterification of almond seed Oil using Heterogenous Catalyst

The result of transesterification of the oil samples using heterogeneous catalyst admixture CaO and MgO at different concentrations and their corresponding biodiesel yields are as shown below.

Effect of concentration of admixture catalyst on biodiesel yield

The concentration of the catalyst mixture used were in the ratio 1:1, 1:2, 1:3, 2:1 and 3:1 of CaO and MgO salts respectively. The biodiesel yields obtained at different ratio of the admixture catalyst of CaO and MgO were as shown in Figure 3. Considering the different ratio of the two salts in admixture, it was noted that ratio 1:3 of CaO and MgO gave the highest yield of 51.50 % while the lowest yield of 43.23 % was noted at catalyst admixture ratio 2:1. Therefore, transesterification reaction using almond seed oil was best at catalyst admixture ratio of 1:3.



Figs 3: Effect of admixture catalyst concentration on the yield of almond oil biodiesel

Effect of Agitation Speed

The effect of agitation speed on yield of biodiesel is shown on Figure 4. It can be seen that as the stirring speed increases from 500 rpm to 1500 rpm, the percentage yields of biodiesel decreased from 54.82 % to 51.50 %. The highest yield of the biodiesel, 54.82 % was obtained at the lowest stirring speed of 500rpm.

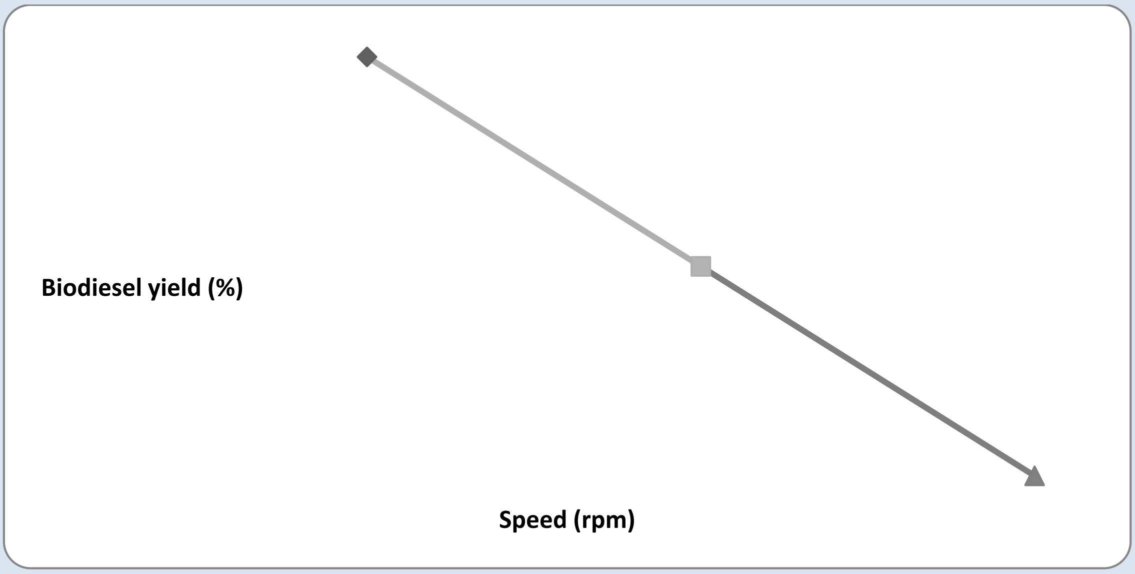
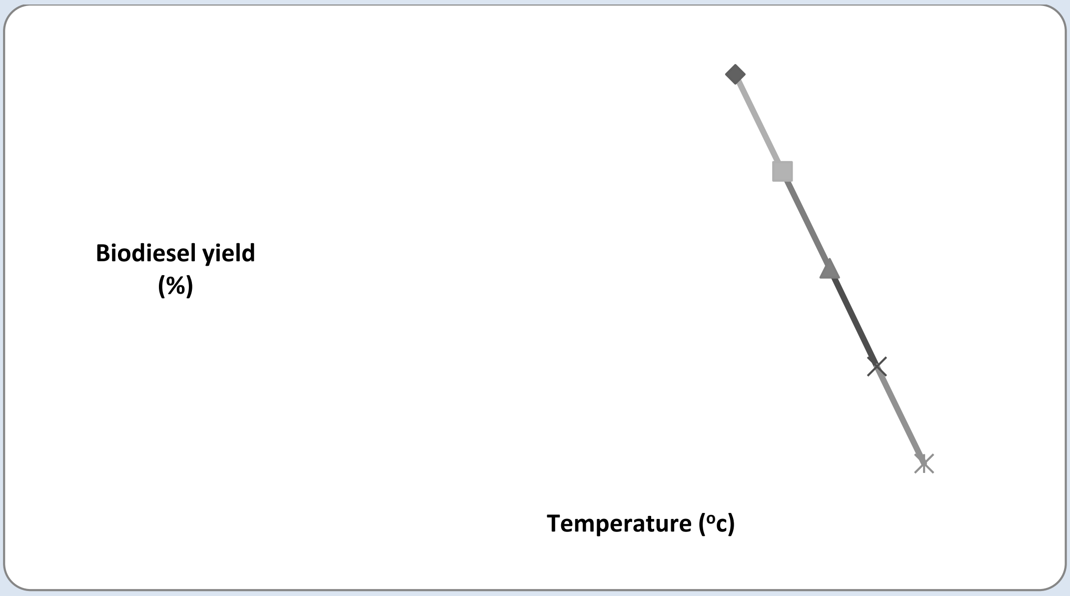


Fig. 4: Effect of agitation speed on the yield of almond oils biodiesel

Effect of Temperature

The extracted oils were transesterified within the temperature range of 50 ^oC and 70 ^oC as shown in fig.5 under optimum reaction conditions such as reaction time 90 min, weight of catalyst concentration of 0.04g, molar ratio methanol/oil 5:1 and speed of 1500rpm. It was noted that moderately high temperature such as 50^oC was the most suitable temperature among the various temperatures considered. At this temperature, 53.16% yield of biodiesel was recovered and decreased to 49.83% at the highest temperature of 70^{o}C. The decreased in the yield can be attributed to loss of methanol during conversion. Since the boiling point of methanol is 63.4^{o}C, an increase in temperature above this point will result into reduction in the quantity of methanol needed for effective reaction as reported by Haq et al, (2008). This suggested the exothermic nature of the process.



Figs 5: Effect of temperature on the yield of almond oils biodiesel

Physico- Chemical properties of the derived biodiesel

The various physico-chemical properties of the derived biodiesel oil are as presented in Table 4 below.

Table 4. Physico-chemical properties of the derived almond seed oil biodiesel

PARAMETER	Value
pH	2.92^{a} ± 0.01
TEMPERATURE (^{o}C)	28.93^{c} ± 0.03
FLASH POINT (^{o}C)	200.00^{e} ± 5.77
FIRE POINT (^{o}C)	240.00^{f} ± 11.55
SMOKE POINT (^{o}C)	110.00^{d} ± 2.89
DENSITY g/cm^{3}	0.92^{a} ± 0.01
VISCOSITY (CSt)	31.84^{c} ± 0.01
ACID VALUE (mg/KOH/g)	11.37^{ab} ± 0.01
FREE FATTY ACID (mg/KOH/g)	5.69^{a} ± 0.01
IODINE VALUE (mg/g)	22.33^{bc} ± 0.02
COLOUR	Light yellow

The density of the seed oil biodiesel 0.92gcm^{-3} was relatively higher than the standard value of 0.88gcm^{-3}. This implies that specific gravity of almond seed oil was higher than the commonly used feed stock such as jatropha for biodiesel production as reported by Belewu *et al* ,(2010).

The flash point of the biodiesel 200 ^{o}C is within the acceptable minimum of 130^{o}C as set by American Standard Testing Materials (ASTM D6751- biodiesel blend stock specification, B100 and ASTM D975) for diesel fuel. Flash point helps to monitor the safe handling and storage of fuel. The higher the flash point the safer the fuel vice versa. Flash point of the biodiesel was higher than that of fossil diesel; therefore it could be said that the biodiesel would be safer to handle than fossil diesel. The viscosity of the biodiesel which was relatively higher than that of fossil diesel, implies that the biodiesel will have more lubricating effect on engines, since, this will reduce wears and tears in the engine.

Characterization of the derived Biodiesel with Gas Chromatography Mass Spectrometer (GCMS)

The chemical composition of almond oil was investigated using GCMS analysis. The presence of Stearic, Palmitic and Oleic fatty acids as the major components of biodiesel oil were detected within the retention times ranging between 3.0 and 23. 0 min. They were found consistent with previous works reported by Lima et al, (2008). The compounds so identified in the oil samples are as shown in Table 5 below. The GCMS analysis for almond oil in Table 5, showed that palmitic acid and oleic acid are the most abundant and prominent fatty acid. Their retention times are 15.59 and 17.29 min while the % peak area are 43.04 and 48.40 respectively. These marked the suitability of the oil for biodiesel production.

Table 5: Chemical compounds identified in almond oil biodiesel.

SAMPLE	RETENTION TIME (min)	FATTY ACID METHYL ESTER (FAME)	WEIGHT PERCENT(wt%)
Almond oil biodiesel	10.16	Diglycol diacetate	0.49
	15.59	Methyl palmitate	43.04
	17.29	Methyl oleate	48.40
	17.44	Methyl Stearate	8.08

CONCLUSION

Biodiesel is a clean-burning diesel with chemical structure of fatty acid alkali esters. The acid and base catalysed tranesterification of oils and fats is currently the most commonly adopted method of the various methods available for producing biodiesel.This study has shown that most of the evaluated properties examined for the biodiesel conformed to ASTM and EN standard values. It could be concluded from this study that the biodiesel produced from almond (*Prunus amygdalus*) seed oil is potentially suitable as alternative fuel to fossil diesel, while the production and effective usage of the biodiesel will help reduce the cost of protecting the atmosphere from the hazards associated with using fossil diesel and hence boosts the economy of the country. The reaction time of 90 min, weight of catalyst concentration 0.03 g, molar ratio methanol/oil 5:1 agitation speed of 1500 rpm and temperature of 60 °C.

REFERENCES

1. Belewu, M.A, Adekola, F.A. Adebayo, G.B Ameen, O.M,.Mohammed, N.O. Olaniyan A.M, Adekola O.F, Musa A.K (2010). Physico- chemical charateristics of Oil and Biodiesel from Nigerian and Indian Jatropha curcs Seed. International J.Biolo. Chem. Sci. 4 (2): 524-529
2. Chettri., A.B. Watts K.C, (2008). Waste Cooking Oil as an Alternative Feedstock for Biodiesel Production. Energies, 1: 3-18.
3. Canacki, M., Gerpan, J.V (2001). Biodiesel Production from fats and oils with high free fatty acid. Am.Soc.Agric.Eng. 44: 1429-36.
4. Encinar, J.M., Gonzalez, J.F., Sabio, E., Ramiro, M.J. (1999). Preparation and Properties of Biodiesel from Cynara cardunculus.L., Ind. Eng. Chem. Res, 38**:** 2927
5. Environmental Protection Agency (2002). A Comprehensive Analysis Of Biodiesel Impact On Exhaust Emission, EPA draft Technical Report:
6. Freedman, B., Pryde, E.H., Mounts, T.L. (1984). Variables affecting the yields of fatty esters from transesterified vegetable oils. J.Am. Oil Chem. Soc. 61, 1638-1643.
7. Lima, R. D, Rodarte de Moura. C. V, (2008). "Biodiesel of Tucum Oil, synthesized by methanolic and ethanolic routes. Fuel, 87(8-9):1718–1723,.
8. Haq Nawaz Bhatt.i, Muhammad Asif Hanif., Umar Faruq., Munir Ahmad Sheikh. (2008). Acid and Base Catalyzed Transesterification of Animal Fats to Biodiesel. Iran. J. Chem.. Eng., 27, (4): 41-48.
9. Ma, F., Hanna, M. A (1999). Biodiesel Production: A Review, Bioresour. Technol., 70(1): 1- 115.
10. Meher, L.C.,Dharmagadda, V.S.S.,Naik, S.N. (2005). Preparation of Biodiesel from Crude oil of Pongamia pinnata, Bioresour,Technol., 96**:**1425
11. Noureddin, H.,Gao, X.,Philkane, R.S. (2005). Immobilized Pseudomona Cepacia Lipase Biodiesel Fuel Production from Soybean oil. Bioresour. Technol.,96: 769.
12. Nzikou J.M, A. Kimbonguila, L. Matos, B. Loumouamou, N.P.G. Pambou-Tobi, C.B. Ndangui, A. A. Abena, Th. Silou, J. Scher and S. Desobry. (2010). Extraction and Characteristics of Seed Kernel Oil from Mango (Mangifera indica). Res. J. Environ. & Earth Sci. 2(1): 31-35,.
13. Ogunsuyi,. H.O (2012). Acid and Base Catalysed Transesterification of Mango (Mangifera Indica) Seed Oil to Biodiesel. IOSR J. Appl. Chem. 2(2): 18-22.
14. Ogunsuyi, H.O., Oyewo I.O., Imolehin O.B. (2013). Production of Biodiesel from Dacryodes edulis seed oil J. Appl Sci.& Technol **in Press**
15. Peterson, C.L, Recce, D.L., Hammond, B.J., Thompson, J.C. (1997). Processsing Characterization and Performance of Eight Fuels from Lipids. Appl. Agric.13(71)

Harnessing Microbial Resources for Energy Production

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ABSTRACT

At different times, the clues to many of man's biggest challenges such as disease control and production of industrial chemicals have been found in microorganisms. In recent time, when climate change arising from the use of fossil fuels is threatening man's very existence, these microscopic forms provide a solace. Microbial resources are inherent in their nature and could be tapped through effective manipulation by man. These include diverse metabolic capability, easy adaptability and high growth and metabolic rate.The effective use of biomass as an alternative energy option lies deeply on how microbial resources are harnessed since biofuels could be produced totally or partly by microorganisms. Microorganisms could serve as the biomass starting material for biodiesel production and through their metabolism could produce ethanol, hydrogen, methane and bioelectricity from diverse biomass sources. Microbial energy production has great potential to be improved through the novel tool of metabolic engineering which could be used to enhance the performance of microbial natural functions as well as design organisms to perform a variety of functions which were hitherto impossible.

Key words: Microorganisms, Biomass, Alternative energy, Biofuel, Metabolic engineering

INTRODUCTION

Microorganisms and man have been associating over time and microbial activities have influenced man in several ways. Despite their roles as agents of disease and food spoilage, microorganisms have provided the clues to many of man's biggest challenges such as disease control and production of food and industrial chemicals. Recently, as climate change arising from the exploration and exploitation of fossil fuels is threatening man's very existence, these microscopic forms provide a solace. Microorganisms by virtue of their small size have properties such as small genome, high growth and metabolic rate, easy adaptability and enormous diversity. These properties lend them as veritable research tools in search of solutions to many of life's challenges and as factories for the production of chemicals. Except for the risks associated with it, fossil fuels are ideal energy sources providing neat, high-density, transportable energy that can be converted to mechanical energy, heat and electricity. Apart from global climate change caused by the net increase in atmospheric CO_2 due to its combustion, there is the risk of its depletion since it is not renewable [Rittman, 2008]. These have led to the quest for the search of alternative energy sources. Chosen alternatives must however match the fossil fuel in its benefits and utility but without its limitations. Among the various sources of alternative energy, solar energy and biomass energy have the greatest potential to provide renewable, C-neutral energy in large amounts relying on sunlight, the ultimate source of energy. Biofuels derived from biomass however are advantageous because they inherently solve the storage problem of solar energy posed by the diurnal fluctuation of sunlight and make carbon-carbon bonds which are high-value mobility fuels [2]. By virtue of her location in the world map, Africa is best suited to benefit from this enormous resource. It is however regrettable that many African countries have not tapped into the great potential in biofuel. On the contrary, continents like Asia, Europe and America have keyed in and it is expected that in the near future, cars and machines from these countries will be designed to be powered by biofuels and African countries like Nigeria who today pride themselvesas exporters of fossil energy will become importers of biofuel energy from these countries. In America, almost all the U.S. states have laws and incentives in their books or legislative pipelines pertaining to biofuels. Incentives almost universally take the form of tax credits [3].

The chemical energy in biomass cannot be used directly as fuel because it has a low energy value, and has to be concentrated. The concentration aims to reduce the substantial oxygen content of the parent feedstock to improve energy density and to create C–C bonds betweenbiomass-derived intermediates to increase the molecular weight of the final hydrocarbon product [4]. The three main technology conversion routes from biomass to biofuel are thermo-chemical, physico-chemical and bio-chemical processes. Among these, biochemical conversions which are based on biological processes are the most environmentally friendly. Biofuel production by biochemical conversion of biomass depends totally or partly on microorganisms [Rittman, 2008]. Microorganisms are therefore useful tools in energy production. Despite their usefulness and great potential, microorganisms isolated from their natural environments have very low efficiencies of producing our desired chemicals and materials [5] since they were not evolved for that purpose. Due to their small genome size, microbes are however more amenable to be improved by genetic engineering techniques than other biomass options.

Employing microbial resources as solutions to life's challenges including the need for a cleaner environment took a new dimension in the 1990s with the advent of metabolic engineering [6]. With this tool, it has become possible to genetically engineer microorganisms to enhance the performance of their natural functions and induce them to perform other hitherto impossible functions. Microbial energy production also has great potential to be enhanced through this method.

Biomass Feedstock for Biofuel Production

Biomass feedstock for biofuel production could be plants, animals, microorganisms or residuals. Residual biomass consists of complex biological residues from normal human activities, agriculture, food-producing industries and municipal and industrial wastewaters. These often constitute nuisance as wastes. Their use as biomass feedstock will also serve the purpose of safely disposing them. A viable biomass option for production of alternative fuel must be widely available at low cost and the desired conversion method must be environmentally friendly in terms of process and product formation [7]. In view of this, microorganisms and residual biomass feedstock are the most viable options.

Converting Residual biomass to biofuel

Since residual biomass is a heterogeneous mixture of other biomass feedstock, their conversion process will be such that will encompass the various processes involved in the use of different biomass feedstock. Residual biomass consists of a mixture of different macromolecules in form of carbohydrates, fats and proteins. Each of the biofuels from biomass could be derived from similar metabolic intermediates that are found in the central metabolic pathways in microorganisms [8]. Fig. 1 shows the pathway for degradation of principal macromolecules in residual biomass.The basic conversion process for the production of stable microbial energy products involves three steps, namely hydrolysis, fermentation and stabilisation [Rittman, 2008].

Polysaccharides are hydrolysed to monosaccharides which are then catabolised through the glycolytic pathway to pyruvate. Proteins are hydrolysed to amino acids which are further catabolised through various pathways that lead to pyruvate, hydrogen and ammonia. Lipids are hydrolysed to fatty acids and glycerol. Glycerol is converted into 3-Phospho-glycerateand eventually pyruvate via glycolysis while the fatty acids are catabolised through β-oxidation to hydrogen, acetic acid and carbon dioxide [9]. In the absence of a terminal electron acceptor, the glycolytic pathway ends at pyruvate and the electrons generated are transferred back to pyruvate, leading to the formation of a variety of possible compounds depending on the organism involved and the prevailing environmental conditions [10]. Possible end products are ethanol, acetate, propanol, formate, butyrate, succinate, butanol and hydrogen.

a.Hydrolysis or Pre-treatment*:* This is the first step and it aims at breaking the complex materials in biomass into constituent parts to make them soluble and more bioavailable for efficient energy conversion. It involves a combination of chemical, mechanical, and enzymatic attack that breaks complex carbohydrates, lipids and proteins to simple sugars, fatty acids and amino acid respectively [11].

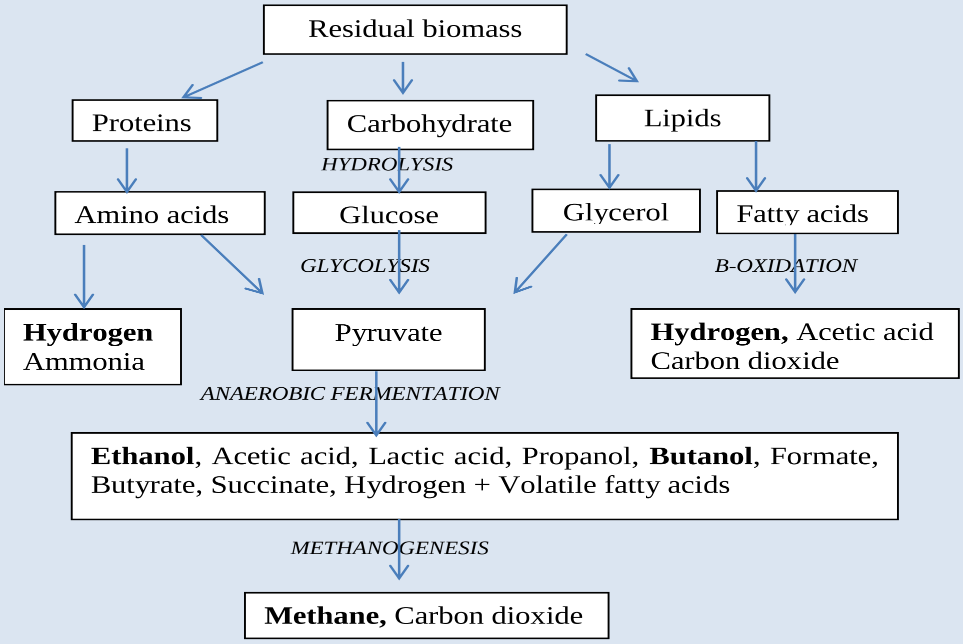

Fig. 1. Pathway for degradation of principal macromolecules in residual biomass.

b. **Fermentation:** Fermentation involves the oxidation and reduction of organic compounds to produce a myriad of products that vary with microbial type and environmental condition. Biomass serves as the electron donor and the fermentation processes aim to extract and concentrate the electrons or energy in biomass. For microorganisms, fermentation is a process that yields energy and reducing power needed to construct and maintain themselves [1]. Some of the fermentation products are high density energy rich electron carriers themselves but they could be further condensed through stabilisation.

c. **c. Stabilisation:** It is the final step in the conversion of biomass to an electron- (and energy-) rich form and determines the form of bioenergy that is produced. Some notable stabilised microbial bioconversion energy products include methane and bio-hydrogen.

APPROACHES TO USING MICROBES FOR ENERGY PRODUCTION

There are basically two approaches to using microbes for energy production (Fig. 2) [7]. Firstly, microbes could through their natural metabolism, serve as cellfactories that convert biomass energy into socially useful bioenergy forms such as methane (natural gas), hydrogen gas, or electricity. Secondly, microbes could be harvested directly as the biomass starting material for energy production. For instance, some photo auto trophicmicrobes (*Algae* and *Cyanobacteria*) contain a high proportion of lipids or oils, which can be used as a feedstock for production of biodiesel. The waste product generated from the second approach could also be used as a raw material in the first approach.

One major consideration in the choice of a suitable alternative to fossil fuel is the cost of production.The energy cost of recovering the product must not be significant when compared with the energy output in the biofuel [1]. Among the numerous biofuels that could be produced by microorganisms, the best three energy outputs that can be directly captured for human use are methane gas (CH_4), hydrogen gas (H_2), and the electrons themselves (i.e. electricity) [1,7]. Bioethanol has a low net energy value. Ethanol is very water soluble and the energy cost of separating it from water consumes about 90% of the energy value of the ethanol product [12].

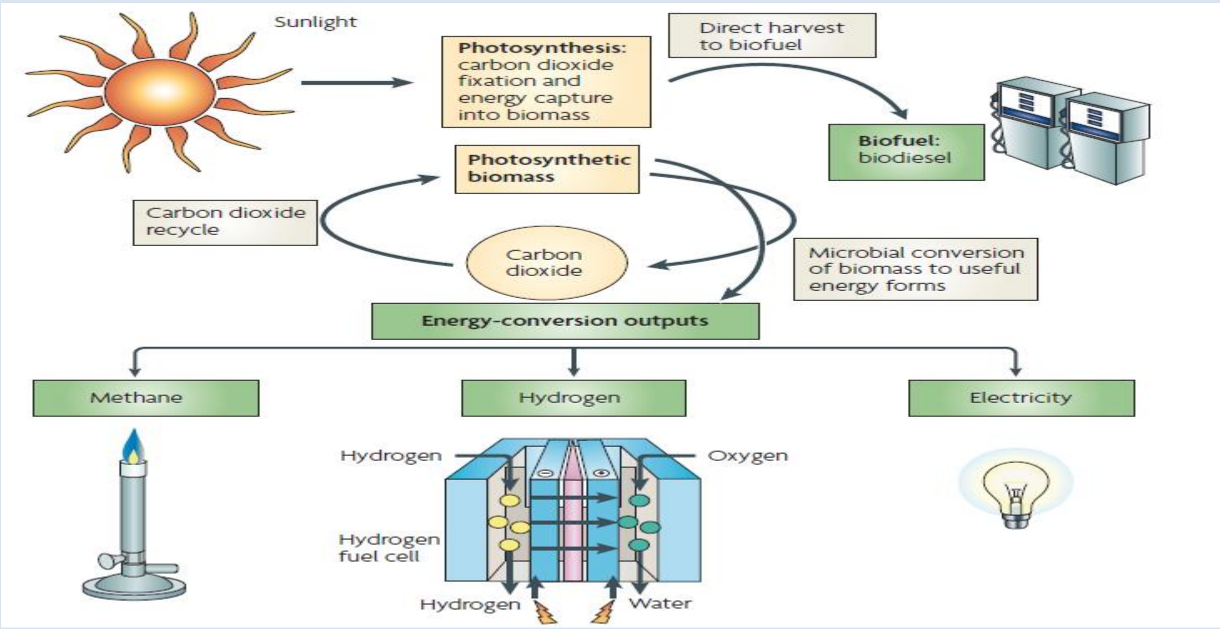

Fig. 2. Approaches to use of microorganisms for production of biofuels. (Source: Rittmann *et al*. [10]).

HARNESSING MICROBES AS CELL FACTORIES FOR BIOFUEL PRODUCTION

The key to harnessing microbes as cell factories for biofuel production lies on tapping into microbial metabolic processes. Since the fuel chemicals are produced as metabolic intermediates or by-products of microbial activities, an adequate understanding of microbial metabolism and physiology that leads to the production of the desired fuel is a prerequisite for effective harnessing. This is necessary since microbes naturally carry out metabolic processes for growth and survival and have not evolved to produce fuels for human consumption. A key feature of microbial systems involved in biomass utilisation is the cooperative relationships (syntrophy) that exist among different types of microorganisms to catabolize a substrate [7]. Effective biomass conversion relies on communities of microorganisms that work synergistically to convert biomass to useful products. Adequate understanding of the composition and roles of the community members is needed for effective harnessing.

Furthermore, microbes will want to derive maximum energy from the utilisation of any substrate. In this regard, the desired pathway from the viewpoint of the microorganism must be that which releases the maximum amount of energy for cellular synthesis and maintenance. This is often aerobic because the greatest amount of energy is obtained when oxygen is used as the terminal electron acceptor [10]. However, for fuel production, excessive growth of microorganisms will lead to large amount of bio solids that will increase production cost of fuel. Generally, anaerobic microbial fermentations have been found efficient for such conversion processes. Some advantages of anaerobic fermentations include low production of sludge, low nutrient requirement and direct production of methane gas [10, 11].

The nature of microbes and their inherent ability to catalyse the breakdown of complex organic matter represent a huge resource which could be manipulated to man's advantage. Currently, using molecular biology techniques, man has explored this resource and through a form of engineering succeeded in rechanneling microbial metabolic pathways towards the production of the desired form of energy.

COST-EFFECTIVE BIOFUELS DERIVED FROM MICROBIAL FACTORIES USING RESIDUAL BIOMASS

A. Methane: Methane is a low solubility gas that can easily be harnessed from fermentation tanks.Biological methane is formed by consecutive biochemical breakdown of polymers of organic compounds to methane and carbon dioxide in an anaerobic environment in which a microbial consortium syntrophically grows and produces reduced end-products. It involves three stages and a simplified pathway for this is given in Fig. 3 below.

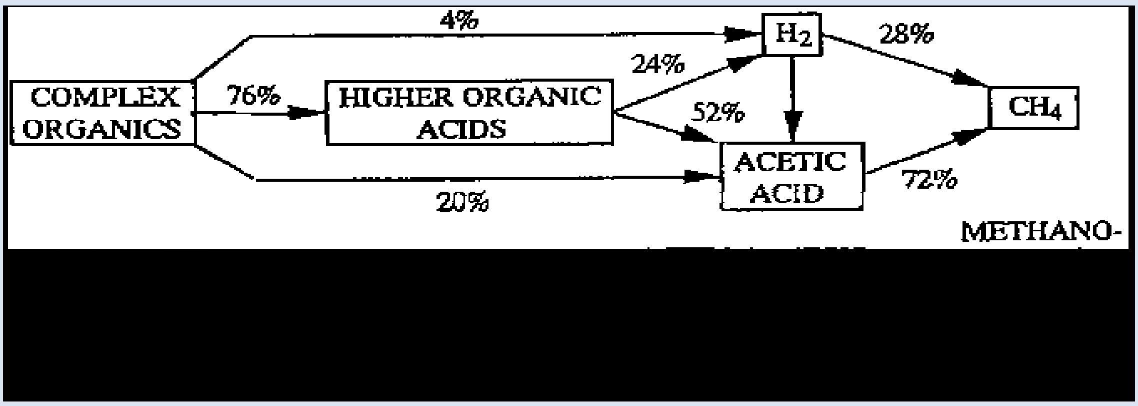

Fig. 3. Simplified pathway for methane formation (Source: McCarty, [13])

The first stage involves hydrolysis of complex polymeric organic matter (carbohydrates, proteins and fats) into smaller molecules - simple sugars, amino acids and fatty acids. These are then successively metabolised by acidogenic bacteria to fermentation end-products such as lactate, propionate, acetate, butyrate, ethanol and a variety of volatile fatty acids by other enzymatic activities which vary tremendously [10]. Some genera of microbes involved include *Clostridium, Peptococcus, Lactobacillus* and *Bacteroides* [14].

The second stage involves acetogenesis and dehydrogenation of higher organic acids (>C2 obtained in stage 1) to yield methanogenic substrates – acetate, hydrogen and carbon dioxide. Although some acetate (20%) and H_2 (4%) are directly produced by acidogenic fermentation of sugars and amino acids, both products are primarily derived from the acetogenesis and dehydrogenation of higher organic acids (13). Representative genera here include *Acetobacter, Syntrophomonas* and *Syntrophobacter*[14].The third stage involves the actual production of methane (methanogenesis) by two unique groups of strictly anaerobic archea [10] called methanogens. One group called CO_2-reducing methanogens (e.g. *Methanosarcina* and *Methanothrix*) oxidizes hydrogen and reduces carbon dioxide according to the reaction shown below:

$$CO_2 + 4H_2 \xrightarrow{CO_2\text{-reducing methanogens}} CH_4 + 2H_2O$$

The second group called aceticlastic methanogens (e,g. *Methanococcus* and *Methanospirillum*) ferments acetic acid to methane and carbon dioxide as shown below:

$$CH_3COOH \xrightarrow{\text{aceticlastic methanogens}} CH_4 + CO_2.$$

Both groups of methanogens are slow growers, require strictly anaerobic conditions, and have almost no other metabolic options besides the reactions shown above [1].

B. Bio-hydrogen: Molecular H_2 has the highest energy content per unit weight among the known gaseous fuels (143 GJ ton−1) [15] and is the only carbon-free fuel which ultimately oxidizes to water as a combustion product. Hydrogen is a low solubility gas that can easily be harnessed from microbial fermentation tanks. The ability to produce hydrogen is widely distributed among various microbial species and the reasons for hydrogen production are principally to dispose of excess reducing equivalents or as a by-product in nitrogen fixation [16]. There are several strategies microorganisms can use to generate hydrogen using two main enzymes – hyrogenase and nitrogenase. These strategies could be broadly classified into – Light dependent and light independent processes. Light dependent processes include direct or indirect bio-photolysis and photo-fermentation whereas the light independent process is the dark fermentation.

❖ **Bio-photolysis:** This is the splitting of water into molecular oxygen and hydrogen in biological systems using sunlight as the energy source and the enzyme hydrogenase. It could be direct or indirect.

i. Direct bio-photolysis. This is independent of carbon metabolism [17]. It has been observed in Microalgae or *Cyanobacteria* . The overall equation is

$$2H_2O \xrightarrow{\text{Photosystems + Hydrogenase + Light}} 2H_2 + O_2$$

ii. *Indirect bio-photolysis:* This is dependent on carbon metabolism [17]. It couples with photosynthesis for carbohydrate accumulation, and dark fermentation forH_2 production. The overall equation is:

$$6CO_2 + 6H_2O \xrightarrow{\text{Photosystems + Light}} C_6H_{12}O_6 + 6\,O_2 \;\ldots\ldots \text{(a)}$$

$$C_6H_{12}O_6 + 6H_2O \xrightarrow{\text{Hydrogenase}} 6CO_2 + 12H_2 \;\ldots \text{(b)}$$

The major limitation in bio-photolysis is that hydrogenase is highly susceptible to O_2, which is formed as a by-product [18]. Also, despite the high theoretical efficiency of 80%, the practical efficiency is often very low, less than 1–2% [19].

❖ **Photo-fermentation:** This utilizes carbon substrates such as organic acids as electron donors. Under anaerobic condition, the electrons obtained from organic acids are transferred to oxidized Ferredoxin (Fd_{ox}) (eqn. a) through a series of membrane-bound, electron transport carrier molecules. Then, the electrons in the reduced Ferredoxin (Fd_{rd}) are primarily used to reduce molecular di-nitrogen (N_2) to ammonia (NH_3) by the action of nitrogenase ($N2_{ase}$) enzyme (eqn. b). However, in the absence of N_2nitrogenase catalyses the reduction of protons to produce H_2 (eqn. c) [17].

$$4H^+ + Fd_{ox} \rightarrow Fd_{rd} + 2\,H_2 \ldots\ldots\ldots\ldots\ldots \text{(a)}$$

$$N_2 + 8H^+ + 8\,e^- + 16ATP \xrightarrow{N_2ase\text{ + Light}} 2NH_3 + H_2 + 16ADP + 16\,P_i \ldots\text{. (b)}$$

$$8H^+ + 8\,e^- + 16ATP \xrightarrow{N_2ase\text{ + Light}} 4H_2 + 16ADP + 16\,P_i \ldots\ldots\text{(c)}$$

The major limitations in photofermentation are :

i. Low catalytic turnover of typical nitrogenase leading to low rate of H_2 production [19]

ii. Re-oxidation of the produced H_2 by uptake hydrogenase.

iii. Requirement of a high cellular ATP level for efficient H_2 production.

❖ **Dark fermentation:** Here organic substrates are the sole source of energy and electrons. It is carried out by many facultative and obligate anaerobic bacteria that ferment a wide range of organic compounds leading to the excessive formation of various by-products and low H_2 yield. The low yield of H_2 has been linked to microbial metabolism since microorganisms did not evolve to produce hydrogen in high yields as an energy source in dark reactions [18], hence microbial H_2 production has been extensively improved through metabolic engineering strategies. In microorganisms, dark fermentative hydrogen production from glucose is possible through three types of biochemical reactions or pathways (Fig. 1). With glucose as substrate, these pathways are same up to pyruvate production [20]. These are:

a) The pyruvate formatelyase (PFL) pathway which generates 2 moles of hydrogen per mole of glucose and is found in facultative anaerobic bacteria such as *Escherichia coli* and Enterobacteriaceae .

b) The pyruvate ferredoxinoxidoreductase(PFOR) pathway which generates 4 moles of hydrogen per mole of glucose under low partial pressures and is found in obligate anaerobes like *Clostridium*species.

c) The NADH:ferredoxinoxidoreductase(NFOR) pathway which generates 4 moles of hydrogen per mole of glucose and is found in thermophilic bacteria and some*Clostridium*species.

Hydrogen yield and hydrogen evolution rates differ in organisms depending on metabolic pathway used to generate hydrogen. Hydrogenases are the key controlling enzymes in hydrogen production and can produce or consume H depending on the prevailing condition [20]. They are generally sensitive to oxygen. *E.coli* possesses four [Ni–Fe] hydrogenases two of which (Hyd-1 and Hyd-2) are shown to possess hydrogen uptake activity, which may result in decreased hydrogen yield. Hyd-3 possesses hydrogen-producing activity while the function of Hyd-4 has not yet been characterised [21].

C. Bioelectricity: Microbes are used to generate electricity from biochemical energy produced during metabolism of organic substrates [22]. Devices that are capable of converting chemical energy available in organic substrates into electrical energy using bacteria as a biocatalyst to oxidize the biodegradable substrates are called Microbial fuel cells (MFC) [23]. The flexibility of microorganisms to use a range of substrates makes the MFC an ideal technology for renewable bioelectricity generation from biomass [24].

❖ **Basic design of a MFC:** The basic MFC design consists of an anode, a cathode, a proton exchange membrane (PEM) and an electrical circuit, as shown in Fig.4 [25]. In the anode compartment, bacterial community present uses organic substrates as fuels to produce CO_2, electrons and protons through biological processes. Through an external electrical circuit, electrons reach the cathode thus producing electric current, which is measured by a voltmeter or ammeter connected to the device [26]. The protons generated are diffused through the PEM to the cathode and subsequently combine with the electrons and oxygen to form water. Anaerobic conditions are maintained in the

anode compartment as oxygen inhibits electricity generation whereas aerobic condition is maintained at the cathode so that water is the end product.
The overall reaction assuming acetate is the starting organic matter is given below:

Anode reaction: $CH_3COO^- + 2H_2O \longrightarrow 2CO_2 + 7H^+ + 8e^-$

Cathode reaction: $O_2 + 4e^- + 4H^+ \longrightarrow 2H_2O$

❖ **Bacterial transfer of electrons in MFC**:In MFCs, the bacterial transfer of electrons from the substrates to electrodes is mainly through two ways - direct transfer (mediator-less) or indirect transfer (mediator -MFC) [27].

Direct transfer: Here, electrons are transfered through respiratory enzymes (cytochrome c- type), biofilms and highly electrically conductive pili (nanowires) from inside the cell to extracellular acceptors. The yeast *Pichiaanomala* has redox enzymes on its outer membrane and can produce current in an MFC and the oxygenic phototrophic cyanobacterium*Synechocystis* sp. PCC 6803 produces conductive appendages called nanowires. Other microbes that can achieve direct electron transfer include - *Shewanellaputrefaciens, Geobactersulferreducens, and Rhodoferaxferrireducens* [28].

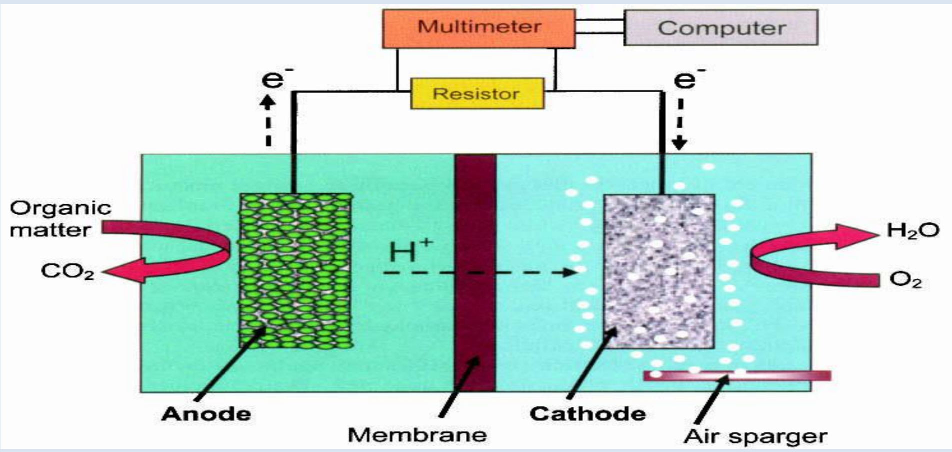

Fig. 4.Basic design of a microbial fuel cell (Source: Logan, B.E. [25]).

Indirect transfer: Here, electrons from microbial carriers are transported onto the electrode surface through an inherent or artificial mediator which acts as shuttles. Some microorganisms that have inherent mediators are *Shewanellaoneidensis* and *Geothrixferementans*. A good artificial mediator should be able to penetrate the cell membranes easily, grab the electrons from the electron carriers, be stable during long periods of redox cycling and should be non-toxic to microbes. Examples of artificial mediators often added to the reactor include neutral red, thionine, methylene blue [29].

❖ **Electrode material:** Due to their stability, high electric conductivity and large surface area, carbon cloth, carbon felt, graphite felt, carbon mesh and graphite fibre brush have been used for anode [30]. For cathodes, platinum, platinum black, activated carbon (AC), graphite based materials have been used [29].

❖ **Microorganisms:** Although electrochemically active microbes such as *Shewanella*and *Geobacter*species abound, MFC could be operated with a wide range of pure and mixed microbial communities. Research effort should be directed on screening of microbes for their ability to generate electric current and power densities.

❖ **Substrate in MFC:** The composition, concentration and type of the substrate also affect the microbial community and power production [31]. The desired substrate should have high Coulombic efficiency. Coulombic efficiency is the amount of electrons recovered as current versus the maximum recovery from the substrate [32]. Sengodon and Hays, [30] itemised the coulombic efficiencies of different organic substrate and their power output as reviewed by many authors. Acetate with a coulombic efficiency of ($0.8 mA/cm^2$) was found to be higher when compared with others. The high coulombic efficiency and power output of acetate was attributed to its inertness towards alternative microbial conversions (fermentations and methanogenesis) [33].

❖ **Prospects:** MFC is a promising technology with potential applications in electricity generation, bio-hydrogen production, wastewater treatment and biosensors for pollution analysis among others.

Harnessing Microbes as Biomass Feedstock for Biofuel Production

Some photoautotrophic microorganisms notably, the eukaryotic algae and the prokaryotic Cyanobacteria like plants can carry out photosynthesis using sunlight energy. Microorganisms due to their nature are more attractive than plants and animals as biomass feedstock. Compared with plants as a biomass feedstock for biodiesel production, microorganisms are better because of their high lipid content, high growth rate, great susceptibility for strain improvement, and the ability to produce co-products without competing for arable land [34].

Biodiesel

The US Department of Energy's Alternative Fuels Data describes Biodiesel as a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant greases [3].
Biodiesel is made from renewable biomass mainly by alkali-catalysed trans-esterification of tri-acylglycerols (TAGs) from biomass derived oils and greases with short-chain alcohols, primarily methanol and ethanol. It thus consists of monoalkyl esters of long-chain fatty acids with short-chain alcohols such as fatty acid methyl esters (FAMEs) and

fatty acid ethyl esters (FAEEs) [35]. Like petroleum diesel, biodiesel is used to fuel compression-ignition engines, which run on petroleum diesel and has potential as a total or partial (in the cold regions) replacement to the fossil diesel, compatible to the current diesel engine [36].

- **Production of biodiesel**

It could be produced from waste cooking oil and various oil-accumulating plants such as rapeseed in Continental Europe, soybean in North America and palm oil in South East Asia [35] as well as corn, jatropha, coconut and oil palm [37]. Currently, industrial-scale biodiesel production has remained geographically and seasonally restricted to oilseed-producing areas. While dependence on waste-cooking oil as the feedstock for biodiesel production will be grossly inadequate to meet the demand for biodiesel, use of the oil-accumulating plants might trigger the food versus fuel controversy since these plants are used for human consumption. Furthermore vegetable oils consist predominantly of TAGs which need to be trans-esterified with short-chain alcohols like methanol or ethanol to yield the FAME and FAEE constituents of biodiesel. This trans-esterification process and the subsequent purification steps are cost intensive and energy consuming, thereby reducing the possible energy yield and increasing the price [35].

Some groups of microorganisms notably algae, bacteria and some yeasts and fungi have been found to accumulate lipids and fatty acids as storage or structural polysaccharides. Microbial species that can accumulate over 20% of lipids in their cell biomass are considered oleaginous species [36]. In these organisms, lipid accumulation varies among different strains and growth conditions such as nutritional and environmental factors. Algae accumulate large quantities of lipid as storage materials, when under stress and growing slowly while Cyanobacteria accumulate lipids in thylakoid membranes with high levels of photosynthesis and a rapid growth rate. Besides being a prokaryote, Cyanobacteria are more amenable to genetic manipulation than algae and therefore have better prospects than algae for biodiesel production [1].After the extraction of oil in biodiesel production, the residue could be used as residual biomass for the production of other biofuels.

Engineering Microorganisms for Fuel Production

Although microbes could be used as biomass feedstock or cell factories to produce biofuels, their full relevance in the production of alternative energy would not be realised by relying on the natural abilities of microbes to yield the desired types and quantities of the different fuel types. The reason is that microbes have not evolved to produce the fuel chemicals for human use, rather they have evolved and developed enzymatic and regulatory pathways for production of chemicals of different types in quantities that would be relevant for their growth and survival.Thus themain challenge in using native hosts to convert feedstocks into advanced biofuels is to overcome the endogenous regulation of biofuel-producing pathways to achieve high yields [38]. The conventional strain improvement strategy in Microbiology was employing multiple rounds of random mutagenesis induced by radiation or chemical mutagens and screening. This produces a 'blackbox' and could cause unwanted alterations in the genome, the consequences of which cannot be easily identified. With advances in recombinant DNA technology, this has given way to targeted engineering strategies aimed at purposeful or rational modification of genes and pathways towards enhanced production of desired products. This is called metabolic engineering and Stephanopoulos [39], defined it as the directed improvement of cellular properties through the modification of specific biochemical reactions or the introduction of new ones, with the use of recombinant DNA technology.

In realisation of the fact that actual microbial processes involve the entire microbial cell rather than a specific pathway and given the interconnectivity of the metabolic pathways and related regulatory processes that form the microbial system, metabolic engineering has given rise to another concept called systems metabolic engineering. Systems metabolic engineering can be defined as systems-level metabolic engineering integrating the 'omic' and computational techniques of systems biology, the fine design capabilities of synthetic biology and the rational and random mutagenesis methods of evolutionary engineering [5]. It is based on integrated analysis of -omics data and genome-scale metabolic models and relies on development of algorithms for more accurate and realistic simulation of *in silico* genome-scale metabolic and regulatory networks [40]. It thus combines mathematical/theoretical approaches with experimental methods. Given the amalgam of metabolic engineering, systems biology, synthetic biology and evolutionary engineering through systems metabolic engineering, it has been possible to achieve some metabolic feats which were hitherto not possible. Some of these include fine-tuning and optimization of the metabolic fluxes that lead to increased yield and concentration of a desired product, increased tolerance of cells to the product and harmful medium components and creation of novel enzymes and metabolic and gene regulatory circuits [5]. Some of the approaches available for engineering microbial hosts include - gene insertion and deletion, overexpression of a homologous or heterologous gene, creation of synthetic pathways, re-directing metabolic pathways and engineering regulatory networks [40]. This technology has great potential in the use of microorganisms for production of biofuels.

ENGINEERING MICROBES FOR BIOHYDROGEN PRODUCTION

Overview of microbial production of biohydrogen

Hydrogen is the most energy efficient fuel [20], hence various efforts have been made to engineer microbes for efficient production. Among the various options available for bio-hydrogen production by microorganisms, dark fermentation is attractive because it could use already existing reactor technology and readily available substrates without requiring a direct input of solar energy. Furthermore, fermentative organisms have high growth rates and very high rates of hydrogen evolution compared with other biological hydrogen production processes [41]. Despite these, major known drawbacks of dark fermentative bio-hydrogen production are related to metabolic fundamentals such as the low H_2 yield per substrate consumed and concomitant production of carbon rich metabolites [42].

Metabolic engineering targets for bio-hydrogen production in Escherichia coli

Efforts to maximize hydrogen yields through metabolic engineering have involved almost exclusively *E. coli*, which however, only has the PFL pathway, so is limited to 2 moles of hydrogen per mole of glucose rather than *Clostridium* which has the PFOR pathway and hence potential capability of generating 4 moles of hydrogen per mole of glucose. The choice of *E. coli* as an ideal microorganism commonly used in genetic engineering is due to its well-characterized genome, well known metabolism, and its ability to utilize a wide range of carbon sources including hexoses and pentoses. In addition, a metabolic pathway database, EcoCyc, for *E. coli* is available, allowing for metabolic pathway prediction [43]. Also, *E coli* has potential advantages over at least some other microorganisms in that it exhibits rapid growth and has simple nutritional requirements as well as tolerance to oxygen [41].

❖ ***Constraints on the production of bio-hydrogen using E. coli.***

i. Lack of any NADH-dependent hydrogenases.
ii. Hydrogen yield is limited by its inherent metabolic pathways - H_2 production gives a low yield on sugars, which are used as the carbon sources. The PFL pathway utilised by *E. coli* yields 2 moles of hydrogen per mole of glucose.
iii. Only one-third of the substrate can be used for hydrogen production, with the remaining two thirds (acetyl-CoA) forming another fermentation product; acetate, butyrate, etc. [44]. This generates large quantities of side products (organic acids) likeacetate, butyrate, butanol, acetone, etc.
iv. Limited substrate availability since ligno-cellulosic biomass, the largely available plant biomass cannot be directly used by *E.coli*for bio-hydrogen production. There is need to hydrolyse cellulose and hemicellulose to fermentable sugars before they can be utilized. A possible target for metabolic engineering is to engineer H_2-producing microorganisms to directly utilize the cellulosic biomass without a pre-treatment for hydrolysis.
v. Hydrogenase enzymes are oxygen sensitive, hence the need to engineer efficient hydrogenases. Since the hydrogen yield is low in many organisms containing an uptake hydrogenase, knocking out the genes encoding uptake hydrogenases has also been performed in order to enhance hydrogen production.

❖ ***Metabolic engineering options available***

In order to engineer *E. coli* for bio-hydrogen production, the under listed options are available among others. Fig. 5 shows the metabolic pathway for hydrogen production via pyruvate formatelyase (PFL) pathway and some encoding genes. This pathway is found in *E. coli*.

i. Elimination of competing pathways: To eliminate pathways competing with those for bio-hydrogen production, the available options include:

- Deletion of pathways for formation of lactate by lactate dehydrogenase (*ldhA*) and succinate by fumaratereductase (*frdBC*) would direct flux towards hydrogen production.Consequently, Yoshida *et al*. [45] showed an approximately 2-fold increase in hydrogen gas yield on disruption of*ldhA* and *frdBC* pathways, which produced the metabolites lactate and succinate, respectively.
- Also, pyruvate is consumed by pyruvate dehydrogenase and pyruvate oxidase encoded by*aceE* and *poxB* respectively. Deletion of *aceE* resulted in an increased hydrogen production and yield [46].

ii. Engineering efficient hydrogenases: The aim is to eliminate the uptake activity of the hydrogenases present, which are responsible for the consumption of hydrogen. This is necessary since*E. coli* possesses four [Ni–Fe] hydrogenases two of which (Hyd-1 and Hyd-2) are shown to possess hydrogen uptake activity, which may result in decreased hydrogen yield. Hyd-3 possesses hydrogen-producing activity [19, 21] and its overexpression may lead to increased hydrogen production rates and yield.

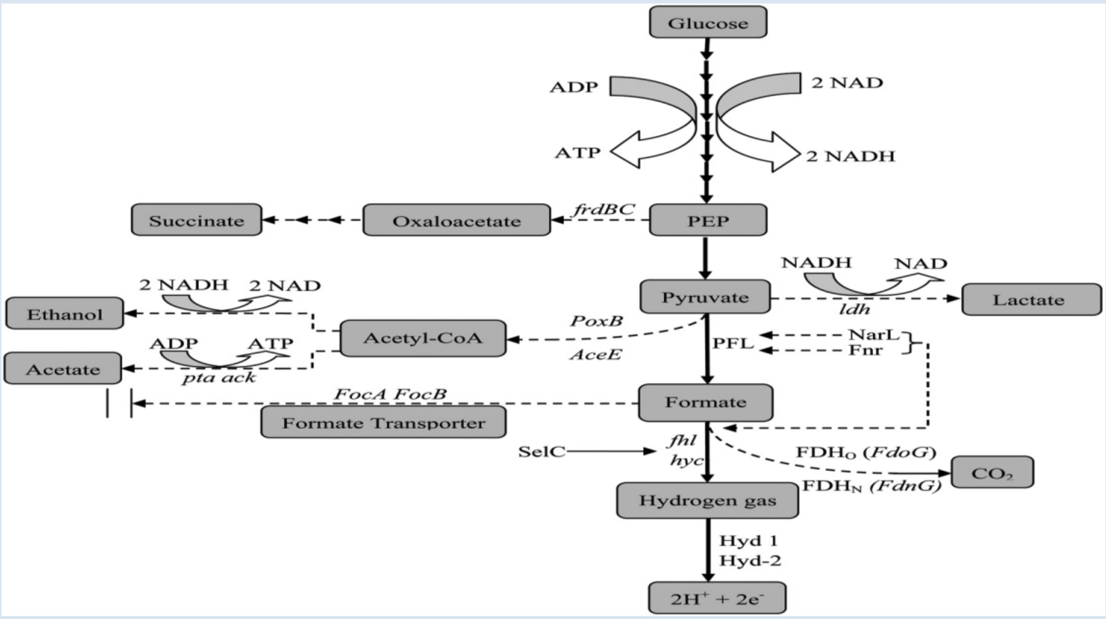

Figure 5: Metabolic pathways for bio-hydrogen production *in E. Coli* (Source: Goyal*et al*. [20])

iii. Cloning of hydrogenase-encoding genes from various hydrogen-producing organisms into E. coli.: Heterologous over expression of hydA (hydrogenase-encoding gene) from *Enterobacter cloacae* IIT-BT-08 in *E. coli* BL-21 resulted in a dramatically high yield of 3.12 mole/mole glucose, which was higher than that from *E. cloacae* IIT-BT-08 itself.

iv. Deletion of genes that consume formate: Formate dehydrogenases encoded by *fdnG*(-formate dehydrogenase- N) and *fdoG*(-formate dehydrogenase-O) consume formate. Also formate transporter encoded by *focA* and *focB* genes transports formate out of the cell. It would be expected that deletion of these genes (*fdnG, fdoG, focA and focB*) may result in increase in hydrogen production [47].

CONCLUSION

Microorganisms, by virtue of their enormous resources no doubt hold the key to the search for alternative energy. Microbial resources are global in view of the ubiquity of microorganisms; however, their effective harnessing would require expertise. Developing countries need to channel more efforts in terms of research and development in order to optimally tap these resources. This is a clarion call especially for countries whose economy leans heavily on exportation of fossil fuel, more-so, given the speed at which the key world industrialised nations are moving in their efforts to by-pass reliance on fossil energy.

REFERENCES

1. Rittman, B. E. 2008. Opportunities for renewable bioenergy using microorganisms. Biotechnology and Bioengineering.100 (2):203-212.
2. Brenner et al., 2006. Engineering microorganisms for energy production (JSR-05-300) Being a report by JASON, The MITRE Corporation 7515 Colshire Drive McLean, Virginia 22102 submitted to the US Department of Energy Director of Science for Biological and Environmental Research Washington, DC 20585.
3. Nayyar, P. 2010. The Use of Biodiesel Fuels in the U.S. Marine Industry.Prepared For US MARITIME ADMINISTRATION.http://www.marad.dot.gov/documents/ The Use ofBiodiesel Fuels in theUSMarineIndustry.pd.
4. Alonso, D. M., Bond, J. Q. and Dumesic, J. A. 2012. Catalytic conversion of biomass to biofuels. Green Chem., 12:1493–1513.
5. Lee, J. W., Kim, T. Y., Jang, Y., Choi, S. and Lee, S. Y. 2011. Systems metabolic engineering for chemicals and materials.Trends in Biotechnology. 29 (8):536-546.
6. Stephanopoulos, G. 2009 -Journal Interviews : 2009 : Metabolic Engineering. Sciencewatch.com
7. Rittmann, B. E., Krajmalnik-Brown, R. and Halden, R. U. 2008. Pre-genomic, genomic and postgenomic study of microbial communities involved in bioenergy. Nat. Rev. Microbiol. 6 :605-612
8. Alper, H. and Stephanopoulos, G. 2009. Engineering for biofuels: exploiting innate microbial capacity or importing biosynthetic potential? Nat. Rev. Microbiol. 7:715-723
9. Paustian, T. 2000. Energy Generation Using a Membrane.©2000 Timothy Paustian, University of Wisconsin-Madison. dwb.unl.edu/…NSF/C11/C11Links/www.bact.wisc.edu
10. Ritmann and McCarty, 2008 Rittmann, B. E. and McCarty, P. L. 2001.Environmental Biotechnology: Principles and Application. McGraw-Hill Companies Inc., New York.
11. Gerardi, M. H. 2003. The Microbiology of Anaerobic Digesters.John Wiley & Sons, Inc., Hoboken, New Jersey.
12. Giampietro, M. and Mayumi, K. 2007. Checking the quality of primary energysources: Why we believe that the idea of large-scale production of biofuels from agricultural land is a hoax. Proc. 9th Biennial Conf. Intl.Society of Ecol. Econ., 16–18 December 2006, New Delhi, India
13. McCarty, P.L., In "Anaerobic Digestion 1981" Eds. Hughes, D.E. et.al., 3-22 (1982) Elsevier Biomedical Press, Amsterdam, New York, Oxford.
14. Prescott, L. M., Harley, J. P. and Klein, D. A. 2002. Microbiology 5th Edition.The McGraw–Hill.Companies, New York.
15. Boyles, D. 1984. Bioenergy technology—thermodynamics and costs.Wiley.NewYork.
16. Kotay, S. M. and Das, D. 2008. Biohydrogen as a renewable energy resource—Prospects and potentials. International Journal of Hydrogen Energy 33: 258 – 263
17. Oh, Y., Raj, S. M., Jung, G. Y. amd Park, S. 2011. Current status of the metabolic engineering of microorganisms for biohydrogen production.Bioresource Technology 102: 8357–8367
18. Brentner, L.B., Jordan, P.A. and Zimmerman, J.B. 2010. Challenges in developing biohydrogen as a sustainable energy source.Implications for a research agenda. Environ. Sci. Technol. 44: 2243–2254.

19. Hallenbeck, P.C. and Benemann, J.R. 2002. Biological hydrogen production;fundamentals and limiting processes.Int. J. Hydrogen Energy. 27: 1185–1193
20. Goyal, Y., Kumar, M. and Gayen, K. 2013. Metabolic engineering for enhanced hydrogen production: a review. Can. J. Microbiol. 59: 59–78.
21. Redwood, M.D., Mikheenko, I.P., Sargent, F., and Macaskie, L.E. 2008. Dissecting the roles of *Escherichia coli*hydrogenases in biohydrogen production.FEMS Microbiol.Lett. 278: 48–55.
22. Das, S. andMangwani, N. 2010. Recent developments in microbial fuel cells: A review. Journal of Scientific and Industrial Research. 69: 727-731.
23. www.microbialfuelcell.org
24. Logan, B. E. 2009. Exoelectrogenic bacteria that power microbial fuel cells. Nat. Rev. Microbiol. 7: 375-381
25. Logan, B.E. 2008. Microbial fuel cells (Wiley-Interscience). John Wiley and Sons Inc., New Jersey.
26. Salgado, C.A. 2009. Microbial fuel cells powered by *Geobactersulfurreducens*. Basic Biotech.5: 1.
27. Yan-ping, X.M. 2008. Preliminary Study on E. coli Microbial Fuel Cell and On-electrode Taming of the Biocatalyst.Chinese Journal of Process Engineering 8, 179-1184.
28. Derek, R. L. 2008. The microbe electric: conversion of organic matter to electricity. Current Opinion in Biotechnology. 19: 564-571.
29. Du, Z., Li, H. andGu, T. 2007. A state of the art review on microbial fuel cells: A promising technology for wastewater treatment and bioenergy. Biotechnology Advances 25: 464-482.
30. Sengodon, P. and Hays, D. B. 2012. Microbial Fuel Cells. Future Fuel Technologies, National Petroleum Council (NPC) Study
31. Cheng, S. and Logan, B.E. 2011. Increasing power generation for scaling up single-chamber air cathode microbial fuel cells.Bioresour. Technol. 102: 4468-4473.
32. Balat, M. 2009. Microbial Fuel Cells as an Alternative Energy Option. Energy Sources, Part A:Recovery, Utilization, and Environmental Effects. 32: 26-35.
33. Pant, D.,VanBogaert, G., Diels, L. Vanbroekhoven, K. 2010. A review of the substrates used in microbial fuel cells (MFCs) for sustainable energy production. Bioresour. Technol. 101: 1533-1543.
34. Hanon, M., Gimpel, J., Tran, M., Rasala, B. and Mayfield, S. 2010. Biofuels from algae: challenges and potential. Biofuels. 1(5): 763–784.
35. Kalscheuer, R., Stolting, T. and Steinbuchel, A. 2006. Microdiesel: Escherichia coli engineered for fuel production. Microbiology. 152: 2529–2536.
36. Zhang, J. and Hu, B. 2011. Microbial Biodiesel Production - Oil feedstocks produced from microbial cell cultivations, Biodiesel - Feedstocks and Processing Technologies, Dr. Margarita Stoytcheva (Ed.), ISBN: 978-953-307-713-0. http://www.intechopen.com/books/biodiesel-feedstocks-and processing-
37. Chisti Y. 2007. Biodiesel from microalgae.Biotechnol Adv. 25(3): 294–306.
38 Peralta-Yahya, P., Zhang, F., del Cardayre, S. B. and Keasling, J. D. 2012 Microbial engineering for the production of advanced biofuels. Nature. 488: 320-328
39. Stephanopoulos, G. (1999). Metabolic fluxes and metabolic engineering, Metabolic Engineering 1:1-11.
40. Park, J. H. and Lee, S. Y. 2008 Towards systems metabolic engineering of microorganisms for amino acid production. Current Opinion in Biotechnology 2008, 19:454–460.
41. Abo-Hashesh, M., Wang, R. and Hallenbeck, P. C. 2011. Metabolic engineering in dark fermentative hydrogen production; theory and practice.Bioresource Technology. 102 (18): 8414–8422.
42. Rittmann, S. and Herwig, C. 2012 A comprehensive and quantitative review of dark fermentative biohydrogen production. Microbial Cell Factories. 11:115-133.
43. Keseler, I.M., Collado-Vides, J., Gama-Castro, S., Ingraham, J., Paley, S., Paulsen, I.T., Peralta-Gil, M. and Karp, P.D. 2005. . EcoCyc: a comprehensive database resource for *Escherichia coli*. Nucleic Acids Res. 33: 334–337.
44. Hallenbeck, P.C. 2009. Fermentative hydrogen production: principles, progress, and prognosis. Int. J. Hydrogen Energy, 34: 7379–7389.
45. Yoshida, A., Nishimura, T., Kawaguchi, H., Inui, M., and Yukawa, H. 2006.Enhanced hydrogen production from glucose using *ldh*- and *frd*-inactivated*Escherichia coli* strains. Appl. Microbiol. Biotechnol. 73: 67–72.
46. Abdel-Hamid, A.M., Attwood, M.M., and Guest, J.R. 2001. Pyruvate oxidase contributes to the aerobic growth efficiency of *Escherichia coli*. Microbiology. 147: 1483–1498. PMID:11390679.
47. Maeda, T., Sanchez-Torres, V., and Wood, T. 2007a. Enhanced hydrogen production from glucose by metabolically engineered *Escherichia coli*. Appl. Microbiol. Biotechnol. 77: 879–890.

Heterogeneous Transesterification of Jatropha Seed Oil: Effect of Molar Ratio of Methanol to Oil on the Methyl Ester Yield

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ABSTRACT

Transesterification is an equilibrium reaction which takes place in three consecutive steps. The reaction is usually affected by variables such as molar ratio, temperature, catalyst type and catalyst amount, reaction time etc. Excess alcohol could be used to shift equilibrium to favour the forward reaction. The effect of molar ratio variation on the transesterification of *Jatropha* seed oil with methanol using calcium oxide catalyst was determined using a gas chromatography with flame ionization detector. Percentage yield of methyl esters produced at one hour each with a molar ratio of 10:1 and 12:1 were 97.75 and 99.96, respectively, while that with a molar ratio of 6:1 was 87.25%. The properties of *Jatropha* biodiesel produced were analysed and were found to satisfy the ASTM D6751.Biodiesel produced from *Jatropha* seed oil has the potential to mitigate climate change and solve environmental pollution crisis because it does not emit excessive harmful gases when it burns in diesel engine as in non-renewable fossil fuels.

Keywords: Transesterification, biodiesel, *Jatropha,* Gas Chromatography, Calcium Oxide, Climate change

INTRODUCTION

The world is confronted with twin crises of fossil fuel depletion and environmental degradation. The use of non-renewable fossil fuel is contributing immensely to global warming leading to climate change and all its catastrophes. Fatty acid methyl esters (FAME) collectively known as biodiesel obtained from renewable vegetable oils such as *Jatropha curcas* seed oil is an alternative fuel for diesel engines]. Biodiesel is an environmentally viable fuel It is biodegradable and does not contribute to global warming. The major benefit of its use as fuel is the reduction in net carbon dioxide emission since all the carbon dioxide emitted were recently captured during the growing phase of the plant from which the biofuel was made[. The use of biodiesel also reduces emission of carbon monoxide and other pollutants such as SulphurIV oxide and unburned hydrocarbons by 20 to 40% [

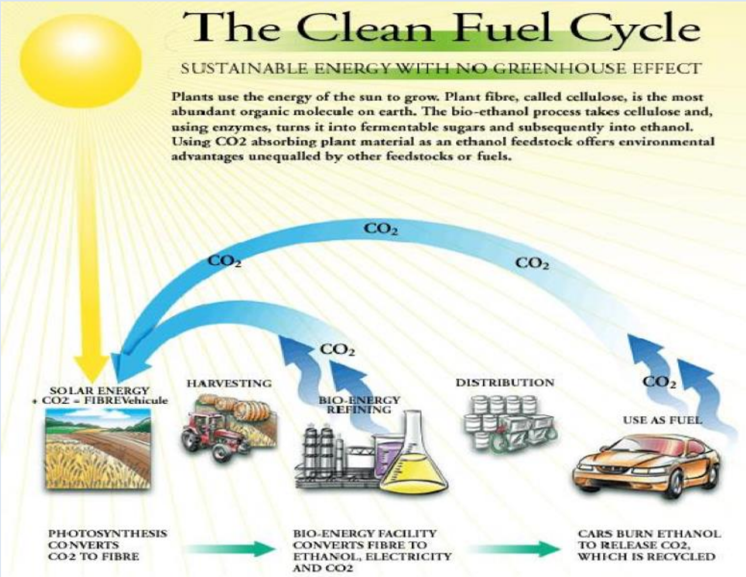

Figure 1.0: The Clean Fuel Cycle (Das, 2008)

By transesterification reaction with methanol, *Jatropha curcas* seed oil can be converted into biodiesel [6]. Transesterification is the most effective way to reduce the viscosity of vegetable oils and to make them fit for use in present diesel engines without any modifications[7][8]. Transesterification is an equilibrium reaction and one of the most important variables affecting the reaction is molar ratio of alcohol to oil [9]. Stoichometrically, transesterification reaction involves 3 moles of alcohol to one mole of triglyceride to produce three moles of fatty acid alkyl esters and one mole of glycerol[10][11]. Excess alcohol or increase molar ratio of alcohol to oil could be used to shift equilibrium to favour the forward reaction (Le Charteleir Principle). Other reaction variables which affects the reaction includes catalyst type and amount, free fatty acid of oil, temperature, reaction time, mixing intensity as well as oil type[12][13] .

In this paper, the effect of variation of molar ratio of methanol to oil on biodiesel yield from *Jatropha* oil transesterification using calcium oxide as catalyst were investigated.

Figure1.1: *Jatropha curcas* seeds *Jatropha curcas* plant with fruits

MATERIAL USED FOR EXPERIMENT

Materials used for the experimental work includes *Jatropha curcas* seed oil extracted from fresh *Jatropha* seeds by mechanical method using hydraulic press, methanol of high grade (HPLC grade) and calcium oxide (fluka) both purchased from Sigma Aldrich company Germany, Hot plate with a magnetic stirrer, an improvised reactor (500ml beaker), gas chromatography with flame ionization detector, cotton wool, mercury thermometer.

Experimental Method

Fifty grammes of *Jatropha* curcas seed oil were weighed into four different 500ml beakers (improvised reactors) namely beaker A,B,C, and D. each of these were heated to a temperature of 70 to 100^{O}C for 10 minutes to eliminate any moisture present in the oil. The dried oil was allowed to cool to room temperature or about 30^{O}C. The beakers containing the oil each were placed on hot plates set at temperatures of 65^{O}C while stirring at 450 to 500rpm. A mixture of methanol and 1% (0.5g) calcium oxide catalyst by weight of oil was added to each to the beakers, and transesterification took place for 60 minutes. The amount of methanol added to beaker A, B,C and D were equivalent of molar ratio 6:1, 8:1, 10:1 and 12:1 methanol to oil. After transesterfying for 60 minutes, samples were withdrawn from each beaker and taken for gas chromatographic analysis to determined percentage methyl ester yield (biodiesel yield) in each of the sample. The free fatty acid of the oil used was 1.4% while the average molecular weight is 939g/mole.

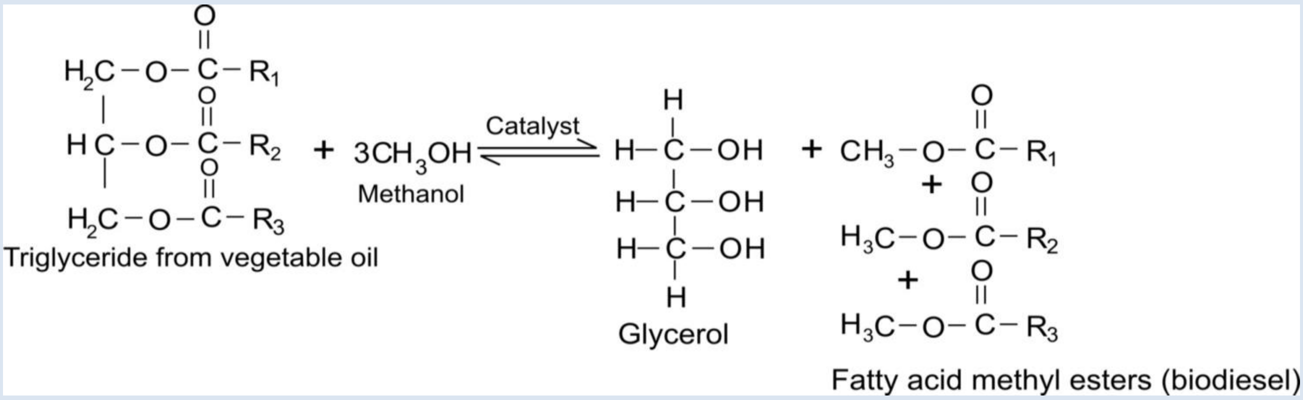

Figure 1.1 shows the transesterification reaction equation

Table 1:

	1% Calcium Oxide			
Molar ratio	6:1	8:1	10:1	12:1
Methyl ester yield	87.249	96.54	97.75	99.96

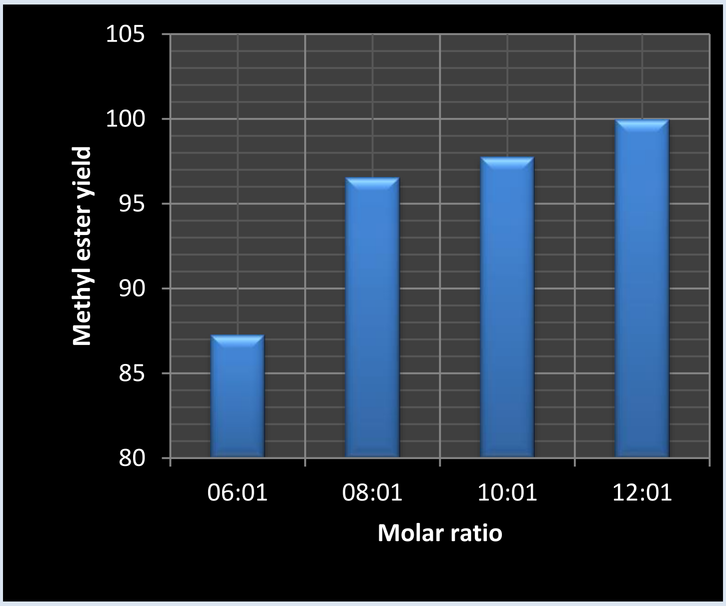

Figure 1.2: Effect of methanol to oil molar ratio on methyl ester yield using 1% Calcium Oxide at 65^{0}C

From the results it could be observed that increase molar ratio increases methyl ester yield, for calcium oxide catalyst, there was a consistent increase in biodiesel yield from molar ratio of 6:1 to that of 12:1. The reason for this could be that calcium oxide being a heterogeneous catalyst (solid catalyst) requires more methanols for increase biodiesel yield because of interfacial surface reaction. The mechanism of the solid catalysed reaction is such that requires increase surface of catalyst pores which reacts with the methanol available before reacting with the oil to form products. Increase catalyst surface and more methanols to react with would therefore increase reaction rate and product yield. Therefore for calcium oxide catalyst, as shown by the result, a molar ratio of 10:1 or 12:1 could be recommended for biodiesel production from this oil. Biodiesel yield of over 96% or 97.75% and 99.96% obtained with a molar ratio of 10:1 and 12:1 respectively are indications of completion of reaction[10][9]. The fuel properties of the oil are shown in Table 2.

The fuel properties of the biodiesel produced satisfies the ASTM D6751. A flash point of 192 shows that the fuel is very safe and can be transported from place to place without any problem [7].

Table 2: *Jatropha* biodiesel fuel Properties

Parameter	***Jatropha* biodiesel @65^{o}C, 1% CaO, molar ratio of methanol to oil 8:1**
Pour Point, ^{o}C	9
Flash Point, ^{0}C	192
Cloud Point, ^{0}C	12
Kinematic Viscosity, mm^2/s	4.86
Calorific Value	42.22
Cetane number	48.94
Specific Gravity	0.893
Acid number	0.47

CONCLUSION

Increase molar ratio of methanol to oil increases yield of biodiesel production from *Jatropha curcas* oil. For calcium oxide catalyst a molar ratio of 10:1, 12:1 or even 8:1 are recommended for the desired conversion. When using calcium oxide a lower molar ratio of 6:1 would require increase reaction time and temperature to achieve the desired yield. The properties of biodiesel produced satisfied the ASTM D6751.

REFERENCES

[1] Singh S.P., and dipti Singh (2010). Biodiesel production through the use of different sources and characterization of oils and their ester as the substitute of diesel (A review).Renewable.

[2] KazlMostafijurRahman, MohammandMashud, Md. Roknuzzaman and Asadullah Al Galib (2011).Biodiesel from *Jatropha* Oil as an Alternative fuel for diesel engine.International Journal of Mechanical and Mechatronics.Vol. 10, No. 03. Pp 1 – 6.

[3] Sharma Y.C., Singh B., Upadyay S.N. (2008) Advancements in development and characterization of biodiesel: A review fuel 87, 2355 - 2373.

[4] Das L.M. (2008).Potential of Biofuels.Roundtable on sustainable biofuels.June 12 & 13, 2008, Indian Institute of Technology, Delhi.

[5] http://en. Wikipedia.org/wiki/biodiesel.production.nw.head.

[6] Bojan S.G. and Durairay S.K. (2012). Producing Biodiesel from High free Fatty Acid *JatrophaCurcas* Oil by A Two Step Method An Indian Case Study, Journal of Sustainable Energy and Environmental 63 – 66.

[7] Rajesh KumarPandey, Rehman A., Sarviya R.M., Savita Dixit (2009), "Development of Clean Burning fuel for compression. Ignition Engines, Asian J.Exp.Sci. vol. 23, No. 1, 223 – 234.

[8] Gerpen Jon Van (2005), Biodiesel Processing and Production. Fuel Processing Technology. 86.1097 – 1107.

[9] Choo Yuen May (2004).Transesterification of Palm Oil: Effect of Reaction Parameters. Journal of Oil Palm Research.Vol. 16, No. 21, 1 -11.

[10] Liping Zhang, Boyang Sheng, ZhongXin, Qun Liu, ShuzhenSuun (2010). Kinetics of transesterification of palm oil and dimethyl carbonate for biodiesel production at the catalysis of heterogeneous base catalyst.Bioresource Technology 101, pages 8144 - 8150.

[11] Noureddini and Zhu (1997).Kinetics of Transesterification of Soybean Oil. JAOCS 74, 1457 – 1463.

[12] PankajTiwari, Rajeer Kumar and SanjeerGarg(2007), Transesterification, Modelling and Simulation of Batch Kinetic of Non-Edible Vegetable Oil for Biodiesel Production. Department of Chemical Engineering, ITT.Kampur, 208016, India pages 1 – 20.

[13] Meher L.C., Sagar D.V. and Naik S.N. (2006) Technical aspects of biodiesel production by transesterification – a Review. Renewable and sustainable energy Reviews 10: 248 – 268.

Mitigating Climate Change through Energy Generation from Wood Wastes in Nigeria

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ABSTRACT

One of the major precursors of climate change is the high dependence on fossil fuel to propel the current patterns of industrialization. Fossil fuel is mostly used as gasoline and low pour fuel oil in industries. Its associated gas is also used for energy generation. Until the industrial revolution, the exchanges between atmospheric carbon, the carbon in the tree and on land were more or less in equilibrium. Now, however, the concentration of carbon dioxide in the atmosphere is higher than it has been for at least 365,000 years as a result of increased utilization of fossil fuel to propel industrialization. As a result of the negative impact of climate change on development, emphases are now placed on clean energy to reduce the rate of green house gas emissions and to mitigate climate change. One of the most importance sources of green energy is wood wastes. In Nigeria, the forest estate is estimated at about 10 million hectares with about 10% of it reserved. Wood based industrial operations in the country include timber logging, sawmilling, wood based panels manufacturing, furniture and joinery and production of wooden items of various types. As a result of low technical efficiency and outmoded processing facilities, wastes generation in the forest products industry is very high. A number of studies have shown wastes generation to be as high as 60%. The wastes can be used for green electricity. They can also be formed into briquettes and carbonized into charcoals that can be burnt to produce heat for steam generation. Through this process, several hundreds of megawatts of electricity can be produced and added to the national grid. This paper seeks to highlight the critical pathway for green energy generation for both industrial and domestic applications in Nigeria.

Keywords: Mitigate, Wood wastes, Carbonized, Electricity, Efficiency

INTRODUCTION

Climate change is emerging as one of the most important challenges of the 21st century. According to recent report of the Iintergovernmental Panel on CClimate Change, more intense and longer drought have been observed over wider areas since the 1970's, particularly in the tropic and sub-tropics. The frequency of heavy precipitation and widespread changes in extreme temperatures has been observed over the last 50 years. Recent trends show a tendency towards greater extremes. Various parts of Africa are becoming steadily arid with increased magnitude and variability of precipitations and storms [1]. The economics of Africa countries depend largely on sectors such as agriculture, fisheries and tourism that are particularly vulnerable to environmental challenges. Among such challenges, climate change is one of the most potent to sustainable development. In Africa, anthropogenic practices most especially fuelwood utilisation for energy generation has been identified as the main source of green house gas emmission. In the continent, climate change has led to increased frequency and severity of drought, floods, and extreme weather events, adding to the stress on water resources, food security, health and infrastructure, thereby stemming overall development. Most Africa communities are vulnerable to these impacts mainly because of high poverty levels, reliance on rainfed agriculture and low technological capability to initiate, maintain and sustain optimal adaptation and mitigation practices.

The issues of poverty, corruption, lack of access to technology have led to intensification of unregulated harvest on natural resources, leading to resource overexploitation and forest degradation. The forest resources have been unmitigatedly exploited since the colonial era. As far back as 1899, the perspective planning for economic development in Nigeria was to exploit forest resources [2]. The export revenue from forestry grows at 4.1%, 8.0% and 28.8% between 1950-60 and 1960-80 respectively [3]. Apart from these, most rural households in Nigeria depend on wood and charcoal for domestic energy generation. Approximately 120 million people rely on wood for heating and cooking. Coupled with this, lumber recovery is low as a result of old equipment. According to Olorunisola [4] the lumber recovery rate in the country is 40-60% while annual rate of return is between 15.2% and 44.3% as a result of the use of outdated technologies. In view of the high rate of deforestation, there have been changes in the structure of the forestry sector. The forest resource survey, 1996-1998, revealed that the forest cover has decreased by 20% over the preceding 18 years. According to [5], the total forest estate which stood at 10% of the country's land area in 1996 is now less that 6%. [6] has estimated that about 26,000 ha of forest land are destroyed annually in the rainforest zone during the conversion of natural forests to plantation forests and other forms of land use. World Wildlife Fund also estimated that over 90% of the natural vegetation had been cleared and that over 350,000 ha of forest and natural vegetations are lost annually [7].

These developments have negative impact on the operations of the forest products industry leading to decline in the contribution of the industry to national industrial development. Studies by RMRDC (2009) indicated that the total volume of usable wood down to 30cm cutting diameter in the forest reserves is only 239,775,500m^3. This is not significantly different from 437,507,205.9m^3 reported by [8]. Various other studies [9, 10, 11, 12, 13] have reported decline in the performance of the forest industry in Nigeria which is brought about principally by increasing demand for wood and shrinking wood supply base. Thus, at the policy level, efforts should be made to promote green private sector investments as well as discourage utilization of solid wood for domestic energy generation. This paper outline the causes and extent of deforestation in Nigeria, the role of deforestation in climate change and the importance of wood wastes utilization for energy generation in mitigating climate change in the country.

DEFORESTATION AND CLIMATE CHANGE

Globally, climate change is a widespread and growing concern that has led to extensive congressional and international discussions and negotiations. In view of the importance attached to climate change globally, evidences are showing that the phenomena will dictate the patterns of industrial development, transportation and energy generation in years to come. The current global change mitigation strategies have focused on reducing emissions of green house gases, especially, carbon dioxide whose major source is deforestation. Forests are carbon sinks in their natural state[14]. Trees absorb carbon dioxide and convert them into leaves, stems and roots while releasing oxygen. Forests accounts for more than a quarter of the land area of the earth and store more than three quarters of the carbon in terrestrial plants and nearly 40% as soil carbon. It has been stipulated that the rate of deforestation in tropical countries accounts for about 20% of the emission of greenhouse gases caused directly by human activities. Consequently, since the early 70s, there has been wide spread public concern about the rate at which tropical forests are being removed or destroyed [15].

In Nigeria, [16] estimated that Nigeria lose about 3.7% of its forests per year and this has resulted in the highest net loss of forests from 2000 to 2010. According to [17], about 14.6 million hectares of natural forests were lost annually to deforestation. Of this, 1.5 million hectares was converted into plantations aimed at increasing wood supply [18]. [19] also reported that Nigeria has the highest rate of deforestation in the world. Between 2000 and 2005 the country lost about 55.7% of its primary forests. Between 1990 and 2005, in total, Nigeria lost 35.7% of its forest cover or 6, 145,000 hectares of forests. As a result of this, a lot of damage has been done to Nigeria's land through the processes of deforestation, thereby, contributing to the overwhelming trend of desertification [20].

The major effect of deforestation on climate change is mainly due to increase atmospheric CO_2 and other trace gases, thereby, affecting climate as the sequistration of carbon is higher in forests than in other land use which they are converted to [21, 22]. The increase in CO_2 level and other greenhouse gas levels in the atmosphere leads to an increase in temperature, and eventually, a change in climate and weather in terms of weather patterns, sea levels, and other cycles that directly affects life on earth [23]. A study conducted in Nigeria from 1901 to 2005, showed there was temperature increase in Nigeria of 1.1^{O}C, while global mean temperature was only 0.74^{o}C. The study also indicated that during the same period, the amount of rainfall in the country decreased by 81mm. It was noticed that both trends simultaneously had sharp changes in the 70's [24]. FAO[25] concluded that the bulk of emissions from deforestation occurs when land is converted to agricultural production, particularly if forests were first cleared by burning. The emissions from deforestation accounted for 87% of the total carbon emissions in Nigeria [26].

Apart from the above, deforestation has caused a loss of biological diversity in both the flora and fauna species. Although the rich diversity of Nigeria's flora and fauna species have been poorly documented, a country study indicated that Nigeria possesses more than 5000 species of plants and 22,000 species of animals [27]. The study identified 200 species of lower plants and over 5013 higher plants. With this number, Nigeria is said to rank 11th in Africa in terms of plant diversity. About 205 of the plant species are endangered, representing the 9th highest in 42 African countries. Animal biodiversity in Nigeria included 247 mammalian species, 900 birds species, 135 reptalian species, 109 amphibian species, 77 mollusks and bivalves, 10 annelids, 648 fish species and 20,000 insect species. The study lists 1,489 species of microorganisms. Nigeria is also known to be a hotspot for primates, ranking 8th in the world for primate diversity with 23 species and 13 genera. Majority of the primates are found mainly in the gulf of guinea forest in Cross River State adjacent to Cameroon. Also the endangered gorilla (*Gorilla diehli*) is found only in a couple of protected areas near Nigeria- Cameroon border. Gbile et al 1981 reported 484 plant species in 12 families of the 4600 plant species in the country to be endangered. About 205 of these species are endemic and their loss mean extinction from the earth. The inherent danger in species extinction is that between the root crops in the south and the grains in the north, there are over 300 edible plants in Nigeria [28]. Only about 20 of these crops are handled in large tonnages [29]. The International Conservation of Nature (IUCN) red lists of threatened species include 148 animals and 146 plant species found in Nigeria. Of these 26 animals are classified as endangered. Also, the numbers of rare Cross River gorilla have decreased to around 300 individuals because of poaching by locals and mass habitat destruction [30].

Likewise, climate change phenomenon is also manifested in persistent drought. The incidence of desert encroachment into Nigeria's savanna forests has been reported [31]. Likewise water stress situations have been reported in the Northern part of the country while rising sea levels and inundation of coastal waters by saltwater in the southern part is evidently on the increase [32]. Coupled with above, average daily minimum and maximum temperature, increasing floods and erosion are being experienced in the country. The observed change in weather pattern will have significant negative effect on the rain fed agriculture mostly practiced in Nigeria [33]. Land degradation has also assumed a definite pattern in Nigeria[34]. For instance, erosion has ravaged much of the eastern parts of Nigeria. In the area, both active and inactive gullied surface areas range from 0.7km for Ohafia and 1.15km for Abiriba in Abia state. The width of the gulleys ranges from 2.4km for Abiriba and 0.4km for Ohafia. Furthermore, a minimum depth of 120km gullied surface has been recorded at Abiriba. Also, problems of widespread sheet wash erosion have resulted in the failure of agricultural activities. In the Northern and Western axis of Nigeria, erosion is equally serious, especially in places like Shendam and Western Pankshin of Plateau State, Efon Alaaye in Ondo state, Ankpa and Okene in Kogi state of Nigeria [35]. Generally, the observation of the patterned nature of land degradation reveals that no part of Nigeria is spared from this wreckage [36]. In Abeokuta South and North local government areas of Ogun state, erosion has done much damage.

There is indication that the portion of Lake Chad in Nigeria has dried up. This has terminated the access of millions of people to means of livelihood interms of fishing, livestock and agricultural activities [37]. Sequel to the tremor in Abeokuta, Ogun State of Nigeria which affected major parts of the region [38]' the National Space Research and Development Agency of Nigeria has warned of the possibility of an earthquake in Nigeria, especially in the South Western Region [39].

CAUSES AND EXTENT OF DEFORESTATION IN NIGERIA

A number of human activities wittingly and unwittingly aided deforestation in the country. One of the major causes in the rural areas of Nigeria is poverty and pronounced deprivation [40]. Among the attributes of poverty are low income and the inability to acquire the basic goods and services necessary for survival with dignity. Poverty also encompasses low access to basic medical facilities, education, clean water and sanitation, inadequate physical security, lack of voice and insufficient capacity and opportunity to better ones life. The forests provide income and employment for forest dwellers who engaged in forest products gathering, processing and marketing as their main source of livelihood or as supplementary source of household income [41]. The collection, processing and marketing of forest products as well as forest labour constitute important economic activities for many rural people [42]. For instance in Cross River State, some school children and poor women in rural communities collect and sell Non Timber Forest Products to enable them pay school fees and meet up with other school demands. Such investments provide poor people an opportunity to escape from the cycle of poverty

[43,44]. Endemic poverty and extensive corruption are general phenomena in most developing countries. High level of poverty coupled with high level of corruption which make it impossible for provision of basic necessities of life has resulted in extensive dependence on wood for domestic energy generation in most parts of the country including the urban areas. Over 90% of the rural/peri-urban population depends on fuel wood and charcoal to meet domestic energy requirements [45]. The consumption of wood and charcoal in Nigeria is still generally based on the data by FAO as reported by [46]. This is based on a per capital charcoal consumption of 0.5t/cap/year and 0.2 t-charcoal/cap/year and projected from the 1991 population census projected at 2.8% growth rate per year. More recently, due to rising prices for fossil fuels, a massive shift from modern fuels such as kerosene and LPG back to charcoal has been taking place. The fuel wood consumption is currently about 1.4kg/head/day; or the energy equivalent in fossil fuels [47].The volume of consumption also varies considerably between states in the country. In Kano state, the fuel wood consumption has been reported to as high as 360kg/person/per year. About 20% of deforestation in developing countries has been attributed to charcoal production [48]. This figure will be significantly higher if the direct use of wood for domestic energy generation is calculated and this has been reported to be responsible for 30% of the total deforestation in the country. Three major types of fuel wood are used in the Country. These are direct fuel woods which are woody materials that are directly removed from forests and other woodlands, indirect fuel wood which includes industrial bye products of wood processing industries and recovered fuel wood from socio economic activities outside the forests and wood processing sectors such as wastes from construction sites, demolition of buildings and containers [49].

Deforestation in Nigeria started slowly at the beginning of this century and became intensified after the Second World War when widespread logging opened a lot territories for use as farmlands for agricultural and tree crops for export [50]. Deforestation also increased during the oil boom years in the 1970's and as a result of various large scale agricultural schemes such as Operation Feed the Nation (1977 – 1979), the Green Revolution (1980 - 1983), Directorate of Food, Road and Rural Infrastructure (DFFRI)(1986 – 1993) and National Agricultural Land Development Authority (NALDA) (1989 -1996).

Other causes of deforestation are population increase, farming systems, extensive grazing and uncontrolled forest fires, urbanization, land tenure system and inadequate forest policy and law (FORMECU, 1996). Also, since 1970, forest exploitation has not been related to working plan as the state departments of forestry have being unwillingly aiding the liquidation of forest capital as a result of political expediency (FORMECU, 1996). The rate of deforestation for reserved and unreserved forests in different vegetation zones between 1976 and 1990 and arrived at a total deforestation rate of 400,000 ha per annum for the country [51]. FAO [52], using a logistic foundation linking deforestation to land area, forest area and population density, estimated population densities for 1980, 1985 and 1990, observed deforestation rates for the periods 1981 – 1985 and 1986 – 1990 as 3.48 and 3.57% respectively. FAO [53] thus concluded that if these rates are maintained, the forest area of Nigeria would disappear within the next three decades.

The constant struggle for additional cropland has become the largest single causal factor for tropical forest destruction [54]. Although forest clearing is rarely completed, forest patches are disappearing fast under the pressure of human population growth, the integration of rural household into market economy, the breakdown of traditional patterns of forest use and government policies [55]. Other factors include inequitable land tenure, loss of available arable land, large scale non agricultural projects coupled with low agricultural productivity [56]. Deliberate, unprescribed burning of the farmland cover to stimulate regrowth of forest forage, a common practice in northern guinea savanna area of Nigeria, also reinforces and accelerates the process of forest degradation [57]. The encroachment situation is becoming increasingly desperate because the socio-economic needs of rural communities are derived from the forests on a daily basis [58]. The situation is worse in states dominated by savanna vegetation in the northern part of the country where the bulk of the revenue from the state (s) forest is being generated from the sale of non timber forest products (e.g. poles, fuelwood, etc). At the current rate of deforestation and considering the need to maintain a viable wood products sector, there is need for policy makers to re-strategize by promoting energy generation options that will discourage utilization of wood while at the same time promoting reuse of wood in the sector.

Wood wastes utilization

According to the United States Environmental Protection Agency, over six million tons of wood wastes were created in 2003. This accounted for the largest portion of residential wastes stream into the nation's landfills. In Nigeria, more than 1.5 million tones of wood wastes are generated annually inform of saw dusts, flakes, slabs and flooring, planks in construction sites, etc [59]. Most of these wastes are burnt off, constituting hazards to the environment. The proportion of a tree converted into products varies widely, and depends on the size (diameter) and form (taper and branching) of trees as well as the particular species. The purposes for which trees are cut also influence utilization and volume of wastes generated. Harvesting pulpwood for paper production uses a higher percentage of the woody biomass than harvesting veneer bolts for plywood or sawlogs for lumber. Cutting to clear a site for agriculture yields a lot of wastes as the woody mass is mostly burnt off to prepare the site for crop or pasture production.

In Nigeria, the unavailability of energy for domestic use poses a great challenge as a result of the high cost of kerosene, cooking gas and environmental hazards. Wood residue accounts for between 15 and 60% by volume in sawmills and between 40-70% by volume in plywood industries most of which are in form of slabs, barks, sawdust, cutoffs, etc [60]. These residues can be used for domestic heat generation. In developed countries, most of the wood wastes are available as an economic attractive source of energy in wood industries. This has necessitated the need to improve on biomass waste and agricultural residues [61]. About 84% of fuel briquettes produced from agricultural land and wood wastes are consumed in the United States by domestic and industrial applications [62,63]. The role of fuel briquettes in domestic energy generation in Nigeria is becoming more and more relevant as a result of decreasing availability of wood. Recent studies have shown that agricultural residues can be processed along with wood wastes to produce high calorific value briquettes. A number of nongovernmental organizations have come up with well defined production processes and equipment for fuel briquette production in rustic environments. Fuel briquettes can be made from readily available raw materials. In urban areas, this can be sawdust and shredded paper while in the villages and rural areas; they can be made from leaves, grass, risk husks and many other agricultural wastes in many combinations. Fuel briquettes projects have been started in many countries in Africa, South East Asia, South and Central America by non governmental agencies and efforts are still being made to promote their wide acceptability as commercial outfits for poverty alleviation and as alternatives to fuelwood. Commercial pressure presses are available. Geographically, appropriate presses can easily be modified to accommodate available raw materials and levels of sophistication in rustic and urban environments [64]. An enterprise producing fuel briquettes can operate profitably in communities consuming bio fuels such as charcoal and firewood that are becoming increasingly scarce and very expensive in many parts of Nigeria. Oladeji [65] concluded that briquettes have positive attributes such as ease of transportation and of storage. The physical and combustion properties of briquettes greatly influence quality in terms of durability, rating and heating values [66]. Appreciable number of studies have indicated potential usefulness of wood wastes and other agricultural waste products such as sawdust and wheat straw [67], maize cub [68] , groundnut and melon shells [69], and waste paper and admixture of coconut husk [70] among others for energy generation in Nigeria.

BAMBOO CHARCOAL AND BRIQUETTE PRODUCTION AND UTILIZATION IN NIGERIA

One of the major advantages of biomass briquetting is that apart from wood wastes, it can be produced from other raw materials. One of the major sources of safe, high value heating energy briquette is from bamboo. Bamboo is one of the fastest growing plant species in the world. It grows up to 1m in 24 hours [71]. Bamboo groves can be established from the scratch and individual culms harvested after 3-6 years depending on species (Aplhonso depending on species [72]. In most cases, the upper parts of the culm that are not of serious industrial use have been recommended for bamboo charcoal and briquettes production. In Nigeria, bamboo is growing wild in 23 out of the 36 states of the federation including the Federal Capital territory. The bamboo resources are currently wasting away as its industrial utilization in the country is currently low. In view of the above, it is necessary to encourage development of bamboo resources locally for energy generation. In China, India, and Thailand, bamboo has been shown to serve as a viable and more sustainable alternative biomass fuel. Due to its extremely fast growing properties, woody nature, high tensile strength and high carbon sequestration rate, bamboo is an ideal sustainable alternative biomass fuel. The development of bamboo as a renewable energy biomass in Nigeria, will address the following:

i: The unsustainable use of wood in firewood and charcoal production.

ii: Production of briquettes with high heating energy value

iii: Efficient mass production of bamboo charcoal and briquette with greater precision.

iv: Reduction in the impact of wood burning on climate change

v: Reduction in the current rate of deforestation.

It has been observed that burning of firewood by African households will release an equivalent of 6.7 billion tonnes of green house gases into the atmosphere by 2050, resulting in further climate change through clearing of tropical forests. Likewise, in terms of health, the burning of fuel wood claim the lives of an estimated 2 million people every year, mostly women and children- who inhale the smoke. Continued widespread indoor use of wood charcoal as a household fuel could cause 10 million premature deaths by 2030 [73]. If biomass business continues as usual, by 2030, biomass energy in sub-

Saharan Africa will still account for about ¾ of total residential energy[74]. Thus, the deployment of bamboo for energy generation in Nigeria is becoming imperative. Rural communities in the country need access to fuelwoods alternatives that are environmentally safe. As bamboo regrows after harvest, it lends itself for energy plantation establishment on degraded lands.

Among the advantages of bamboo charcoal and briquette is that they can be made through control burning in various types of kilns. The technology developed in China is adapted to producing large quantities of charcoal to of rural communities as well as to produce bamboo briquettes that are ideal for cooking as they burn for longer periods and produces less smoke and air pollution than wood charcoal.

Advantages of briquette utilization for energy generation in Nigeria

One of the major advantages of energy generation from biomass is reduction in fossil fuel utilization. The production and utilization of biomass fuel and bio based products is one way to reduce dependence on oil and gas and improve environmental quality. Biomass can be used as an offset to fossil fuels such as coal, natural gas, gasoline, diesel oil and fuel oil. At the same time, biomass uses can enhance domestic economic development by supporting rural economies and fostering new industries, making a variety of renewable fuels, chemicals and bio based products [75,76]. Biomass is the largest domestic source of renewable energy, producing 3.227 quadrillion BTU (quads) or approximately 48% of the USA renewable energy [77].

Studies of conversion technology show that 1 dry ton of forest waste can be converted to 75 to 85 gallons of ethanol fuel or 550 to 650 kw of electricity. Thus apart from domestic energy generation, the possibility of generating electricity from wastes in Nigeria is high. This has been demonstrated in India where bamboo briquette is being used to generate electricity for communities in Mizoram state in India [78].

Biomass briquetting is a technique for converting low density biomass into high density biomass. Wood wastes and briquettes are ready substitutes of coal /wood in the industrial boiler and brick for thermal application. They have high specific density (1,200kg/m^3) and bulk density (810kg/m^3) compared to 60 to 180kg/m^3 of loose biomass. They can withstand the ardors of long distance transport. Compared to firewood or loose mass, briquettes have much higher boiler efficiency as a result of their low moisture and higher density. They are fairly good substitutes for coal, lignite and firewood and possess the following advantages:-

- Briquettes are cheaper in terms of cost
- Oil, coal or lignite, once used, cannot be replaced
- High sulfur content of oil and coal, when burnt, pollutes the environment.
- Biomass briquettes have a higher practical thermal value and much lower ash content (2-10% as compare to 20-40% in coal).
- Briquettes have consistent quality, higher burning efficiency and are ideally sized for complete combustion.
- Combustion is more uniform compared to coal.
- Briquettes are usually produced near the consumption centers and supplies do not depend on erratic transport from long distances.

Prospects for climate change mitigation through wood wastes utilization.

While wood substitution for high embodied energy materials such as aluminium, concrete, and steel should be pursed as means of mitigating climate change in Nigeria, the dependence on fuelwood for domestic energy generation should be legislated against as a result of the high rate of forest destruction and degradation in the country. Prospects for decreasing deforestation could only be realised if the necessary policy can be initiated to promote increased use of wood wastes/bamboo briquettes and charcoals. The forest estate in Nigeria has been denuded of trees and capacity utilisation in forest industry is low. For Nigeria to be able to contribute meaningfully to climate change mitigation there is need for policies that will eliminate the use of solid wood for domestic energy generation. Such a policy should be able to promote increased utilization of wastes for energy generation. A policy that does this will motivate investors to invest in briquetting both wood wastes and bamboo. If entrenched, the trees will be freed and investment in bamboo development through plantation establishment will increase. In view of its high carbon sequestration potentials and fast growth rate it will result in climate change mitigation through reduction in carbon dioxide of the atmosphere. To foster this initiative, carbon credits can be canvassed for bamboo growers and the briquette producers. This is one of the major ways this initiative can be encouraged and promoted in Nigeria. This practice in combination with investment promotion in plantation establishment of industrial tree species, is likely be the major hope of the forest industry in Nigeria. Wood and paper wastes accounts for almost half of all the waste that goes to landfills and in incenerators Forest products (paper and wood) constitute 38.3% by weight of municipal solid wastes and 51.9% by weight of all products (excluding food scraps and other domestic wastes) sent to municipal waste facilities in Nigeria [79]. Waste paper also constitute 48% of green house gas emitted during the production of products that winds up in a ton of municipal wastes sent to landfill and 64% of commonly diverted waste. Conversion of the wastes to briquettes will reduce pollution in two wastes. The first is by saving forests and second, by making use of energy that would be lost during inceneration or decomposition in landfills. Thus, briquetting wood wastes and other agricultural and forest wastes reduces pollution, saves energy and reduce green house gas emission rather than disposing of them in landfills. Replacement of fossil fuels with briquettes in energy generation should be a priority strategy for reducing global warming effects associated within energy generation in developing countries such as Nigeria.

CONCLUSION

Climate change effects are being felt in several ways in Nigeria. Incessant flooding, high temperature and land degradation are common occurences in the country. These have led to several deaths. They have also increased the local level of poverty among the people in both urban and rural areas. A major cause of land degradation in Nigeria is extensive deforestation. As fuelwood utilisation is a major cause of deforestation, the briquetting of agriculturel and forest wastes coupled with bamboo charcoal and briquettes production and utilisationwill librate librate the trees for more important uses, promote plantation establishment and reduction in the national contribution to climate change agents.

REFERENCES

1. IPCC (2000). Land use, land use change and forestry. Special Report. Cambridge University Press, Cambridge.
2. Adeyoju, S. K. (1975). Forestry and the Nigerian Economy. Ibadan University Press, Nigeria, 308pp.
3. Aribisala, A. O. (1993): Raw Materials Revolution and Impact on Industrialisation in Nigeria. Mednet Publications Ltd. (1993). ISBN 978 – 024 – 000 – 4
4. Olorunisola. A. O., (2007). Production of fuel briquettes from waste paper and coconut husk admixtures. Agicultural Engineering International. The CIGR E Journal, Manuscript EE 06 006 Vol IX.
5. Adeyoju, S. K (2001) Forestry and Natural development. A critique of Nigeria Situation. In Popoola, L; J.E. Abu, and P.I. Oni (ed). Proceedings of the 27th Annual Conference of the Forestry Association of Nigeria, held in Abuja, FCT, 17 – 21st Sept, 2001.pp 55-68
6. Ola-Adams, B.A. and Iyamabo D.E. (1977) Conservation of Natural Vegetation of Nigeria: Environment Conservation 4(3): 217-226.
7. WWF (1989). Cross River National Park. Oban Division. Plan for Developing the Park and its support zone. World Wildlife Fund (WWF Goldaming)
8. Akindele, S.O, Dyck.J.,Akindunmi, F.F,Papka, P.M, and Olaleye, O.A. (2001) Estimate of Nigeria`s Timber Resources. In L Popoola, J.E. Abu and P.I Oni (ed.) Proceedings of the 27th Annual Conference of the Forestry Association of Nigeria, Abuja FCT. Pp1-11
9. Oriola E.O (2009). Forestry for Sustainable Development In Nigeria. International Journal of African Studies. ISSN 1451-213X Issue 1 pp 11-16.
10. Olorunnisola, A.O (2000): Workshop Structure in the small Scale Furniture Industry in Ibadan metropolis. Journal of Tropical Forest Resources 16(1):46-57.
11. Ogunwusi, A.A. (2012a). Forest Products Industry in Nigeria. *African Research Review.* 6(4): 191-205.
12. Aribisala, A. O. (1993): Raw Materials Revolution and Impact on Industrialisation in Nigeria. Mednet Publications Ltd. (1993). ISBN 978 – 024 – 000 – 4
13. RMRDC (2003). Multi-Disciplinary Task Force Report of the Techno Economic Survey on Wood and Wood Products. Raw Materials Research and Development Council Publications, 2003.
14. Gorte, R.W. and Sheikh, PA. (2010). Deforestation and climate change. Congressional Research Service. Prepared for Members and Committees of Congress. www.crs.gov. R41144. 41pp
15. ITTO (2005). Status of Tropical Forest Management 2005. ITTO Technical Series No.2 4.
16. FAO (2010) Global Forest Assesmant Report 2010. Main Report, FAO Forestry Paper. 163. Pp 378
17. FAO (2000). The Global Forest Assessment. 2000. Summary Report. Report No. 2001/INF.5., Committee on Forestry, FAO, Rome, Italy
18. Onafeli O.A. (2011). Forest contributions to rural livelihood and threats to their sustainability in Nigeria. In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the
19. FAO (2005). www.mongabay,com visited on 1oth February, 2011
20. Omofonmwan, S.I. and Osa-Edoh, G.I. (2008). The challenges of environmental problems in Nigeria. Journal of Human Ecology 23(1):53-67
21. Woodwell G.M., Hobbie, J.E, R.A. Melill, J.M. Moore, B. Peterson and Slaver, G. R. (1983). Global deforestation: Contributions to atmospheric carbon Dioxide. Science .222: 1081-1086
22. Dixon, R.K. (1995)Agroforestry systems:Sources or sinks of green house gases?. Agroforestry Systems31: 99-116
23. GFF (1998). Deforestation, Cuses, Implications and Solutions http//www/global.ff.org/Feature_articles/Prevoius_Articles/pre-defo.htm
24. Odjugo, P.A (2010). General overview of climate changeimpacts in Nigeria. Journal of Human Ecology.29(1):45-55. EBSCO.
25. FAO (2000). The Global Forest Assessment. 2000. Summary Report. Report No. 2001/INF.5., Committee on Forestry, FAO, Rome, Italy
26. Adegoke, A.I and Ogunsanwo, A.Y. (2011). Impact of charcoal production on environmental sustainability in the derived savanna belt of South Western Nigeria In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of Nigeria, Osogbo, Osun State Nigeria, pp 453-460.

27. FEPA (1992). Country study report for Nigeria on costs benefits and unmet needs of biodiversity conservation sponsored by United Nations Environmenta Programme. National Biodiversity Unit, Abuja, Nigeria. 53p
28. NEST 1991
29. Okafor, J.C. (1993). Strategies for development of forest trees and non timber forest products in Nigeria In E.A. Oduwaye (ed) Forestry for Urban and Rural Development in Nigeria Proceedings of the Conference of the Forestry Association of Nigeria, 1993.
30. Deutsch, J. (2007). Regional action plan for conservation of the Cross River Gorilla. Environment News Service, New York, June 21.
31. Adegoke, A.I and Ogunsanwo, A.Y. (2011). Impact of charcoal production on environmental sustainability in the derived savanna belt of South Western Nigeria In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of Nigeria, Osogbo, Osun State Nigeria, pp 453-460.
32. Ogunwusi A.A. and M.A Jolaoso. (2012). Bamboo, Conservation of environment and sustainable development in Nigeria. Advances in Arts, Social Sciences and Education 2(9):346-358.
33. Ogunwusi, A.A. (2011a). Potentials of bamboo in Nigeria's Industrial Sector. *Journal of Research in Industrial Development* 9(2): 136-146.
34. Jimoh, H.I., O.D. Ajewole, S.I. Onotu and R.O. Ibrahim (2012). Implications of land degradation, reclamation and utilizations in the oil producing areas of Nigeria; perspectives on environmental sustainability and development. Environmental Research Journal 6(2): 100-105.
35. Jimoh, H.I., O.D. Ajewole, S.I. Onotu and R.O. Ibrahim (2012). Implications of land degradation, reclamation and utilizations in the oil producing areas of Nigeria; perspectives on environmental sustainability and development. Environmental Research Journal 6(2): 100-105.
36. Asadu, C.L.A, P.I Ezeaku and G.U Nnaji (2004). Land use and soil management situations in Nigeria: An analytical review of changes. J. Outlook Agric USA., 33:27-37
37. Adegoke, A.I and Ogunsanwo, A.Y. (2011)Impact of charcoal production on environmental sustainability in the derived savanna belt of South Western Nigeria In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of Nigeria, Osogbo, Osun State Nigeria, pp 453-460.
38. Muhammed, H. (2009). NARSDA hints of possible earthquake in Nigeria. Daily Trust October 2, 2009.
39. Adegoke, A.I and Ogunsanwo, A.Y. (2011)Impact of charcoal production on environmental sustainability in the derived savanna belt of South Western Nigeria In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of Nigeria, Osogbo, Osun State Nigeria, pp 453-460.
40. Adeniran, O.A., Famuyide, O.O., Adebayo., and Olugbire, O.O. (2011). Contribution of non timber forest products to poverty and hunger reduction in Nigeria. In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of Nigeria, Osogbo, Osun State Nigeria. Pp 161-167
41. Etigale, E.B., Uduofia, S.I and Olajide, O. (2011). Economic consequences of deforestation on forest dwellers in Nigeria. In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of Nigeria, Osogbo, Osun State Nigeria. Pp 434-444
42. Vyas, G.D.P. (2006). Community Forestry. Agrobios (India), Jodhpur. Pp 1-111
43. FAO (1989). Forestry and Food security. FAO Forestry Paper No. 90 Rome. Pp 1-74 Houghton, R.A. (1990). The global effects of tropical deforestation . Environment, Science and Technology. 24(4)414-421
44. Vyas, G.D.P. (2006). Community Forestry. Agrobios (India), Jodhpur. Pp 1-111
45. FDF/FME(1999). Nigeria Forestry Action Programme. Main Report, 1999.
46. Adegoke, A.I and Ogunsanwo, A.Y. (2011) Impact of charcoal production on environmental sustainability in the derived savanna belt of South Western Nigeria In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of
47. Adegoke, A.I and Ogunsanwo, A.Y. (2011) Impact of charcoal production on environmental sustainability in the derived savanna belt of South Western Nigeria In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of Nigeria, Osogbo, Osun State Nigeria, pp 453-460.

48. Adegoke, A.I and Ogunsanwo, A.Y. (2011)Impact of charcoal production on environmental sustainability in the derived savanna belt of South Western Nigeria In L. Popoola, K Ogunsanwo and F. Idumah (eds) Foresrty in the next millennium and development goals. Proceedings of the 34th Forestry Association of Nigeria, Osogbo, Osun State Nigeria, pp 453-460.
49. FAO (2004). Proceedings: FAO Advisory Committee on Paper and Wood Products. FAO Rome, Italy. 166pp.
50. FORMECU (1996). Nigerian Forest Action Programme. Volume II, Main Report. February,1996. GFF (1998). Deforestation, Cuses, Implications and Solutions http//www/global.ff.org/Feature_articles/Prevoius_Articles/pre-defo.htm
51. Roby A.J. (1991). The Supply of Forest Products in Nigeria (TFAP Nigeria: First Step Sector Analysis, Annex 5). Natural Resources Institue, Chatam, Kent, United Kingdom.
52. FAO (1992). Country Notes on Forest Plantation Areas. Forest Resources Assessment 1990-1992. Tropical Forest plantation Resources. FAO Document Repository.
53. FAO (1992). Country Notes on Forest Plantation Areas. Forest Resources Assessment 1990-1992. Tropical Forest plantation Resources. FAO Document Repository.
54. TFAP (1990). The Tropical Forestry Action Plan (TFAP) handbook,pp13.
    the development of solar-PV Sub Sector in Nigeria. Nigerian Journal of Renewable
55. Schelhas J. and R. Greenberg (1996). Forest Patches in Tropical Landscape. In Compass Newsletter No. 2 October, 1999 p43. Island Press, U.S.A.
56. Afuwape, A, M.; A, O. Amosun,; J. A. Fagbenro; L. O.Ojo and C.O. Adeofun (2002). Towards Eradicating Deforestation; What Option for Nigeria. Nig. Jour For. 32 (1&2)).pp 95- 103.
57. Hobson, K.A., E.M. Bayne and S. L. Van Wilgenburg (2002). Large scale conversion of forests to agriculture in the Boreal Plains of Sskatchwen. Conversion Biology, 16(6):1530-1541.
58. Osemeobor J.G.J. (1993) An Input Assessment of Agricultural Land Use Practices on the Nigerian Environment In. Proceedings of 23rd Annual Conference of Forestry Association of Nigeria, Ikeja, Lagos State. 29th Nov. -3rd December, 1993.
59. Ogunwusi, A.A. (2012a). Forest Products Industry in Nigeria. *African Research Review.* 6(4): 191-205.
60. Hakkila, P. and Parikka, M. (2002). Fuel resources from forest . In: Bioenergy from Sustainable Forestry: Guiding Principles and Practice (eds) J. Richadson, R. Bjorheden, P Hakkila, A.T. Lowe and C.T Smith. Kluwer Press, The Netherlands
61. Fapetu, O.P. (2000a). Production of charcoal from tropical biomass for industrial and metallurgical process. Nigerian Journal of Engineering Management. 1(2): 34-37
62. Fapetu, O.P. (2000b). Management of energy and tropical biomass. Nigerian Journal of Engineering Management. (1): 14-19.
63. USDA(2002). Successful Approached to Recycling Urban Wood Waste. Report FPL-GTR-133. Madison,WI,USA.
64. Stanley, O.S. (2003). Manual on production of briquettes from wastes. Manuel Press. Laos.
65. Olajide, O and Eniang, E.A. (2000). Unguided forest resources exploitation and destruction in Nigeria: Socio-Ecological Impacts. International Journal of Environment and Development 4(1): 39-43.
66. Sotannde, O.A,. A.O. Oluyege and G. B Abah (2010). Physical and combustion properties of briquettes from sawdusts Azidiracta indica. Journal of Forestry Research.21(1);63-67.
67. Wamukanja, I. and Jenkins, B. (1995). Durability and relaxation of sawdust and wheat straw briquettes as possible fuels in Kenya. Biomass and Bio-energy.8(3):175-179.
68. Wilaipon, P. (2007). The effect of moderate die pressure on cob briquettes: A case study in Phitsanulok, Thailand.
69. Oladeji, J.T,. Enweremadu, C.C and Olafimihan, E.O. (2009). Conversion of Agricultural residues into biomass briquettes. JAAAR 5(2):116-123.
70. Olorunisola. A. O., (2007). Production of fuel briquettes from waste paper and coconut husk admixtures. Agicultural Engineering International. The CIGR E Journal, Manuscript EE 06 006 Vol IX.
71. Alfonzo, D.J., (1987). Let's plant bamboo. Agribusiness Weekly, 1 (19):25
72. Alfonzo, D.J., (1987). Let's plant bamboo. Agribusiness Weekly, 1 (19):25
73. INBAR (2011). New Bamboo Charcoal Technologies promise to jump start African Bioenegy Sector, slow deforestation and fight climatec change. INBAR Newsletter e-Newsletter www.inbar.int./2011/2012/new-bamboo-charcoal-technologies-to jumpstart-africas-bioenergy.
74. IAE(2007). International Atomic Energy. News Reports. No. 47. 13pp

75. English, B.C., D.G. De La Torre Ugarte, K. Jensen, C. Hellwinkel and M. Walsh (2006) 25% Renewable energy for the United States by 2025: Agricultural and Economic Impacts. University of Tennessee, Knoxville.
76. Sheehan, J., A. Aden and Kpaustain, K. Killian, J. Brenner, M. Walsh and R. Nelson (2004). Eenergy and Enviromental Aspects of using corn stover for ethanol. Journal of Industrial Ecology.
77. IAE(2007). International Atomic Energy. News Reports. No. 47. 13pp
78. INBAR (2011). New Bamboo Charcoal Technologies promise to jump start African Bioenegy Sector, slow deforestation and fight climatec change. INBAR Newsletter e-Newsletter www.inbar.int./2011/2012/new-bamboo-charcoal-technologies-to jumpstart-africas-bioenergy.
79. Eneh, A. E. O and Oluigbo, S.N.(2012). Mitigating the Impact of Climate Change through Waste Recycling. Research Journal of Environmental and Earth Sciences 4(8): 776-781.

The Potential Effect of Cogeneration System in Combating Climate Change

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ABSTRACT

The energy problems in Ghana and Africa in general have perpetuated the need for sustainable energy production sources. One of the sustainable energy production systems is the cogeneration system. Cogeneration is the simultaneous production of useful heat and energy by using a primary fuel which is supposed to be easily available. It is fast gaining grounds, especially in the timber industry as an efficient means of maximizing the usage and economic value of wood residue. This research was carried out to assess the cogeneration system of Samartex Timber and Plywood Company, Ghana. The input and output volumes of logs (irrespective of species) at the four production departments of the company (sawmill, plymill, veneermill and the moulding sector) were calculated to identify the estimated wood residue volume generated at each department.

The quantity of electricity generated from the residues was calculated to assess the rate of electricity production. The company had an average percentage residue of 44.50%. This yielded a volume of 619.654 m^3 per month which was able to generate an estimated electricity of 2,408,055.694 Kw·h per month. It was realized that any wood species can be used for cogeneration but its feasibility depends on continuous supply of the primary fuel. The amount of carbon dioxide (CO_2) emitted during the burning of wood residue is typically 90% less than when burning fossil fuel which helps to reduce the amount of carbon in the atmosphere which reduces the global warming. It is recommended that the system should be practiced in the timber industry which usually has enough wood residues for primary fuel.

Keywords: Cogeneration, wood residue, climate change and percentage residue

INTRODUCTION

The issue of climate change has long been a common concern for all the human races. Climate change, which is a term for the change in climate as a result of the direct or indirect human activities that alters the global atmosphere composition over a period of time, has adverse effects which call for the widest possible cooperation by all countries to at least reduce or halt. Its effects threaten the very foundation of human life on earth (UNFCCC, 2013). One of the contributors to climate change is the reduction of the forest cover through excessive production of wood residue leading to lesser yield volume.

Forests store large quantities of carbon and contain more biomass per hectare in vegetation than other biomes; therefore a decrease in its coverage area will enhance higher rates of carbon release into the atmosphere to cause global warming and consequently climate change (Gorte and Sheikh, 2010). Wood residue is one of the most abundant and environmentally friendly biomass resources especially in the wood industry. Manufacturers generate an enormous amount of wood residue in the process of making products such as lumber, furniture, pallets and paper. In general, less than 50 percent of trees end up in a final product, the balance representing a vast under-utilized resource. Increasing yield through wood residue usage would help to reduce the rate of forest tree harvesting.

Dost (1966) defined wood residue as the remnant of the original raw material after the economic value has been removed. NISER (1974) also defined wood residue as the pieces of materials that are lost from the process of harvesting up to when the final products have been taken. Hence, residues may be regarded as negative product of wood processing. In Ghana, there is a problem with sustainable power supply marked by its common power outages. The timber industry is one of the high energy consuming industries in Ghana. This industry is characterized by relatively low conversion efficiency, leading to a lot of wood residue being generated, hence the principal producer of wood residues (FAO, 2005). There is a great potential of utilizing these residues for energy generation. These residues contain energy and instead of being allowed to go waste in the environment, it can be used to generate electricity to power the processing machines in the factory. Wood residue contains potential energy which can be harnessed to generate electricity through the cogeneration system (EERE, 2004; Enters, 2001). This system is the simultaneous production of useful heat and electricity using a primary fuel. The technologies for converting wood to energy are well established. No other type of fuel has been used successfully in more types of system designs than wood or wood residues (The Renewable Energy Institute, 2010). Cogeneration, also known as "Combined Heat and Power" (CHP) is more attractive than the conventional power and heat generating options due to:

- Its relatively lower capital investment.
- Reduced fuel consumption.
- Reduced environmental pollution

This cogeneration system is known for its 85% efficiency as against modern electricity plants which usually have 55% efficiency. Through this system the emission of one of the greenhouse gases carbon dioxide (CO_2) is reduced significantly to about 90% which also aids in carbon sink (Smit, 2006). This study was carried out to identify how much electricity can be generated from a given volume of wood residue at one of the leading timber industries in Ghana which has a cogeneration plant.

MATERIALS AND METHODS

The study was carried out at Samartex Timber and Plywood Company Limited, one of the leading timber companies in Ghana. It is located at Samreaboi in the Amenfi West District, in Western Region of Ghana. Samartex Timber and Plywood Company has four main production departments, namely: the plymill, sawmill, moulding mill and the veneer mill.

The species that were used in the study are*Antiaristoxicaria*(Kyenkyen), *Danielliathurifera*(Sopi), *Khayaivorensis*(Mahogany), *Tieghmellaheckelii*(Makore), *Anigeriarobusta*(Asanfina) and *Erythrophleumivorense*(Potrodom). Tape measure was used to take the diameter and length measurements of the logs. The diameter measurements excluded the bark. Ten logs each from the four production departments at Samartex (Ply mill, Sawmill, Veneer mill and Moulding mill) were randomly selected and their respective input and output volumes calculated. In all 40 logs were used.

Volume calculation of each of the logs, before processing was carried out using the Smalian's formula;

$V_1 = 0.7854 D_{av}^2 L$ (m^3) **Equation 1** (Brack and Wood, 1997).

Where,

V_1 = volume of log (m^3),

D_{av} = Average diameter of the logs (m),

L = Log length (m)

0.7854 = Constant

The volumes of products produced (plywood, veneer, lumber and mouldings) during the study were calculated using the following formulae:

The formula for the volume of the fixed width products was given by;

V_2= [L x W x T] n **Equation 2**
Where,
V_2 = Volume of the product (m^3)
L = Length (m)
W = Width (m)
T = Thickness (m)
n = Total number of pieces of products obtained.

The random width products were tallied. The length, width and thickness, were measured and the volume was given by;
V_2= L x T x W_t**Equation 3**
Where,
V_2 = Volume of the product (m^3)
L = Length (m)
W_t = Total Width (m)
T = Thickness (m)

The sum of the volume of the products was the total recovery. The percentage yield or percentage recovery was given by the ratio of the volume of the products to the volume of the input log in metres cube expressed in percentage as defined by Tsoumis (1991). The Recovery Rate was calculated using the formula,

$$RR = \frac{V_2}{V_1} \times 100$$ **Equation 4**

Where,
RR = Recovery Rate (%),
V_2 = Volume of products obtained after conversion (m^3),
V_1 = Volume of round logs before conversion (m^3)

The total volume of wood residue generated from the conversion of logs was given by the difference between the log volume and the total product volume and was calculated using:
$V_R = V_1 - V_2$**Equation 5**
Where,
V_R = Volume of wood residue (m^3)
V_1= Volume of round logs before conversion {bolt} (m^3)
V_2 = Volume of product obtained after conversion (m^3).

The percentage residue was therefore calculated using the formula

$$\text{Percentage of residue} = \frac{VR}{V1} \times 100$$ **Equation 6**

Moisture meter was used to measure the moisture content of some of the residues selected randomly and the averages recorded. The moisture content is recorded because moisture content affects the energy content of wood when burnt and the amount of wood fuel required to achieve the desired heat or steam outputs (JUCA, 2011). The value was

used to mathematically calculate the densities of the wood at that moisture content, by comparing it with their densities at 12% moisture content.
The average mass of residue generated per month was calculated as below:

Average Mass = $\frac{Ad}{Ai}$ **Equation 7**

Where,
Ad = Average Density of all species involved
Ai= Average Monthly input volume for all the mills

The averages of the following parameters of all the mills were also calculated: percentage residue, conversion efficiency, species densities and monthly input. The average amount of electricity in Kilowatts per hour (Kw·h) that was generated was recorded from electric meters.This was done for seven continuous days (from Monday to Monday) and the average daily electricity generated was calculated.From enquiries at the study site, it was acknowledged that at least 4 tons of residues were needed for the turbines to generate their daily amount of electricity. This was known as a result of previous research by the company into the quantity of residue needed by the cogeneration plant for its daily electricity production. The capacity of the turbines was therefore stated as: 4 tons of wood residues generate the average daily electricity produced by the turbines. This was used to calculate the electricity produced per month, by multiplying it by the average mass of residue generated per month by the four mills.

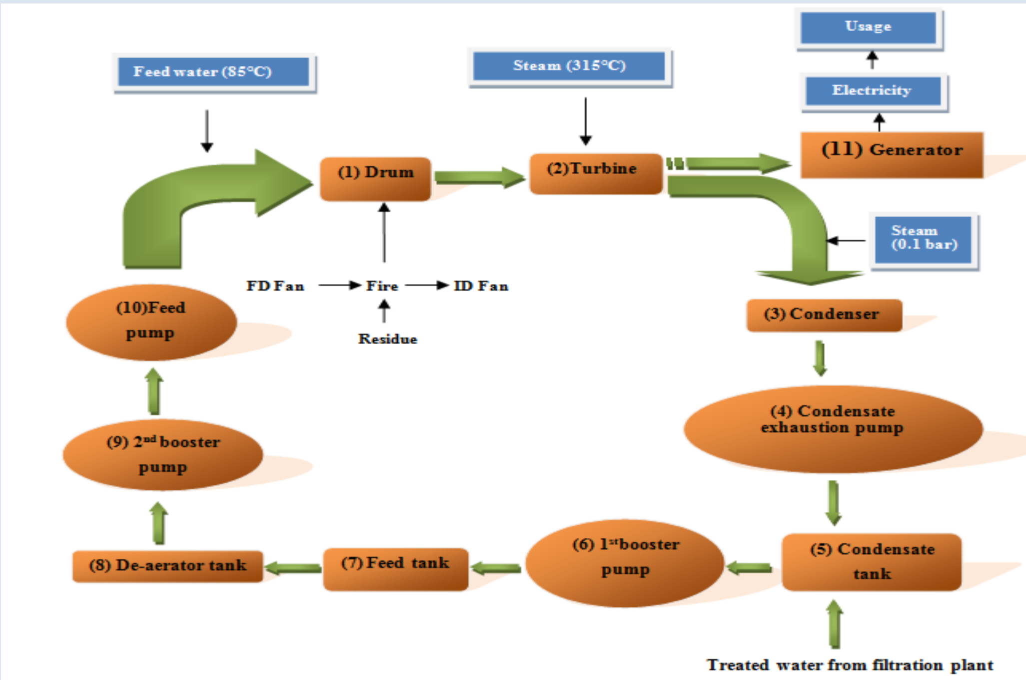

Fig 1.A Simplified Electricity generation at Samartex
ID Fan – Induce Draft fan (takes air out of the furnace)
FD Fan – Force Draft fan (blows air into the furnace)

Results and Discussion

Percentage Residue at the various mills

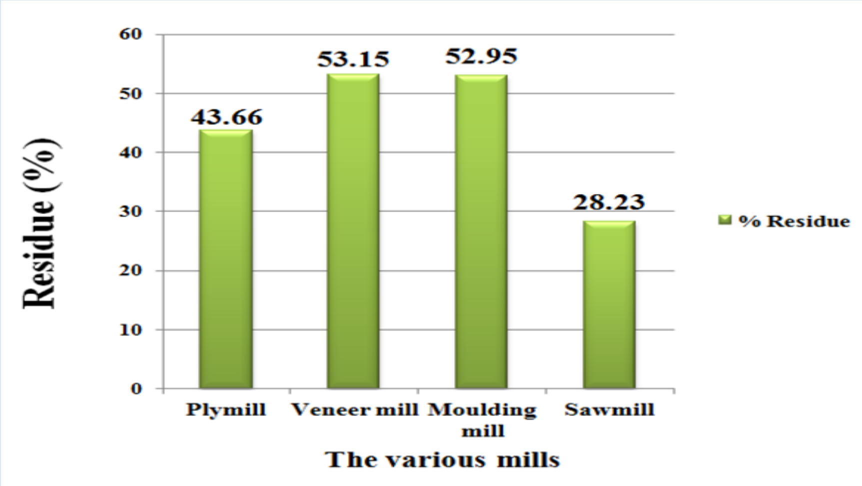

Fig. 2 Percentage Residue at the various mills

Fig. 2 and Table 1 show that the veneer mill had the highest amount of percentage residue that was generated (53.15%), with respect to its input volume. It was realized that log flitching contributed much to the residue that was generated. This was due to the fact that quarter sawing was used in the flitching of the logs. Mills using the quarter sawing pattern usually experience a sharp decline in yield volumes, giving rise to high residue generation. According to Ontario Woodlot Association (2000) quarter sawing takes more time and results in lower yields per log and narrower boards. The Moulding mill had many processing procedures to reach its final product and this contributed to its high residue generation (52.95%). The Plymill had a residue of 43.66% thus a recovery of 56.34%. It was realised that the plymill had quite a number of processing stages which contributed to its high residue percentage. According to FAO (1990) and Enters (2001), plymills usually have a recovery rate of about 43-50% and this study confirms it. The Sawmill had the lowest residue generated (28.23%). However according toNketiah *et al.* (2001) lumber recovery in sawmills is about 30-45% of the log input, with residue of about 55-70%. The low level of residue could be attributed to the downstream processing at the study area. Also, live sawing pattern was used. According to Walton (1974) in live sawing there is little waste.

Table 1.0 Parameters at the various mills

DEPARTMENT	INPUT (M^3)	OUTPUT (m^3)	RESIDUE GENERATED (m^3)	RESIDUE GENERATED(%)	CONVERSION EFFICIENCY (%)
Plymill	**16.323**	**9.196**	**7.127**	**43.66**	**56.34**
Sawmill	**15.394**	**11.049**	**4.345**	**28.23**	**71.77**
Veneer mill	**55.407**	**25.960**	**29.447**	**53.15**	**46.85**
Moulding mill	**65.887**	**31.000**	**34.887**	**52.95**	**47.05**

Residue and Conversion Efficiency of the four mills

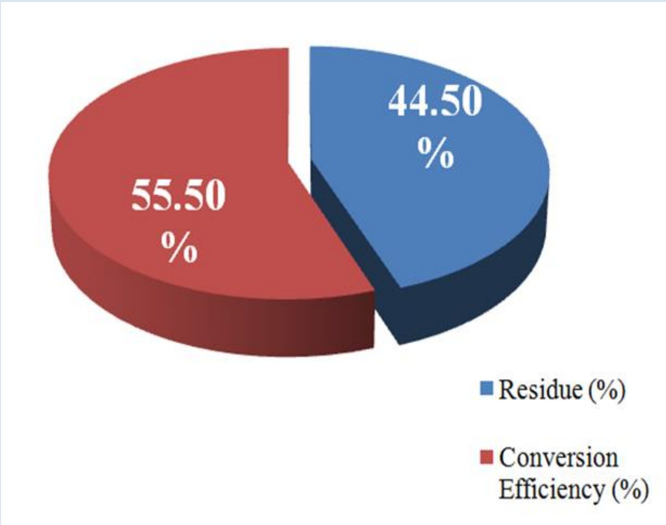

Fig. 3 Percentage Residue and Conversion Efficiency at the mills

Figure 3 shows that an average percentage residue of 44.50% was produced at the four departments. However Sekyere and Okyere (2007) reported 49% residue of most timber industries in Ghana. This means that Samartex produced high yields after processing the logs. The reasons for the high conversion efficiency at Samartex were due to the following factors; most of the logs had larger diameters and longer length. The average length and diameter at all the mills were 5.94m and 2.21m respectively. According to Adams (2007), length and diameter are the major factors that contribute to high conversion efficiency. Samartex is situated in the high forest zone of Ghana and has about thirteen concessions. This has provided a lot of possibilities for the company to acquire logs of larger diameters and longer lengths.

The average Density of all Species involved was given by the sum of the densities of the species (six) divided by 6. This was 621Kg·m^3.

The average monthly Input for the company was given by the sum of the average monthly input of the four departments. This was 1,392.485m^3.The estimated volume of Residue produced monthly was given by 44.50% of 1,392.48. Thus the monthly volume of residue was 619.654 m^3.

From turbine readings at the power station, the quantity of electricity produced daily by the cogeneration plant was 25,031.43 kw·h. This means that a monthly wood residue volume of 619.654 m^3 generated 25,031.43 kw·h daily and 750,942.90 kw·h or about 750 Mw·h monthly. Whiles generating this amount of electricity the carbon dioxide emissions to atmosphere was 90% less than that of fossil fuels. The wood residue being used as the primary fuel in this system contains no heavy metals or sulphur which contributes to acid rain production (IEA, 2007).

CONCLUSION

A wood residue volume of 619.654 m^3 generated 25,031.43 kw·h daily and 750,942.90 kw·h or about 750 Mw·h monthly. The production of this amount of electricity through the cogeneration system was associated by a 90% less carbon dioxide emissions.

RECOMMENDATION

Enhancing the application of the cogeneration system in manufacturing industries especially the wood or timber industry would greatly reduce the rate of carbon dioxide released into the atmosphere and enhance carbon sink to the reduction of global warming and climate and change as a whole.

REFERENCES

Brack, C. L. and Wood, G. B. (1997).Measurement of Logs. Pg1. http://fennerschool-associated.anu.edu.au/mensuration/BrackandWood1998/LOGS.HTM01-11-12

Dost, A.W. (1966).Progress in Wood Residue use in California. Paper presented at the Spring Meeting of the Northern Section of Forest Products Journal. Berkeley, California. Pg 42. www.spinger.com 10-04-09

EERE (2004).Biomass energy, focus on wood waste. U.S Department of Energy. Web: www.eere.energy.gov/femp

Enters, T. (2001).Trash or Treasure? Logging residues in Asia-Pacific.Asia-Pacific Forestry commission, Rap publication. Web: http://ftp.fao.rog/docrep/fao/003/x6966e/x6966e00.pdf, pp4-16, 11/04/11

FAO (1990).Report, Food and Agriculture Organization. pp30

FAO (2005).Yearbook of Forest Products 2003.Food and Agriculture Organization, Rome, Italy.pp8-19

Gorte, R. W and Sheikh, P. A. (2010). Deforestation and Climate change. Congressional Research Service report. Web: www.fas.org/sgp/crs/misc/R41144.pdf deforestation and climate change

IEA, (2007).Biomass for power generation and CHP.International Energy Agency.web: http://www.ies.org/techno/essentials3.pdf .pp1-4 07/04/11

JUCA (2011).Amount of energy in wood fuel.JUCA. http://mb-soft.com/juca/print/311.html, pp1, 22/04/11

NISER (1974).A Report on the state of the Sawmilling Industry in Nigeria.Prepared for ministry of Agricultural and Natural Resources.http://www.asopah.org 20-03-09

Nketiah, S. K., Atakora, S. B., and Brew-Hammond, A. (2001). Ghana Sawmill Energy Efficiency Study. Final Report. Intermediate Technology Consultants (ITC) and UK Department for International Development (DFID): xiii.

Renewable Energy Institute, (2010).Cogeneration technologies, Cogeneration solutions LLC.company. http://www.eren.doe.gov/consumerinfo/refbriefs/ea6.html, pp116/10/2010

Sekyere, D. and Okyere, P. Y. (2007).The potential of using wood residue for energy generation in Ghana. International Conference of Wood based Bioenergy, Hannover, Germany. Pp1-28.

Smit, R. (2006).Distribution Generation and Renewable-Cogeneration, Power quality and utilization guide, Copper Development Association. pp 1-8.

Todoroki, C.L. and Ronnqvist, E.M. (1999). Log sawing optimization directed by market demands. New Zealand Journal of Forestry, 2001. Pp29-32

UNFCCC (2013).UNFCCC Convention.United Nations Framework Convention on Climate Change.Web: http://unfccc.int/essential_background/convention/background/items/1349.php , 8/07/13

Walton, J.A. (1974). Woodwork in theory and practice. Fifth edition.Harrap, London in association with Australasian publishing company. 629pp

Crossover between PEG and BT/NZF Magnetoelectric Nanocomposite for Tailoring Applicable Multiferroic Materials

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ABSTRACT

The composites materials with formula (1-x) [$Ni_{0.5}Zn_{0.5}Fe_2O_4$ + $BaTiO_3$] + (x) (PEG); $0 \leq x \leq 1$, have been prepared via citrate autocombustion method. Physical properties of composite materials consisting different of polyethylene glycol powder were investigated. With the variation of x; typical magnetic hysteresis loops of composites have been observed in the composites at room temperature. When PEG content increase, the saturation magnetization decrease. Meanwhile, the coercive force tends to stable. Additionally, the dielectric constant (ε') and dielectric loss factor (ε'') of composites materials shift toward higher frequency. The value of ε' decreased with increasing frequency, which indicates that the major contribution to the polarization comes from orientation polarization.

Keywords: poly (ethylene glycol); Polymer Modification; BT/NZF Composites; Dielectric constant; Magnetization

INTRODUCTION

A nanocomposite is a material that contains a reinforcement component in the form of one or more ultrafine phase with dimensions less than 100 nm. The nanocomposite approach has been used to improve various materials properties including mechanical, chemical, structural, optical, electrical and magnetic properties [1, 2]. The multiferroic composites consisting of piezoelectric and piezomagnetic component phases show a magnetoelectric coupling effect (ME) due to the magnetically or electrically induced mechanical deformation between these two phases [3]. To the magnetic field induced ME effect, the applied magnetic field generates a strain in piezomagnetic phase that deforms piezoelectric phase.

As a result, the deformation of piezoelectric phase produces an electric field. Similarly the electrical field induced ME effect can be realized by applying an electric field. The ME effect occurs as a product property between piezoelectric and piezomagnetic phases and is not available in their individual component phases. Ferroelectric materials have wide applications such as nonvolatile memories, capacitors, transducers, actuators, etc. Likewise, magnetic materials are also used in data storage and a variety of other applications. There is great technological promise and fundamental interest if ferroelectricity and ferromagnetism co-exist at room temperature. Further, if there is a coupling between the two order parameters, it should be possible to cause electric polarization by applying either an electric or a magnetic field. Thus writing of a data bit with an electric field and reading it with a magnetic field, and vice-versa, will be possible. This certainly offers additional degree of freedom in device designing [4]. The materials with magnetoelectric (ME) effect are named as magnetoelectric materials, and they are considered to be a kind of promising new materials for sensors, processors, actuators, and memory systems [5].

Wet chemical methods such as co- precipitation, sol- gel, hydrothermal, flash combustion, citrate, and other chemical methods [6] are used for synthesis of multicomponent oxides materials in nanocrystalline size at relatively lower temperature [7, 8]. Among the wet chemical methods, citrate autocombustion using as prepared considered economical means of producing fine particles in nanosize [9]. Magnetic polymer nanocomposites represent a class of functional materials, in which the magnetic nanoparticles are embedded in polymer matrices. These nanocomposites hold immense potential for the new fields of applications as for instance in drug target, electromagnetic devices and industrial autoimmunization besides electromagnetic interference suppression [10-13]. These properties, along with their great physical and chemical stability, make these materials suitable as for magnetic recording media [14, 15]. Polyethylene glycol (*PEG*) is a condensation polymer of ethylene oxide and water with the general formula $H\ (OCH_2CH_2)_nOH$, where n is the average number of repeating oxyethlene groups typically from 4 to about 180. *PEG* is water – solver and in many organic solvents including aromatic hydrocarbons. They are used to make emulsifying agents and detergents, and as plasticizers, humectants, and water- soluble textile lubricants. Polyethylene glycol (*PEG*) is non- toxic, odorless neutral, lubricating, non-volatile and nonirritating is used in a variety of pharmaceuticals and in medications as a solvent.

In the present paper, the main goal is to achieve bi-modal improvement of the physical characteristics of 0.5BT + 0.5NZF nanocomposite due to influence of different concentrations of PEG powder and gain more insight in the morphology and chemical structure of these materials. This is performed through room temperature mixing and cold pressing of the PEG ratio of $0 \leq x \leq 1$.

EXPERIMENTAL DETAILS

Preparation of composite

A wet chemical method; citrate autocombustion method [16] was used to prepare the nominal composition of (1-x) [$Ni_{0.5}Zn_{0.5}Fe_2O_4 + BaTiO_3$] + (x) (PEG); $0 \leq x \leq 1$ system with Stoichiometric compositions of reagent grade Ni (NO_3), Zn $(NO_3)_3 \bullet 5H_2O$, $Ba(NO_3)_2$, tetrabutyl titanate, deionized water, and citric acid used as starting materials. All the reagents were of high degree of purity. Firstly, tetrabutyl titanate was dissolved in citric acid solution and various nitrates were then added, followed by stirring to yield a transparent aqueous solution. The mole ratio of citric acid to the total metal cation content was 1:1. The precursor solution was heated to form a sol and subsequently a gel. The gel was calcined at 700°C for 5 h in air. A part of drying powder added to different ratios of polyethylene glycol (PEG) ; x = 0.1, 0.3, 0.5, 0.7, 0.9 and, 1 (*PEG*) then good grinding to obtain very fine nanocomposite powder. Cold pressing for these composites was carried out using a uniaxial pressure of 8×10^5 N/m^2.

Characterization

Characterization of physical properties of PEG doping BT-NZF composite was carried out using X- ray diffraction, infrared spectrometry, scanning electron microscope, transmission electron microscope, ac electrical conductivity, and magnetic measurements. The crystal structure of BT-NZF composite and their constituent phases were determined by X-ray diffractometer model Proker D_8 with CuK_α radiation (λ = 1.5418°A) in a wide range of Bragg's angle (2θ) ranging from (10°- 70°) at room temperature. The average crystallite size (t) was calculated from X- ray line broadening using (311) peak and Debye- Sherrer's equation [17]; $D = 0.89\ \lambda / \beta \cos\theta$; β is the FWHF and λ is the wavelength of the radiation. The infrared spectra (FT-IR) of the investigated samples recorded on IR spectrometer model JASCO FT / IR – 6100 in the range 4000 to 400 cm^{-1} in the KBr medium. The infrared spectra of the samples were used to provide information about the nature of the interaction of PEG and the composite nanoparticles. The microstructure of the samples was carried out using the scanning electron microscope (SEM) (model JEOL JSM-5600LV). Transmission electron microscope (TEM) of the powder samples was done by model (TEM, JEOL – 1010) used to observe the morphology and particle size of the samples. The hysteresis and magnetization measurements were performed at room temperature in magnetic fields up to 6 kOe using vibrating sample magnetometer (VSM; 9600-1 LDJ, USA). The dielectric constant ('), dielectric loss factor (''), and electrical conductivity was carried out at room temperature using RLC Bridge (Hioki model 3531 Japan) at different temperatures from room temperature and various frequencies from 100 kHz to 5 MHz.

RESULTS AND DISCUSSION

Structure characterization

XRD patterns of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ + (0.5) ($BaTiO_3$); ME composites before doping PEG powder are shown in Fig. (1). It is clear that, there are two phases; single-phase cubic structure $NiZnFe_2O_4$ ferrite (piezomagnetic PM) and perovskite tetragonal crystal structure $BaTiO_3$ (piezoelectric PE). There is no third phase existed in the composites. This means that, no significant chemical reaction takes place during sintering of the mixed powders. The values of lattice constant (a) for our composite is about 8.3883°A for PM and 4.0049°A, c = 4.0048°A for PE phases respectively. The lattice constants are well good agreement with the lattice constants of the components when present as single phases.

Scanning electron microscopic analysis

In order to obtain a super magnetoelectric (ME) effect in the composite, three criteria have to be satisfied [18]: first, no chemical reaction occurs between compositions; second, the resistivety of the piezomagnetic phase should be as high as possible; third, mechanical defects such as pores at the interface between the two phases should not exist. It has already been verified in XRD due to no third phase other than PZT and ferrite indicating there is no chemical reaction. The scanning electron micrographs (SEM) of the investigated samples are shown in Fig. (2). It is clearly seen in the micrographs that, the average grain size of PEG increase with increases the ratio. Typical representative transmission electron micrograph (TEM) of our samples is presented in Fig. (3). Accordingly, the particles are in good spherical and have a crystallite size of 171 nm.

FT- IR analysis

Figure (4) show FTIR spectra of the corresponding pure *PEG* and (BT+NZF) /*PEG* nanocomposites with PEG content of 0, 0.1, 0.3, 0.5, 0.7, 0.9, and 1 respectively in the range 4000– 400 cm^{-1}. It is revealing that, the broad peak observed at 2860 and 1420-1450 cm^{-1} respectively attributed the adsorbed water which are assigned to the vibration of O- H and H- O- H groups [19, 20]. These bands are observed in the all concentrations of *PEG* and as well as in blank *PEG*, but the intensity of these bands are different. The band around 550 cm^{-1} corresponding to the stretching vibration of the interactions produced between the oxygen and the cation occupying the octahedral and the tetrahedral sites

[21]. While, for pure *PEG*, clear bands are observed at around 3200- 3250 cm^{-1} (ν_{O-H}) and 1000- 1030 cm^{-1} (ν_{C-O}) which indicates the presence of –OH and C- O group vibration modes. Bands between 1200 – 600 cm^{-1} and 2880 – 1600 cm^{-1} are corresponding to the plane deformation of C – H group bending and stretching vibrations respectively. The band at 1470 cm^{-1} is due to the stretching vibration of C – C of *PEG* [22]. The above bands show a change in intensity and positions with the different concentrations of PEG. Besides, when the PEG content is greater than 50%, the FTIR spectra of the (BT-NZF) / PEG composites are almost the same as that of normal PEG sample [23]. As shown in the figure, with the increase of PEG content, the intensity of the band at 570 cm^{-1} corresponding to (BT-NZF) composite [24] increased distinctively, and those bands corresponding to PEG characteristics, such as 2900 cm^{-1}, shift to higher wave numbers. This indicates that there is some interaction between PEG and (BT-NZF) nanoparticles. Moreover, the adsorbed water is featured by bands at 3420 and 1620–1630 cm^{-1}, which are assigned to O–H stretching and H–O–H bending modes of vibration [25, 26]. These bands are observed in all the PEG coated and as well as in blank PEG but the intensity of these bands is different.

Electrical conductivity

Figure (5: a, b) shows the variation of dielectric constant (ε') and dielectric loss factor (ε'') with frequency as a function of PEG content (x). It is evident that the dielectric constant and loss factor decrease with increasing both frequency and PEG content (x) giving rise the same trend but with different values. In the starting low frequency range both (ε') and (ε'') have higher values. As the frequency increased both ε' and (ε'') are decreased and become almost constant up to 1 MHz for all compositions. The observation may be explained on the basis of dipole relaxation [27] indicating the inability of the electric dipoles to follow up the field variations. The low frequency dielectric dispersion was increased with the increase in PEG concentration. This due to the fact that, the ferroelectric regions are surrounded by nonferroelectric ones as the case of relaxer ferroelectric materials [28], resulting in interfacial polarization because the two media have different permittivities and conductivities, the applied electric field will produce space charges provided by the NZF phase which accumulated at the inter face of the two phases. This indicates that the dielectric constant of NZF/BT can be improved by introducing PEG.

Variation in electrical conductivity of the composite materials at different PEG content (x) is shown in Fig. (6: a, b). It is clear that, the value of conductivity decreases with increase (x) up to 0.5 then increases. Fig. 9b indicated the effect of different PEG on the electrical conductivity of the magnetoelectric composites NZF/ BT. It is clear that, the doping increasing ratio of PEG decreases the conductivity up to x=0.5 then increases. This may be attributed to the difference in the conductivity of ferrite and ferroelectric phases as well as the conductivity of composite is an effective of its constituent phases. The maximum conductivity is observed at x = 0.5 perhaps due to the addition of conductivity of the constituent phases. Moreover, the increase in conductivity of the composites as compared to constituent phase may be ascribed to the serial arrangement of ferrite and ferroelectric grains with adding PEG content. [29].

The dielectric loss factor (□'') is as displayed in Figure (7). The dielectric loss factor is considered to be the most important part of the total core loss in composites [30]. The dielectric loss factor is seen to be similar to that of dielectric constant as in Fig. (8). The low dielectric loss values make these composites to be used in the higher frequency applications. The low dielectric parameters obtained for the present samples and the small abnormal behavior was observed at lower frequencies is due to the collective contribution of both positive and negative (p, n) charge carrier [31] where the electronic exchange between Fe^{2+} Fe^{3+} are responsible for such behavior. Furthermore, the jumping frequencies of localized charge carrier are almost equal to that of the applied a. c. electric field.

Figure (9) shows plots of ln□ against f (Hz) at different PEG content (x). It can be seen that plots are straight lines indicating the dependence of conductivity with frequency the investigated samples. It is clear that, the hopping of electron between Fe^{2+} and Fe^{3+} ions on the octahedral sites is responsible for conduction in ferrites. Also hole hopping between Ni^{2+} and Ni^{3+} on B site will also contribute to electric conduction in ferrites. The frequency dependence can be explained with the help of Maxwell–Wagner two-layer model or the heterogeneous model of the polycrystalline structure of ferrites [32] According to this theory, two layers formed dielectric structure. The first layer consists of ferrite grains of fairly well conducting (ferrous ions), which is separated by a thin layer of poorly conducting substances, which forms the grain boundary. These grain boundaries are more active at lower frequencies; hence the hopping frequency of electron between Fe^{3+} and Fe^{2+} ion is less at lower frequencies. As the frequency of the applied field increases, the conductive grains become more active by promoting the hopping of electron between Fe^{2+} and Fe^{3+} ions, thereby increasing the hopping frequency. It was also noticed that this remains the same for samples with different volume fractions of the magnetic filler.

Magnetization measurements

In order to study the effect of PEG on the magnetic behavior of the investigated composite, magnetization measurements were performed. Figure (10) illustrated the variation of hysteresis magnetic loops of composite (1-x) [$Ni_{0.5}Zn_{0.5}Fe_2O_4$ + $BaTiO_3$] + (x) (PEG); $0 \leq x \leq 1$. It is clear that, composites materials exhibit typical magnetic hysteresis of the magnetic materials, indicating that the composites are magnetically ordered. Moreover, it could be observed that there is no hysteresis and a complete reversibility at 300 K was found: it is more clearly denoted in the inset of Fig. 10, where neither coercivity nor magnetic remanence in the composite is observed corroborating with a typical superparamagnetic behavior [33],

The variation of the magnetization parameters such as saturation magnetization (M_s), remanence magnetization (M_r), and M_r/M_s of the composites with different PEG content (x) is plotted in Fig. 11a and Table (1). It is clearly indicated that, M_s of the composites decreases linearly with the increasing PEG content. These reductions are mainly due to the finite size effect of the nanoparticles (NZF) besides to the contribution of the volume of the nonmagnetic (PEG) coating layer to the total sample volume. While the saturation magnetization of $BaTiO_3$ is unity due to its inherent nonmagnetic nature and magnetic nature of PEG. Therefore, the magnetization parameters (M_s and M_r) of composites decreases linearly with the increasing PEG content while the ratio Mr/Ms is still constant. in the other words, the nonmagnetic coating layer can be considered as a magnetically dead layer at the surface, thus affecting the uniformity or magnitude of magnetization due to quenching of surface moments [34]. Fig. 11b shows the dependence of the coercivity of the composites on x. It is clearly indicated that the coercivity has high value for all the concentrations, indicated that, although the particles are nanoscale, they are not superparamagnetic. While at x=0.5, H_c =0 where the coercivity sharply decrease which may be caused by the inhomogeneous distribution of PEG phase around the NZF/BaT phases.

CONCLUSION

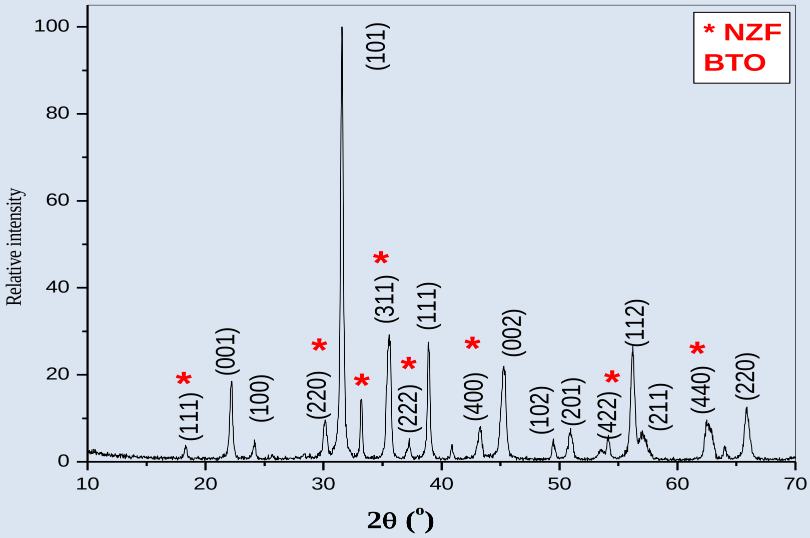
The investigations of the barium ferrite powders and tested composites consisting of (1-x) [$Ni_{0.5}Zn_{0.5}Fe_2O_4$ + $BaTiO_3$] + (x) (PEG); $0 \leq x \leq 1$ as a ferrite phase and $BaTiO_3$ as a ferroelectric phase, were prepared using the citrate autocombustion method allowed to formulate the following statements:

1. The X-ray diffraction enabled the identification of both ferrite and ferroelectric phases before adding PEG content
2. SEM images reveal that the shape of PEG particles is irregular while the size increase with increases PEG ratio.
3. The grains of the Ni ferrite are at nanoscale. This is very advantageous for gas sensing applications as smaller grains have a larger specific area and as a result a higher response to analyst gases.
4. Since the conductivity of the composite increases with increase PEG content, Composites with x = 0.5 composition shows maximum conductivity at room temperature.
5. The frequency dependent ac conductivity measurements suggest that conduction is due to small polaron hopping.
6. The dielectric behavior of composites shows normal as well as diffuse phase transition, which is explained in terms of heterogeneity of the samples and ordering of micro regions of spontaneous polarization.
7. The decrease in ε' with increase of frequency is due to the orientation polarization indicates that the dielectric constant of NZF/BT can be improved by introducing PEG.
8. The increase in conductivity of the composites as compared to constituent phase may be ascribed to the serial arrangement of ferrite and ferroelectric grains with adding PEG content.

9. Saturation magnetization of the composites decreases linearly with the increasing PEG content due to the finite size effect of the nanoparticles (NZF).
10. Coercivity has high value for all the concentrations except x=0.5 give H_c =0
11. The efficacy of organometallic block polymers as nonreactors can be used to template and synthesized nanoparticles at room temperature.
12. The composites with doping PEG polymer may be useful for technological applications such as thermistors, transducers, magnetic probes, etc.

REFERENCES

[1].S. Taylor, L. OU, Biomacromolecules, **5** (1) (2004)245.
[2] A. Vila, A. Sanchez, M. Tobio, Journal of Controlled Release, **78** (2002) 15.
[3] V. M. LALETIN, *Sov. Tech. Phys. Lett.* **17** (1991) 1342.
[4] VR. Palkar, SK. Malikm, Solid State Commun **134** (2005) 783.
[5] YH. Tang, XM. Chen, Li YJ, XH. Zheng, Mater Sci Eng B **116** (2005) 150.
[6] T. Hyeon, Chem. Commun., **8** (2003) 927.
[7] F. Li, K. Hu, J. Li, D. Zang, G. Chen, J. Nucl. Mater., **300** (2002) 82.
[8] S. Vivekanandhan, M. Venkateswarlu, N. Satyanarayana, J. Mater. Litt., **58** (2004) 2717.
[9] R. V. Upadhyay, R. V. Metha, K. Parekh, D. Srinivas, R. P. Pant, J. Mag. Mag. Mater., **20** (1999) 129.
[10] J.S.Salafsky, Phys. Rev. B. **59** (1999)10885
[11] S.J. Su, N. Kuramoto, Synth. Met. **114** (2000)147.
[12] L.J.Zhang, M.X. Wan, J. Phys. Chem. B**107** (2003) 6748
[13] A. Dey, S. De,A.De, S.K. De, Nanotechnology **15** (2004) 1277.
[14] R. Skomski, J. Phys.: Condens. Matter, **15** (2003) R1 – R**56.**
[15] Haitao Zhap, Xudong, Changhui Mao and Jun Du, Physica B **404**(2009)69
[16] Xu, Q., Chen, X. L., Chen, W., Chen, M., Xu, S. L., Kim, B. H. *et al.*, *Mater. Sci. Eng. B*, **130** (2006) 94.
[17] B.D.Cullity, elements of X –ray diffraction, Addison Wesley, M A, (1978).
[18] J. Ryu, S. Priya, K. Priya, K. Uchino, H. Kim, J. Electroceram. **8** (2002) 107.
[19] M. S. Hegde, D. Larcher, L. Dupont, et al., Solid State Jon. **93** (1997)33.
[20] L. B. Newalkar, S. Komarneni, H. Katsuki, Mater. Res. Bull., **36** (2001) 2347.
[21567.
[22] Anuar Kassim, H.N.M. Ekarmul Mahmud, Lim Mei Yee and Nurain Hanipah, The pacific journal of science and technology, **7, 2** (2006) 103.
[23] R. Kostic, D. Rakovic, S.A. Stepanyan, I.E. Davidova, L.A. Gribov, J. Chem. Phys. **102** (1995) 3104.
[24] Y. Tamaura, P.V. Buduan, T. Katsura, J. Chem. Soc. Dalton (1981) 1807.
[25] M.S. Hegde, D. Larcher, L. Dupont, et al., Solid State Ion. **93** (1997) 33.
[26] L.B. Newalkar, S. Komarneni, H. Katsuki, Mater. Res. Bull. **36** (2001).] M. A. Ahmed, En El- Khawas, M. Y. Hassan,et al.,Indian J.Phys.,**74** (2000)
[27] D.H. Wang, W.C. Goh, M. Ning, C. K. Ong, Appl. Phys. Lett. **88** (2006) 212907.
[28] K.K. Patankar, S.A. Patil, V. Sivakumar, R.P. Mahajan, Y.D. Kolekar, M.B. Kothale, Mater, Chem. Phys. **65** (2000) 97.
[29] C. P. Smyth, *Dielectric behavior and Structure*, McGraw Hill, (New York. 1955), p. 53.
[30] R. V. Mangalaraja, S. Ananthakumar, p. Manohar, F. Gnanam, J. Mag. Mag. Mater, **253** (2002) 56.
[31] H. I. Gul, A. Maqsood, J. Alloys Comps. **465** (2008) 121.
[32] C G Koops *Phys. Rev.* **83** (1951) 121
[33] B.D. Cullity, Introduction to Magnetic Materials, Addison Wesley Publishing Company, (1972).
[34] R. Kaiser, G. Miskolczy, J. Appl. Phy. **41** (1970) 1064.



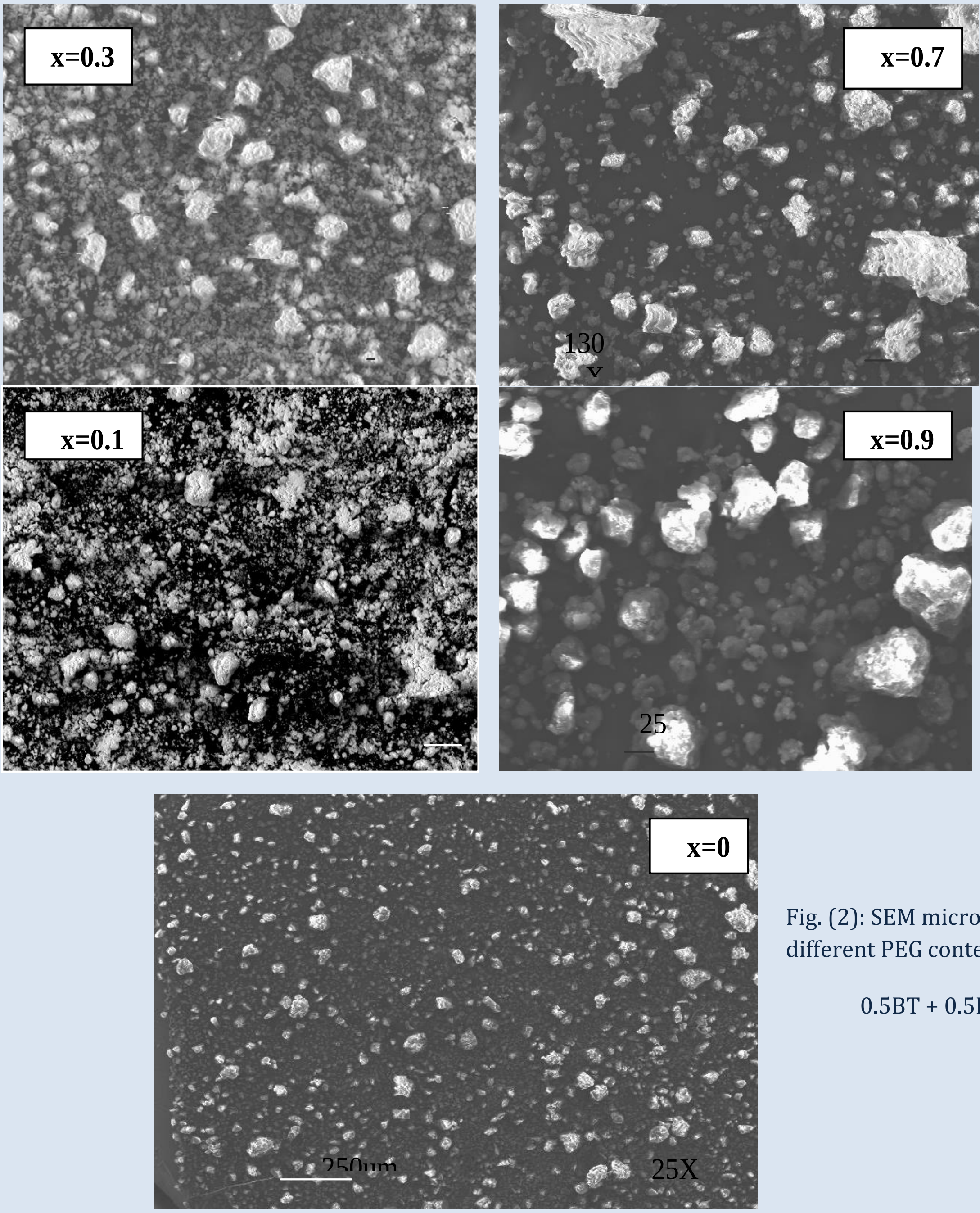


Fig. (2): SEM micrograph for different PEG content for

0.5BT + 0.5NZF

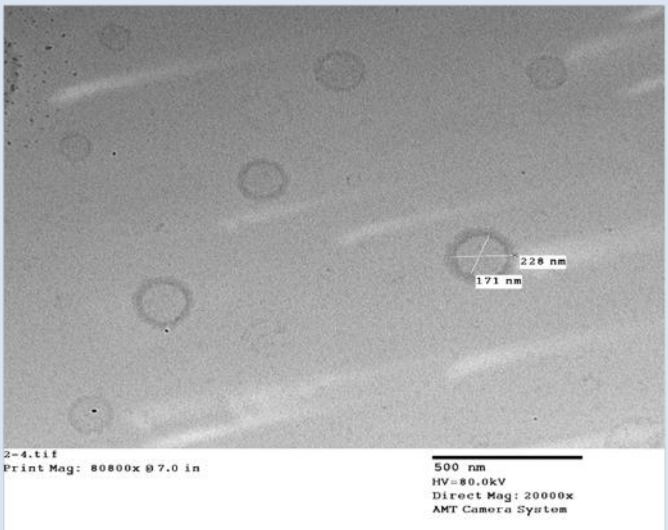


Fig. (3): TEM for 0.5BT + 0.5NZF nanocomposite

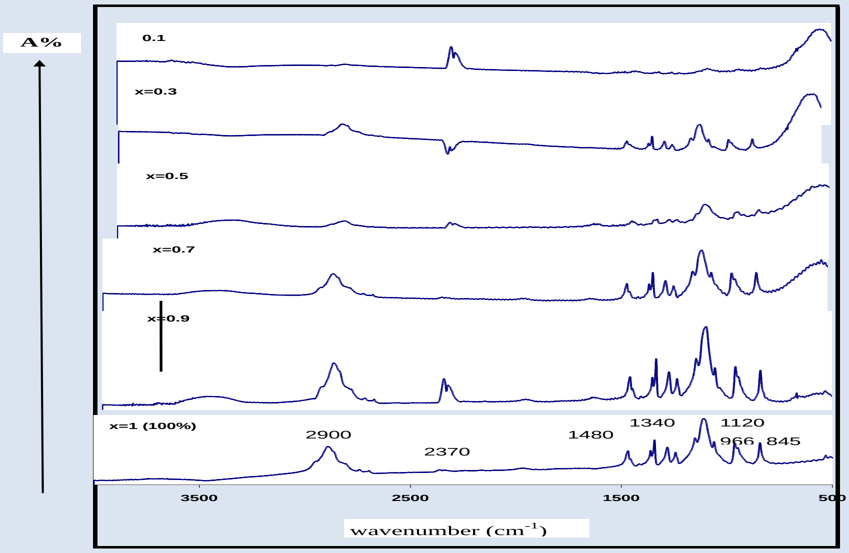


Fig. (4): FT- IR spectra of pure PEG and 0.5BT + 0.5NZF nanocomposite doping different PEG content (x).

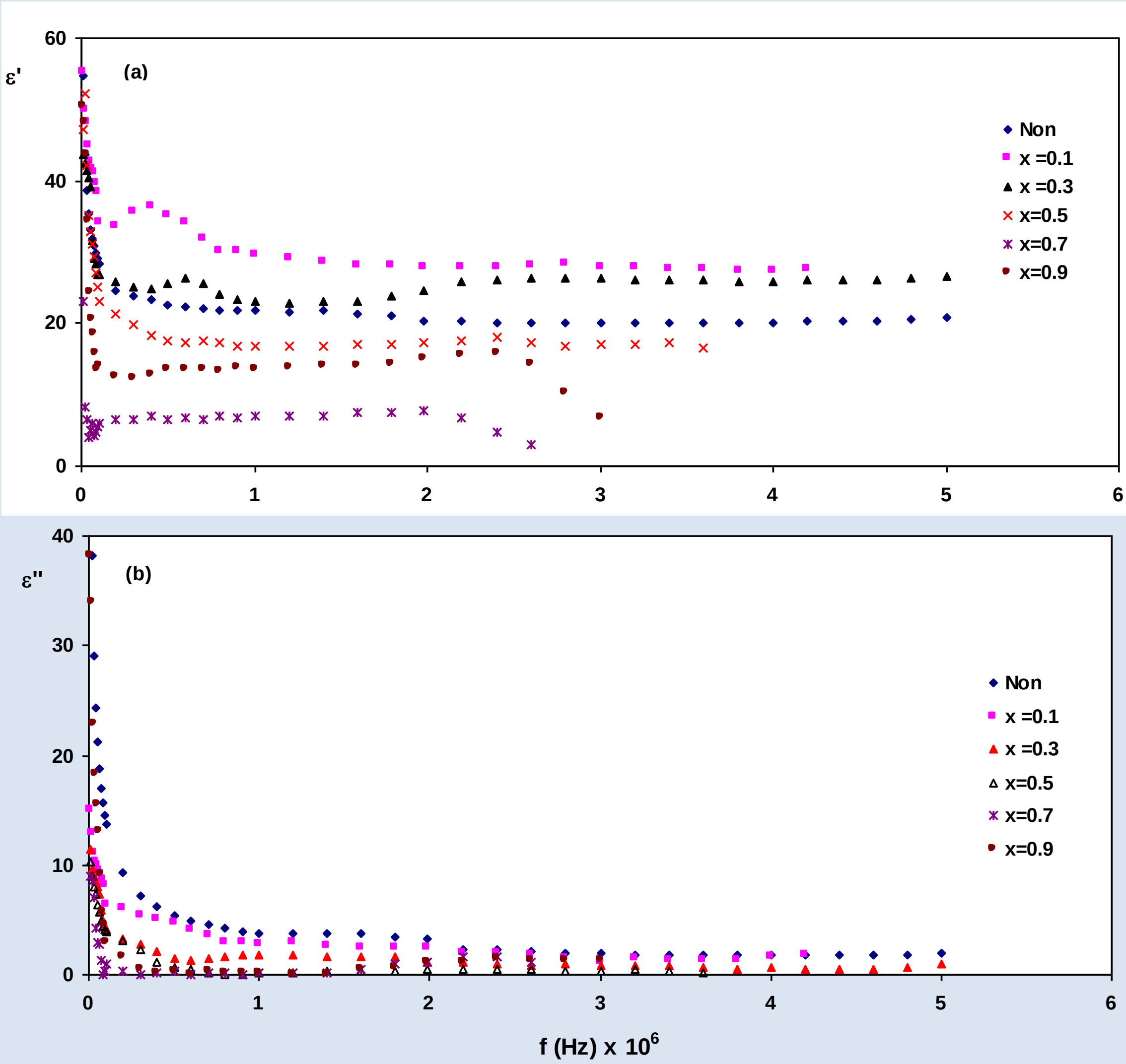


Fig. (5: a, b): a. Effect of applied frequency on dielectric constant (ε') at

different PEG conce f (Hz) 5BT + 0.5 NZF nanocomposite.

b. Effect of applied frequency on dielectric loss (ε'') at different

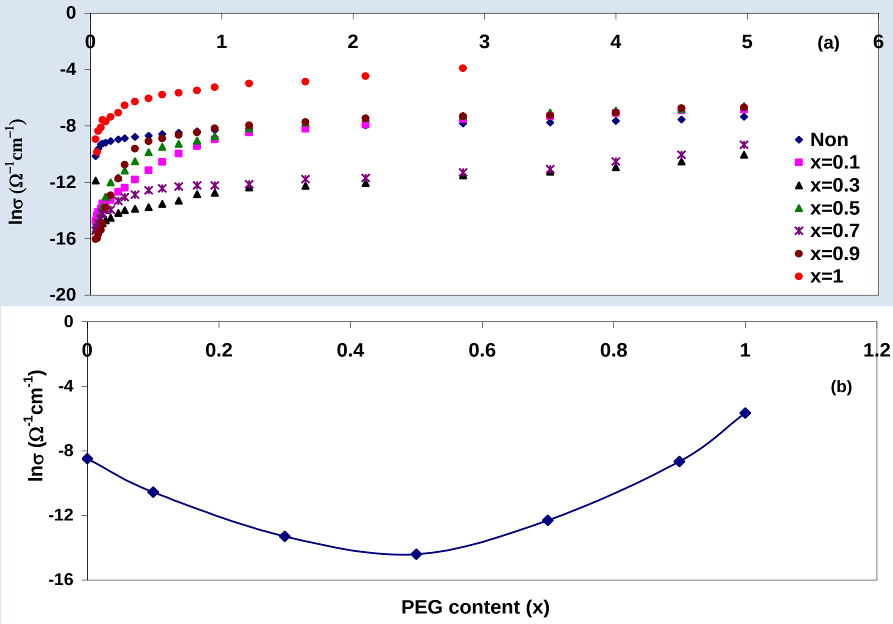


Fig. (6: a, b): a. Variation of electrical conductivity *(lnσ) at different PEG content*

(x) for BT /NZF nanocomposites.

b. Effect of different PEG concentration on the electrical

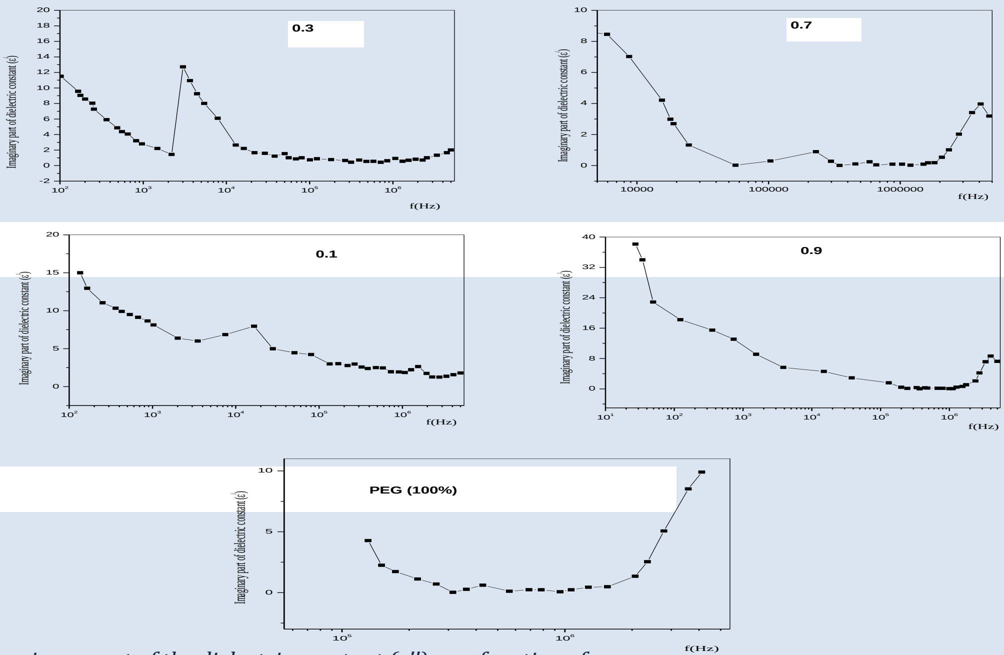


Fig. (7): Imaginary part of the dielectric constant (ε'') as a function of

frequency at different PEG content (x) for 0.5BT + 0.5 NZF

nanocomposite.

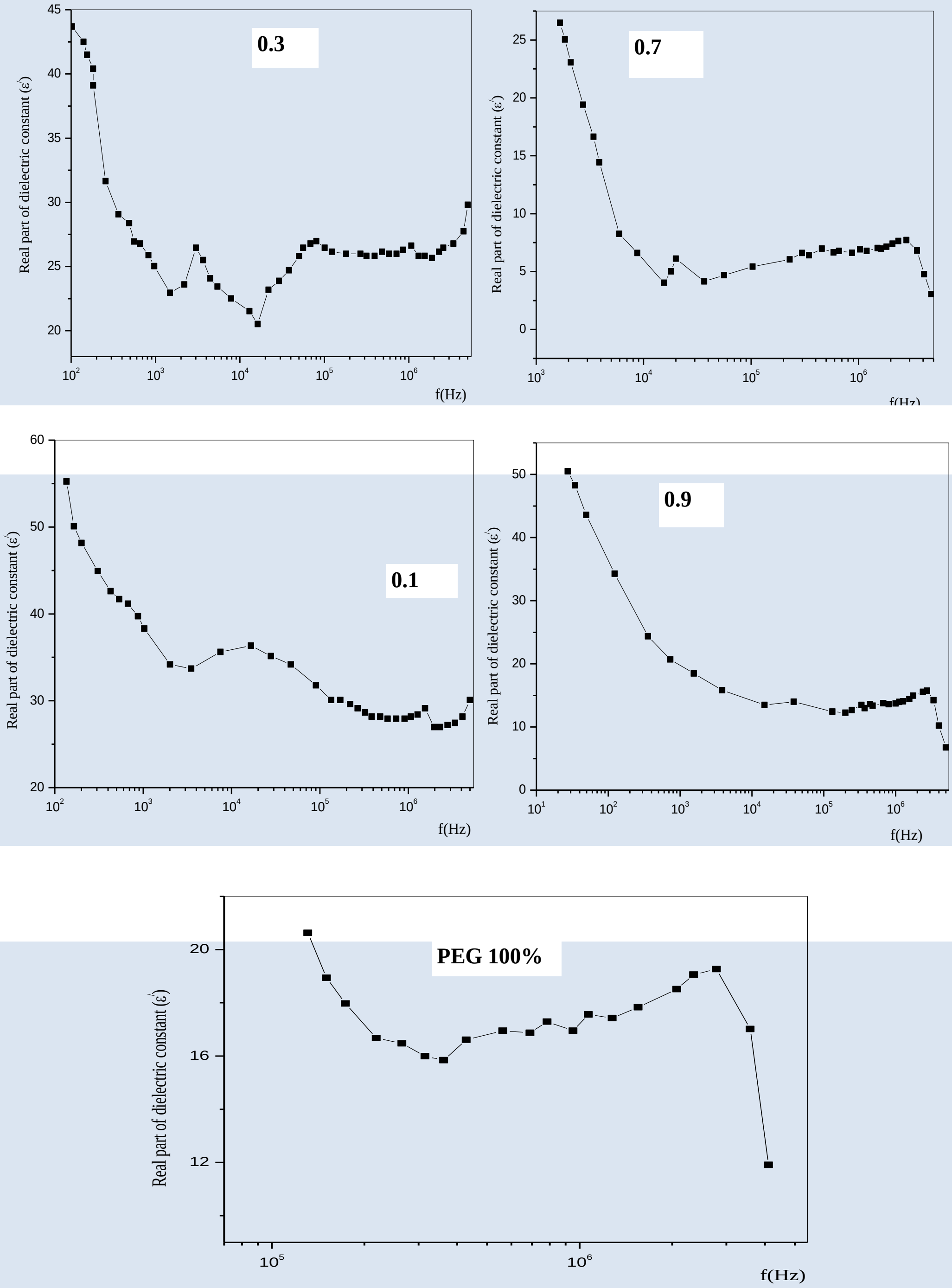


Fig. (8): Real part of the dielectric constant (ε') as a function of frequency at different PEG content (x) for 0.5BT + 0.5 NZF

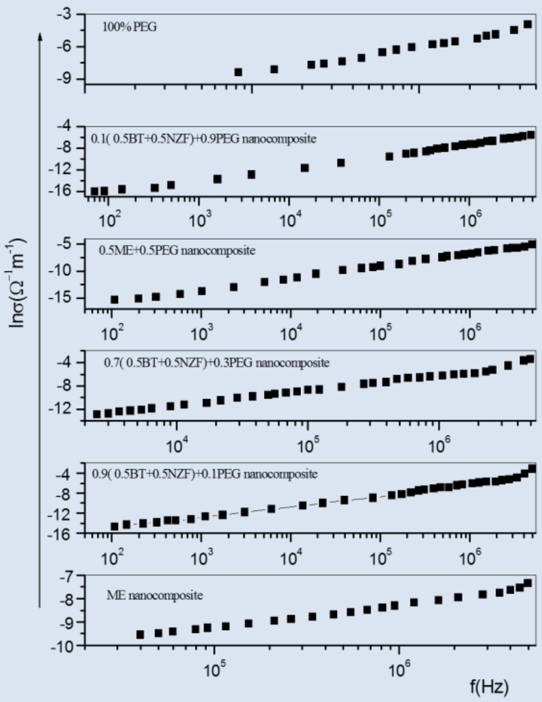


Fig. (9): Electrical conductivity versus frequencies of (1-x) (0.5BT + 0.5 (NZF) + (x) PEG nanocomposites; x= 0, 0.1,0.3, 0.5, 0.7, 0.9 and, 1.

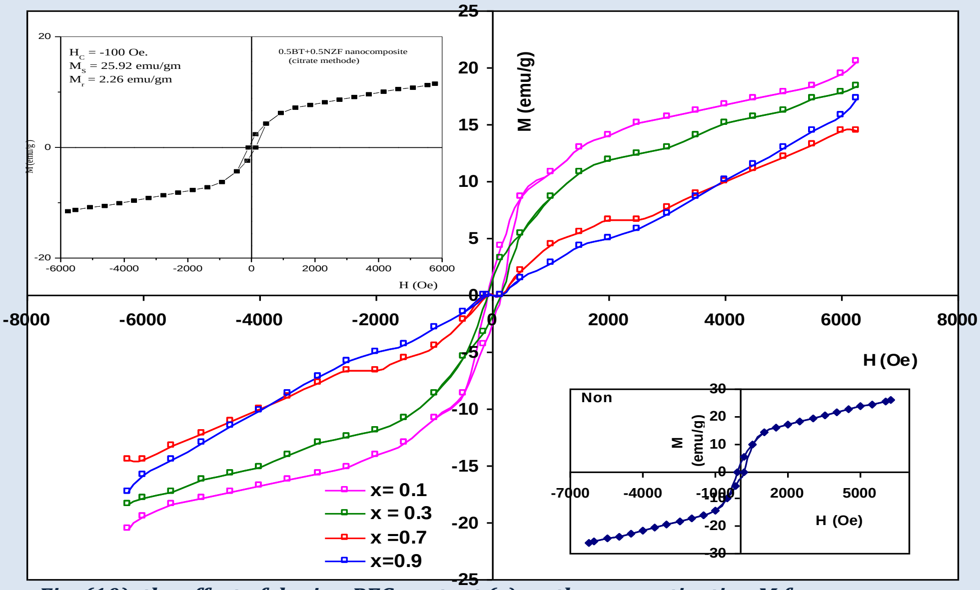


Fig. (10): the effect of doping PEG content (x) on the magnetization M for

(1-x) (0.5BT + 0.5 (NZF) + (x) PEG nanocomposites; x= 0, 0.1,

(a)

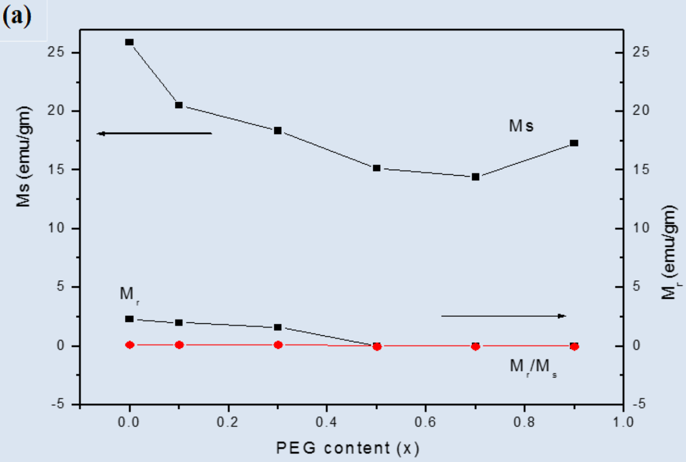


Fig. (11a) : *Magnetic parameters ; M_S, M_r and M_r/M_S of* (1-x) (.5BT+0.5NZF)+ (x)PEG nanocomposite for different PEG content (x)

(b)

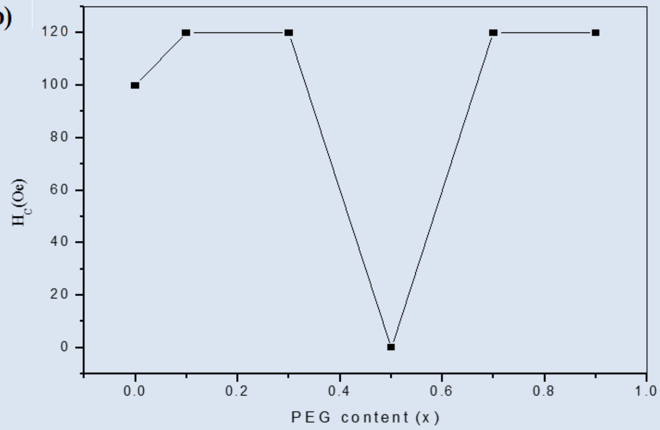


Fig. (11b): *Magnetic coercive field of* (1-x) (.5BT+0.5NZF)+ (x)PEG nanocomposite for different PEG content (x)

Table (1): the effect of PEG content (x) on the magnetization parameters for (1-x) (0.0NZF)+ (0.5BT)/ (x) PEG; $0 \leq x \leq 1$ nanocomposites.

x	M_s	M_r	M_s/M_r	H_c
Non	25.92	2.26	0.087	100
0.1	20.52	2	0.097	120
0.3	18.36	1.6	0.087	120
0.5	15.18	0	0	0
0.7	14.4	0	0	120
0.9	17.28	0	0	120

THEME 4: CLIMATE CHANGE AND FOOD SECURITY

Appreciation of Issues of Climate Change and Food Security among Female Undergraduates: Implications for Success in Mitigation

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ABSTRACT

Climate change and food security are critical and important 21st century themes that elicit a consensus of their global occurrence and impact. It is important that female undergraduates in universities in the developing world should have a good knowledge concerning these issues. This study was prompted by the importance of climate change and food security in recent times. As a preliminary study, 20 science-based female undergraduate students of Nnamdi Azikiwe University, Awka, Nigeria, were randomly selected and interviewed for a quick test. Although they all answered 'yes' to the question: 'Do you understand what is meant by climate change?', 9 out of 20 of them did not know what greenhouse gases were and 10 out of 20 did not know whether or how mitigation was possible. To further assess the level of background knowledge, 200 female undergraduates were randomly selected and a questionnaire: climate change and food security (CCFS) was used to collect data for the study. Sixteen research questions were formulated to guide the study and data obtained were analysed using means and percentages. The results obtained showed that there was a low level of appreciation of issues of climate change and food security, as well as measures of mitigation. The level of understanding was more in the young females within the 21-25, 26-30 age group than the freshly-admitted 17-20 years group. The developing countries have been impacted negatively by climate change and food security and it is crucial that women should have a thorough understanding of the issues on climate change to order to join the debate. Women are needed to develop cheap and effective strategies, adaptive technologies for mitigation. These young female adults would become mothers and are expected to pass the information to the next generation. Recommendations include more awareness creation than currently exists.

INTRODUCTION

Climate change is the variation in global or regional climates over time and reflects changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years [1]. These changes can be caused by processes internal to the Earth, external forces or, more recently, human activities [2], [3]. Food security is a related term and refers to the availability of food and one's access to it on a stable basis and in a sustainable way. A household is considered food-secure when its occupants do not live in hunger or fear of starvation [4]. For approximately 2 billion people throughout the world, this security is anything but guaranteed [5].

Major scientific agencies of the world agree that climate change is occurring and that humans are contributing to it. In 2010, the National Research Council in the United States concluded that climate change is occurring, is very likely caused by human activities, and poses significant risks for a broad range of human and natural systems [2]. Many independent scientific organizations have released similar statements, both in the United States and abroad. The global average temperature increased by more than 1.4°F over the last century. In fact, according to the National Oceanic and Atmospheric Administration (NOAA) [6], the decade from 2000 to 2010 was the warmest on record, and 2010 was tied with 2005 as the warmest year on record. Rising global temperatures have also been accompanied by other changes in weather and climate. Many places have experienced changes in rainfall resulting in more intense rain, as well as more frequent and severe heat waves. For example, between the months of May to June, 2013, there have been floods in Europe: Germany, Budapest, Czech Republic, and Ukraine [7], [8]. Also affected by floods are regions in India, China, Japan, Pakistan and Mozambique [9]. At present, the super typhoon Utor has made landfall in the island of Phillipines, leaving a massive destruction in its wake [10].

Climate change and food security are related issues. Food insecurity results from climate change, urban development, population growth and oil price shifts that are interconnected and rarely confined by borders [2]. It's an issue of global importance, and explored in-depth in articles, videos and comments [4], [6], [11]. Several converging threats – from climate change, population growth and unsustainable use of resources – are steadily intensifying pressure on humanity and world governments to transform the way food is produced, distributed and consumed [12]. Our climate is changing and, given the levels of greenhouse gases already in our atmosphere, will continue to do so [13]. Areas currently suffering from food insecurity e.g. Africa is expected to experience disproportionately negative effects on, for example, food supplies, livelihoods and economies. it Climate change amplifies the environmental and socioeconomic drivers of food insecurity causing a rise in the sea level, affecting fishing communities (both men and women) not only in terms of fish-catch but also with regard to water scarcity, as seawater gets into fresh water. Also, when the land is inundated, infrastructure (roads and houses) are damaged. Large scale migration from inundated areas is expected and much of the burden of migration falls on women. Some of the world's major food producing regions lies in mega-deltas which are threatened by escalating rates of saltwater intrusion [13]. In Africa, the pronounced gaps between actual and potential crop yields and shrinking per capita land base inhibit food security [14].

Controversies exist concerning the issues of climate change and food security. Primary issues concerning the existence and cause of climate change include the reasons for the increase seen in the instrumental temperature record [15], whether the warming trend exceeds normal climatic variations [16], whether humankind has contributed significantly to it [2]. Scientists have resolved many of these questions decisively in favour of the view that the current warming trend exists and is ongoing, that human activity is the primary cause, and that it is without precedent in at least 2000 years. Additional disputes have concerned estimates of how responsive the climate system might be to any given level of greenhouse gases, projections of continued warming in response to the existing build up of greenhouse gases plus future emissions, and what the consequences of global warming will be. Although the primary issues are regarded in the scientific literature as settled, these additional disputes are still the subject of mainstream scientific debate [17]. Multiple emergent challenges – food insecurity and under-nutrition, climate change, increasing competition for energy and water, degradation of land and biodiversity–are connected in complex ways and demanding integrated management approach. The issue at hand is climate change, and it has literally and figuratively taken every corner of our world by storm. People are increasingly aware that this environmental threat could be the defining issue of our time [18], [19]. Scientists continue to research these questions so society can be better informed about how to plan for a changing climate. However, enough certainty exists about basic causes and effects of climate change to justify taking actions that reduce future risks [13].

Women are the key to agriculture and food security because the face of agriculture around the globe is often female [21]. Women produce more than half of the world's food, yet own only two percent of titled land and receive less than ten percent of the income [20]. In many of the world's regions, women work alongside with men in the fields that provide nourishment and income for their families. They contribute to commercial agriculture, which includes high-value products such as vegetables and cut flowers for local and export market. When women farmers have the opportunity to earn and control income, they are more likely to focus their spending on their children's nutrition, education and health. Women are integral to alleviating hunger and malnutrition because they are primarily responsible for ensuring that food for their families is reliably available, accessible and nutritionally-balanced. It is important that women are viewed as primary food providers for their families as well as key players in efforts to expand commercial agriculture to grow nations' economics. Women are particularly vulnerable to climate change because they are more prone to the adverse impacts from climate change. Their limited adaptive capacities arise from prevailing social inequalities and ascribed social and economic roles that manifest itself in differences in property rights, access to information, lack of employment and unequal access to resources. Furthermore, changes in the climate usually impact on sectors that are traditionally associated with women, such as paddy cultivation, cotton and tea plantations, and fishing. This means increased hardship for women [21]. It is imperative from the fore going that young women should be aware of the issues of climate change and food security since, like it or not, they will be impacted by their effects. It is important to be aware of the current burning issues so as to flow with the times. The female undergraduates will be considered 'educated' at the end of the day and would be required to lead, and pro-actively, on issues that impact women. The extent to which the female undergraduate understands the issues involved in climate change and food security is the subject of this study.

Research Questions

The following research questions were formulated to guide the study:

- To what extent do the female undergraduates understand the issues involved in climate change and food security?
- What are the perceptions of the undergraduates about the current debate in climate change and food security?
- To what extent do the undergraduates understand sustainable mitigation strategies?

METHODS

A descriptive survey design was used in this study. The study was carried out in Nnamdi Azikiwe University, Awka, Nigeria. Random sampling was used to select a sample of 200 female undergraduates within the ages of 18-35 years. A sixteen item structured questionnaire development was used to collect the data. The questionnaire was in three sections. Section A was used to collect information on the age group, course specialisation and year of study of each respondent. Section B was formulated using the 4-point Linkert scale [22] where the respondents expressed their level of agreeing or disagreeing with the items. Section B was weighted thus: Strongly Agree (SA) = 4; Agree (A) = 3; Strongly Disagree (SD) = 2; Disagree = 1. Any item with a mean lower than 2.50 was rejected while any item greater than the mean of 2.50 was accepted. Section C consisted of open-ended questions where the undergraduates had the choice of ticking which item was satisfactory or not satisfactory to them. Two experts in Department of Statistics of Nnamdi Azikiwe University, Awka validated the instrument. The researchers administered copies of the instrument to a sample of 20 respondents that were not part of the study sample. Copies of the questionnaire were distributed to the respondents and were collected as soon as they were done. Data collected were analysed using means and percentages.

RESULTS

A total of 200 female undergraduates belonging to 10 different areas of disciplines were sampled for the study. The different age groups of the female undergraduates and their various areas of disciplines are as shown in Table 1(a). The respondents belonged to a total of 10 departments across the life sciences. Table 1(b) indicates the year of study of the respondents against the age groups. There were more female undergraduates in the 17 - 20 age groups than in any other group with a higher percentage of 34.5%

Table 1(a): The age group of the respondents and their area of discipline.

	Total No. of students in the Department of										
Age group	*MCB	BCH	ZOO	BOT	PARA	CSC	GEOL	BIO/EDU	PHY	STAT	TOTAL
17 – 20	53	12	14	27	8	8	6	6	1	3	138
21 – 25	28	1	7	10	6	-	1	2	1	-	56
26 – 30	2	-	-	2	-	-	-	-	-	-	4
31 – 35	8	-	1	1	-	-	-	-	-	-	2
Total	81	13	22	42	14	8	7	8	2	3	200

*MCB-Microbiology; BCH-Biochemistry; ZOO-Zoology; Para-Parasitology/Entomology; CSC-Computer Science; GEOL-Geology; BIO/EDU-Biology Education; PHY-Physics; STAT-Statistics.

Table 1(b): The total number of female undergraduates and their year of study.

Year of study	Total number of students'	% of Total
1	69	34.5
2	43	21.5
3	41	20.5
4	47	23.5
Total	200	100

Table 2 shows the extent of appreciation of the subject of food security and climate change. The female undergraduates showed an appreciation of the subject of food security and its relation with climate change. There was an agreement about the role of the government in the worsening of the problem contributing to food shortage. The respondent agreed that climate was related to food and that something needs to be done to increase agricultural inputs and towards a greater food production and security. A good percentage (40) agreed that mitigation measures should be put in place but they did not know about any specific measure (10). Women

Table 2: Female undergraduates' appreciation of food security and climate change

Reasons	**SA**	**A**	**SD**	**D**	**Ẍ**
1. Food security is when all people have physical and economic access to basic food	25	13	21	36	2.6
2. Food security is presently guaranteed for everybody in the world	17	53	39	56	2.2
3. Food security is a political issue and must be left only for the government officials	10	16	75	68	1.8
4. Government's chronic mismanagement can lead to gross food shortages	84	72	13	11	3.2
5. Food security is an issue of global importance and should concern us all	93	83	9	10	3.3
6. Climate change and food security are interconnected	54	83	5	11	3.1
7. The supply of food has suffered erratically due to climatic calamities	47	93	14	25	2.9
8. Food security is a problem only in the developing poor countries	20	68	33	52	2.3
9. Famines are by brought on by an increase in human numbers	19	76	27	41	2.4
10. Hunger in one country can affect neighbouring countries	19	77	18	35	2.4
11. Food security is more a problem of people than that of a country's political economy	19	72	49	43	2.4
12. Food security is one of the biggest problems of the 21st century	42	68	15	14	3.0
13. Mass urban migrations do not affect food security in a country	17	35	57	60	2.1
14. Biological approaches can enhance global food crop production	77	80	3	4	3.4

Table 3: Background knowledge of the female undergraduates of climate change and food security

Level of understanding	Percentage (%)
▪ I know what climate change are	95
▪ I have seen evidence of climate change	20
▪ I am aware of global warming	70
The importance of the issue	
▪ A slight change in climate can affect humans	25
▪ CO_2 emissions are harmful	10
▪ The earth is warmer today than before	60
Who to blame	
▪ The government	70
▪ Human beings in general	35
Knowledge of specific terms	
▪ I know about green house gases	35
▪ I know about the ozone layer	30
▪ I know about CFCs	10
Measures of mitigation	
▪ Something can be done	40
▪ I know of at least one measure	10
▪ Useful measures can help in alleviation	50
Role of women	
▪ Women are needed in the measures	70
▪ Women can help	40
Way forward	
▪ Prompt action needed	35
▪ Mitigation measures can work	10
▪ People should get serious	15
▪ It is not too late to act	45

The responses of the open-ended questions provide additional insight into the undergraduates' background and interest in the issues. In item one, 95% has heard about climate change and global warming. However, in the knowledge of specific terms, especially terms like CFCs, eco-friendly environments, carbon emissions, going green, and the respondents (10%) stated that they did not know. They agreed that women could be important players (70%) and that they should help. However, they did not know of cheap technologies that can be used to alleviate the problem. For the way forward, 45% said that it was not too late to act.

DISCUSSION

From the responses to the items in Table 2, it can be seen that the items with means greater than 2.5 were the items accepted. The other items in the Table that had means lower than 2.5 were rejected. The female undergraduates were found to have related more to terms they must have heard over time. For example, the definitions of food security was accepted; it was agreed that the government had a role to play in the worsening situation; that food security was related to climate change; food security was one of the biggest 21st century issues and that biological approaches were needed to enhance global food production. However, in the specific terms of what women should do; how women should help; what technologies to use; the role of women in the issues;

the role of the individual women in the mitigation measures; there were weak responses or lack of knowledge.

Nigeria has one of the lowest rates of female entrepreneurs. The majority of the women are concentrated in the casual, low skill and low-paying formal sector [23]. As has already been mentioned, the Nigerian female undergraduate should be made aware of her position, especially since she is counted as educated. Some of her counterparts outside of her environment are not as fortunate. In Nigeria, two thirds of illiterate adults are female [23]; girls' school drop-out rates are high Nigeria has the highest of out of school children in the world. Nigeria ranks 118 out of 134 countries in the Gender Equity Index. [24], [25].

Climate change and food security effect more impact on women as already noted by Parikh, (2001) [21]. According to him, women are particularly vulnerable to climate change because they are more prone to the adverse impacts from climate change. Their limited adaptive capacities arise from prevailing social inequalities and ascribed social and economic roles that manifest itself in differences in property rights, access to information, lack of employment and unequal access to resources. Further, changes in the climate usually impact on sectors that are traditionally associated with women, such as paddy cultivation, cotton and tea plantations, and fishing. Women bear a disproportionate burden of climate change consequences. With changes in climate, traditional food sources become more unpredictable and scarce. This exposes women to loss of harvests, often their sole sources of food and income. Women are more dependent for their livelihood on natural resources that are threatened by climate change.

It is important that more awareness should be created for a better understanding of the issues and a resolve not only to join the debate but to join hands in the measures for alleviation.

RECOMMENDATIONS

This study showed the depth of awareness of the female undergraduates concerning issues of climate change and food security. Some recommendations are given below which will help to stir and sustain the interest of the female on issues which will later impact her life, even after her formal education [21], [26], [27]. Education in all aspects of the issues especially in areas of mitigation. Awareness creation is key to increase the level of appreciation that currently exists. Providing formal and informal environmental education which should be considered as an essential awareness tool.

Women also have a role deriving from their own strength. The female can be made aware of what she can do e. g. women are engaged in a number of activities such as brick-making, charcoal-making waste management and agro-processing where Energy efficiency can lead to CO2 mitigation and their role in mitigation in these vital areas can be vital. Since Climate change is a sustainability challenge of sustainable mitigation measures should be taught.Education, on how to create measures of tackling food insecurity at the grassroots level.Educations, on how to effectively salvage, develop and apply traditional knowledge and technologies to combat environmental problems.

CONCLUSION

Women are needed to develop human adaptive strategies, simple mitigation techniques strategies for sustainability. This group, the female educated group are also to pass on the vital information to the next generation when they become mothers. They will be the group that will tackle food shortages brought about by planlessness or wastefulness. Many of the actions taken to address climate change will have other benefits, such as cleaner, healthier air. For food security, actions will bring bountiful harvests of food. In addition, communities can take action to prepare for the changes we know are coming.

REFERENCES

1. Thornthwaite, C. W. (1948). "An approach toward a rational classification of climate". Geographical Review. 1: 55–94.
2. NRCC, (2010). National Research Council. Advancing the science of climate change. The National Academies Press, Washington D.C., USA.
3. DiMento, J. F. C.; Doughman, P. M. (2007). Climate change: What it means for us, our children and our grandchildren. The MIT Press. p. 68. ISBN 978-0-262-54193-0.
4. FAO. 2011. The State of the Food Insecurity in the World: How does international price volatility affect domestic economies and food security? Rome, Italy: Food and Agriculture Organization of the United Nations.
5. FIG, (2010). The Food Insecurity Gateway was produced by the Pulitzer Center on Crisis Reporting in partnership with the Project for Under-Told Stories and Saint Mary's University.
6. NOAA (2011). 2010 Tied for warmest year on record. National Oceanic and Atmospheric Administration. www.noaanews.naoo.gov/stories2011. Accessed 12th August, 2013.
7. Deutsche Welle, (2013). Deadly floods hit Germany and Central Europe. 3rd June, 2013.
8. BBC News, (2013). Thousands flee as Central Europe flood waters rise. 3rd June, 2013.
9. CNN World News, (2013). Cable Network News. May – June, 2013.
10. Saunders, M. and Lea, A. (2013). 'August forecast update for Northwest Pacific typhoon activity in 2013'. Tropical storm risk consortium. 6th August, 2013.
11. FAO, (2009). The State of Agricultural Commodity Markets. High food prices and the food crisis - experiences and lessons learned. Food and Agriculture Organization of the United Nations. Rome. March 2009.
12. Africare, Oxfam America, WWF-ICRISAT Project. 2010. More Rice for People: More Water for the Planet, System of Rice Intensification (SRI). Hyderabad, India: WWF-ICRISAT Project.
13. Beddington, J., Asaduzzaman, M., Fernandez, A., Clark, M., Guillou, M., Jahn, M., Erda, L., Mamo, T., Van Bo, N., Nobre, C. A., Scholes, R., Sharma, R., Wakhungu, J. (2011). Achieving food security in the face of climate change: Summary for policy makers from the5Commission on Sustainable Agriculture and Climate Change. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.
14. United Nations Population Division. 2010. World population prospects: the 2010 Revision. New York: United Nations Department of Economic and Social Affairs United Nations Population Division.http://esa.un.org/wpp/unpp/panel_population.htm. Accessed 12th August, 2013.
15. NAS, (2008)."Understanding and Responding to Climate Change". United States National Academy of Sciences. 2008. www.dels-old.nas.edu/dels/rpt_briefs/climate_change.2008_final.pdf. Accessed 12th August, 2013.
16. EPA (2010). Climate Change Indicators in the United States. U.S. Environmental Protection Agency, Washington, DC, USA. www.epa.gov/climatechange/science/indicators.
17. Oreskes, Naomi (2004). "BEYOND THE IVORY TOWER: The Scientific Consensus on Climate Change". *Science* **306** (5702): 1686.

18. Brigham-Grette, J. (2006). "Petroleum Geologists' Award to Novelist Crichton Is Inappropriate". Eos 87 (36). Retrieved 13 March 2013. "The AAPG stands alone among scientific societies in its denial of human-induced effects on global warming." Accessed 12th August, 2013.
19. Boykoff, M.; Boykoff, J. (2004). "Balance as bias: global warming and the US prestige press1". Global Environmental Change Part A. 14 (2): 125–136. www.doi10.1016/j.gloenvcha.2003.10.001. Accessed 12th August, 2013.
20. World Food Day, 2012. USAID Report.
21. Parikh, J. (2001). "Mainstreaming Gender into Climate Change Policies". Integrated Research and Action for Development (IRADe), New Delhi commissioned by UNDP, India.
22. Allen, E. and Seaman, C. (2007). Linkert scales and data analysis. Quality progress. 64 – 65.
23. Gender in Nigeria Report, 2012. British Council and UK AID Department of International Development.
24. FGN/UNICEF (1992). The Federal Government of Nigeria/United Nations Children Education Fund. Situation and policy analysis of basic education in Nigeria. Lagos, UNICEF Document.
25. World Bank: Poverty and Equity Data. http://povertydata.worldbank.org/poverty/home/
26 Foresight. Migration and Global Environmental Change: Future Challenges and Opportunities. 2011. Final Project Report. Futures. London, UK: Government Office For Science.
27. FAO. 2010. The state of food insecurity in the world: addressing food insecurityin Protracted crises. www.fao.org/docrep/013/i1683e/i1683e.pdf.
FAO Country Profiles. China: Food Safety and Security.

Bio-Fungicidal Effect of *Azadirachta Indica* in Abating Climate Change Impact on Banana Productivity in Nigeria, Africa

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ABSTRACT

The incessant world population has posed great challenge on food security. Over 800 million people do not have access to adequate food while about two billion are faced with hunger and malnutrition. Banana (*Musa spp.)* is the world's fourth most important global food crop after rice, wheat and maize in terms of production. The cultivation of banana is however threatened by pests and diseases as a result of diverse anthropogenic activities that influence and change the climate. Generally, Climate change impacts on agriculture and food security across the globe can decrease crop productivity. Extreme weather conditions such as flooding, drought, hurricanes etc. influence disease transmission. *Fusarium oxysporum*, a soil borne fungus affects banana production. Plant extracts have, however, played significant role in the inhibition of seed-borne pathogenic *F. oxysporum*. Neem (*Azadirachta indica*) extracts have been reported to have gained importance over inorganic fungicides because they are environmentally friendly. A study was carried out to investigate the efficacy of Neem (*Azadirachta indica)* seed extract at varying concentrations of 10, 20 and 50 % against *F. oxysporum* in Potato Dextrose medium using pour plate and cork boring methods. The results obtained showed inhibited growth of the test fungus with 50 % having the greatest percentage inhibition. This indicates that *A. indica* seed extract has fungicidal effect on *F. oxysporum* and has the potential to improve banana yield and enhance its production and hence food security. This paper therefore seeks to encourage the formulation of policies in Nigeria and Africa that support the use of environmentally safe bio-fungicides. This could help reduce climate change impacts, control pests and diseases, increase food productivity and hence achieve food security for the teeming population.

Key words: Food security, climate change, banana, *Azadirachta indica, Fusarium oxysporum,* bio-fungicide, environmental safety, policy

INTRODUCTION

The incessant world population has posed great challenge on food security. Reports from Food and Agricultural Organization (FAO), (2013) reveals that about 12.5 % of the world's population are undernourished. An earlier report (FAO, 2005) showed that of the more than 800 million malnourished world population, 25 % were from Sub-Saharan Africa. Globally, banana (*Musa spp.)* is acknowledged as the 4th most important food crop after rice, wheat and corn in terms of gross value production (FAOSTAT, 2003; Babayemi *et al*., 2010; Ravi and Mustapha, 2013). Banana provides basic staple food, supplying up to 25 % of food energy requirements for 70 - 100 million people in Africa (IITA, 2009; Tripathi, 2009; Viljoen, 2010). Banana is cultivated in over 100 countries in the tropics as well as subtropical regions of the globe with about 35 % of global production from sub-Saharan Africa (Tripathi, 2005). The cultivation of banana in Africa is however threatened by climate change impacts.

Climate Change has been identified as a significant constraint influencing banana yield and vulnerability to diseases (Meadu, 2011). According to the Intergovernmental Panel on Climate Change (IPCC) (2007), Africa is one of the most vulnerable continents to climate change and climate variability. It has been estimated that climate changes in form of extreme weather conditions (rising temperatures, flooding, drought, desertification etc.) are likely to impact on agriculture, seasonal yield losses and global food security in the 21st century especially in the developing world (Petzoldt and Seaman, 2006; IPCC, 2009; Byamukama *et al,.* 2011). Temperature increase according to Petzoldt and Seaman, (2006) has potential impacts on plant diseases especially fungi causing diseases. Specifically, Meadu, (2011) stated that some diseases are suitability affected by very warm weather caused by global warming effect. Rising temperatures affect the diversity of agricultural pests and diseases and are likely to lead to new disease outbreaks (Gregory *et al.,* 2009).

Management of pests and diseases (weevils, nematodes, viruses, fungal and bacterial diseases) has played a major role in food production especially in the last 40 years (Chakrabortya and Newton, 2011; Karamura *et al*., 2012). Research shows that 10 –16 % of global harvests are destroyed by pathogens (Chakrabortya and Newton, 2011). According to Oerke, (2006), plant pests and diseases have the potential of depriving humanity of about 82 % of the attainable yield in cotton production and over 50% for other major crops. Specifically, Fusarium wilt, banana bunchy top disease (BBTD), sigatoka, weevils and nematodes were reported as the main constraints in banana plantations (Niyongere *et al*., 2012).

Fusarium wilt, caused by *Fusarium oxysporum*, is one of the most widespread and destructive diseases of more than 120 major ornamental and horticultural crops (Hua-Van *et al*., 2001; Davis, 2005). This soil borne fungus causes vascular wilts by infecting plants through the roots and grows internally through the cortex to the stele (Beckman, 1987; Tjamos and Beckman, 1989; Hua-Van *et al*., 2001; Viljoen, 2010). Fusarium wilt of banana (Panama disease) is caused by the soil-borne fungus, *Fusarium oxysporum* f. sp. *cubense* (Foc) (Karangwa *et al*., 2012; Li *et al*., 2012; Rozeita *et al*., 2012; Thangavelu and Mustaffa, 2012). The disease is a major challenge and one of the most damaging banana disease that adversely affects banana yield worldwide (DPIFM, 2006; Stewart *et al*., 2006; Rozeita *et al*., 2012; Thangavelu and Mustaffa, 2012; Viljoen, 2012). The degree of destruction as a result of this disease has led to the development of various management options.

Recently, much attention has been given to biological control of crop pests with the development of safe and economical plant extracts for plant diseases been explored

(Verma and Kharwar, 2006; Niaz *et* al., 2008). Plant extracts have played significant role in the inhibition of *F. oxysporum* and in the improvement of seed quality (Nwachukwu and Umechuruba, 2001). Current advances in nematode and *Fusarium* wilt control have been achieved through the application of plant extracts (Ogechi *et al*., 2006). Neem (*Azadirachta indica*) has been identified to be an effective bio-fungicide against over 100 species of different pests with the highest active ingredients present in the seeds (Stroll, 2001). In order to significantly enhance banana production in Africa and beyond, there is the need to deploy the use of neem extracts in drastically reducing yield losses of crops.

This research work was therefore carried out to investigate on the efficacy of Neem (*Azadirachta indica*) seed extract incorporated into aseptic Potato Dextrose Agar (PDA) medium at varying concentrations of 10, 20 and 50% on *Fusarium oxysporum* fungus.

MATERIALS AND METHODS

A study was carried out to investigate the efficacy of Neem (*Azadirachta indica*) seed extract incorporated into aseptic Potato Dextrose Agar (PDA) medium at varying concentrations of 10, 20 and 50% and tested on *Fusarium oxysporum* fungus isolated aseptically from banana trees' top soils (0 – 15cm). Two (2) methods were adopted for the 5-day experiment these are: Pour Plate Method and Cork-boring Method and incubated at room temperature of $28^{o}C \pm 2^{o}C$. A control plate of PDA medium without extract was also inoculated with the test fungus to serve as the control. The inhibition percentage was then calculated.

Results and Discussion

Three (3) fungi were isolated from the banana plant soils these are: *Fusarium oxysporum*, *Aspergillus niger* and *Mucor spp.* However, for this study, only *Fusarium oxysporum* was selected for the anti-fungal study. Neem seed extracts at 10, 20 and 50 gm/100 ml concentrations all showed inhibitory effect to *Fusarium oxysporum* growth in ascending order. This fulfils one of the basic criteria of an effective fungicidal formulation which states that it must be lethal to the fungus at very low concentration. Percentage inhibition on *Fusarium oxysporum* by *A. indica* seed extracts are shown in Figures 1 and 2.

In the pour plate method (Fig. 1), the percentage inhibition of the concentrations of 10, 20 and 50 gm/100 ml were respectively 20, 40 and 53.3% after 24 hours. By 72 hours of incubation, the percentage inhibition had increased to 37.5, 50.0

Figure 1: Effect of concentrations of Neem Seed Extract on *Fusarium oxysporum* using the Pour Plate Method

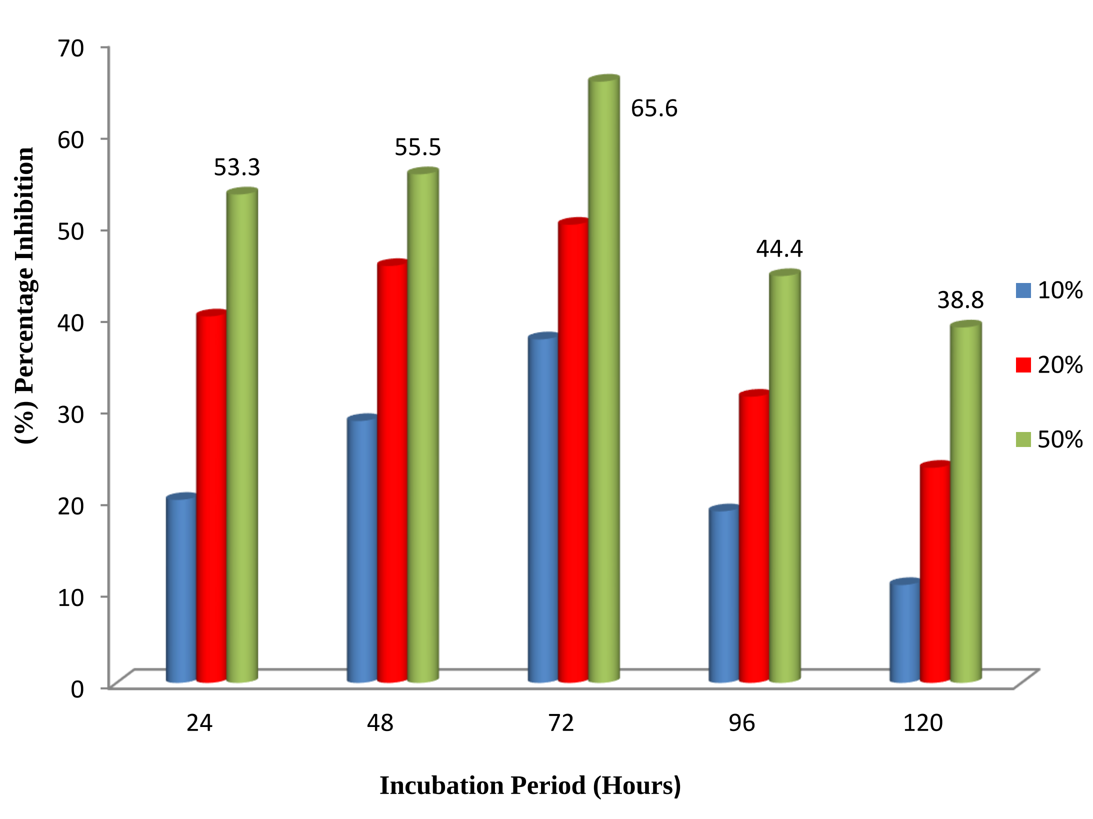
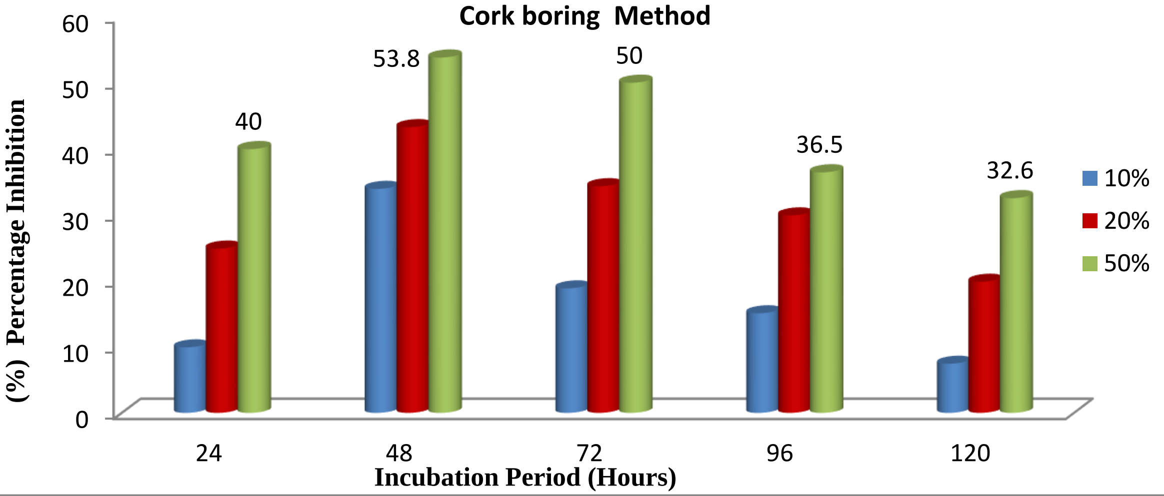


Figure 2: Effect of concentrations of Neem Seed Extract on *Fusarium oxysporum* using the Cork boring Method



and 65.6 % respectively. For the cork boring method after 24 hours of incubation (Fig. 2), the percentage inhibition was 10, 25 and 40 % respectively and by 72 hours of incubation the percentage inhibition had increased to 19.0, 34.4 and 50 % respectively. Results obtained revealed that Neem seed extract inhibited the growth of the test fungus at 50

gm/100 ml concentration having the highest and 10 gm/ 100ml having the least percentage inhibitions.

This confirms the findings of several researchers which include Singh *et al*., (1993), Otaru, (1996), Srivastava *et al.,* (1997), Niaz and Kazmi (2005), Agbenin and Marley (2006), Verma and Kharwar, (2006) and Hassanein *et al*., (2008) that *Azadirachta indica* plant extract suppresses mycelial growth of *F. oxysporum* and is an effective bio-fungicide with increasing inhibitory potential as its concentration increases. The penultimate and last days (96 and 120 hours) of the incubation showed sharp decrease in percentage inhibition in the two methods. According to Olayinka, (2009) and Oladipo, (2013) this may be attributed to the exhaustion of nutrients and accumulation of toxic metabolic wastes in the medium. This may therefore reduce the concentration of the neem seed extract and thus its reduced effectiveness. The control showed no restriction in fungal growth throughout the incubation period as compared to the rate of growth of *Fusarium oxysporum* in the test samples at varying concentrations of the neem seed extract. This confirms the fungicidal effect of *Azadirachta indica* seed extract on *Fusarium oxysporum*. The percentage inhibitions in the pour plate method were higher compared with those of the cork boring method. This reveals that the pour plate method is a more effective method than the cork boring method. This may be attributed to the uniform distribution of the neem seed extract in the medium and hence increased contact with the test fungus than in the well method. The test fungus had limited contact with the neem seed extract being in the 'wells' alone in the cork boring method.

CONCLUSION AND POLICY RECOMMENDATION

The outcome of this study establishes the inhibitory effect of *A. indica* seed extract at 10, 20 and 50 gm/ 100 ml concentrations on the growth of *Fusarium oxysporum*. The study also revealed that the percentage inhibition of the test fungus growth increased with increasing concentration of the *A. indica* seed extract. It can therefore be concluded that *A. indica* seed extract is an effective bio-fungicide against *Fusarium oxysporum* growth. The neem seed extract at these concentrations and beyond could drastically reduce the yield losses of banana plants caused by *Fusarium oxysporum* thus mitigating climate change impact, enhance healthy banana production and hence ensuring food security in Africa and the globe.

It is essential to stimulate policies for effective, cheap and environmentally safe biological control to mitigate incidences of pathogens commonly amplified by climate change effects. This would enhance increased healthy banana production and hence improve the food security status for the teeming population.

REFERENCES

Agbenin, O.N. and Marley, P.S. (2006). *In vitro* assay of some plant extracts against *Fusarium oxysporum f. sp. Lycopersici* causal agent of tomato wilt. *Journal of Plant Protection Research* 46 (3): 215 - 220.

Babayemi, J.O, Dauda, K.T, Kayode, A.A., Nwude, D.O., Ajiboye, J.A., Essien, E.R. and Abiona, O.O. (2010). Determination of Potash Alkali and Metal Contents of Ashes obtained from Peels of some Varieties of Nigerian Grown Musa Species. *BioResources* 5(3): 1384 – 1392.

Beckman, C. H. (1987). The Nature of Wilt Diseases of Plants. American Phyto-pathological Society, St. Paul, M N.

Byamukama, B., Carey, C., Cole, M., Dyszynski, J. and Warnest, M. (2011). *National Strategy on Climate Change and Low Carbon Development for Rwanda Baseline Report*. Smith School of Enterprise and Environment, University of Oxford, Oxford, United Kingdom. See: http://www.smithschool.ox.ac.uk/wp-content/uploads/2011/03/Rwanda-Baseline.pdf

Chakrabortya, S. and Newton, A. C. (2011). Climate change, plant diseases and food security: An overview. *Plant Pathology* 60: 2–14.

Davis, R. (2005). Fusarium wilt (Panama disease) of banana. Pest Advisory Leaflet # 42 Secretariat of the Pacific Community, New Caledonia.

DPIFM (Department of Primary Industry, Fisheries and Mines) (2006), Northern Territory Government, Fact Sheet on Banana. www.horticulture.nt.gov.au accessed on 26th August 2013.

FAOSTAT Agriculture Data (2003) (Food and Agricultural Organisation of United Nations, Rome) Accessed at http://apps.fao.org on September 19th 2012.

Food and Agricultural Organization (FAO), (2005). Comprehensive Africa Agricultural Development Programme. FAO Corporate Document Repository. Accessed at www.fao.org on 10th November 2006.

Food and Agricultural Organization (FAO), (2013).The State of Food and Agriculture: Food Systems for Better Nutrition. Assessed online on the 13th of July 2013 at www.fao.org/publications

Gregory, P.J., Johnson, S.N., Newton, A.C. and Ingram, J.S.I. (2009). Integrating Pesats and Pathogens into the Climate Change/Food Security debate. *Journal of Experimental Botany* 60: 2827 – 2838.

Hassanein, N.M., Abou Zeid, M.A., Youssef, K.A. and Mahmoud, D.A. (2008). Efficacy of Leaf Extracts of Neem (*Azadirachta indica*) and Chinaberry (*Melia azedrach*) against Early Blight and Wilt Diseases of Tomato. *Australian Journal of Basic and Applied Sciences* 2 (3): 763-772. INSInet Publication ISSN 1991-8178.

Hua-Van, A., Langin, T. and Daboussi, M. (2001). Evolutionary History of the *impala* Transposon in *Fusarium oxysporum*. *Molecular Biology and Evolution.* 18 (10): 1959–1969. ISSN: 0737-4038.

Intergovernmental Panel on Climate Change (IPCC) (2007). Summary for policymakers, climate change 2007: Impacts adaptation and vulnerability, contribution of working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (PDF) http://www.ipcc.ch/SPM2feb07.pdf. Cambridge University Press, Cambridge, U.K. 7-22. Accessed on 2008-11-18.

Intergovernmental Panel on Climate Change (IPCC) (2009). The Intergovernmental Panel on Climate Change. Available at hhp://www.ipcc.ch.(accessed 22 September, 2009).

International Institute of Tropical Agriculture (IITA, 2009). Banana and Plaintain Systems, *http://www.iita.org/cms/details/banana-plaintain_details.aspx?newsid=268&zoneid=66&activity=Banana*

Karamura, E., Ocimati, W., Tinzaara, W., Karamura, D., Blomme, G. and Staver, C. (2012). Key Banana Pest and Disease Challenges and Their Mitigation in Africa in Book of Abstracts

Intl. Banana Symposium: Banana Improvement, Health Management, Use Diversification and Adaptation to Climate Change Session 3: *In Vitro* Technology/Tissue-Culture. Pg 42.

Li, C., Zuo, C., Kuang, R.B., Hu, C., Yang, Q., Wei1 Y. Sheng, O. Dong, T. and Yi, G.J. (2012). Production of Beauvericin and Fusaric Acid by *Fusarium oxysporum* f. sp. *cubense*, Causal Agent of Fusarium Wilt in Banana in Book of Abstracts International Banana Symposium: Banana Improvement, Health

Management, Use Diversification and Adaptation to Climate Change Session 4: Soil and Plant Health. Pg. 70.

Meadu, V. (2011). Banana boom and bust as Climate Changes. Research Program on Climate Change, Agriculture and Food Security on Adaptation and Mitigation Knowledge Network.

Niaz, I. and Kazmi, S.A.R. (2005). Neem seed coat oil fractions on stored grain fungi*. International Journal of Biology and Biotechnology* 2 (3): 705 - 706.

Niaz, I., Sitara, U. and Qadri, S. (2008). Effect of Different Seed Oils and Benlate Fungicide on *In Vitro* Growth of Four *Drechslera* species. *Pakistan Journal of Botany* 40 (1): 397 - 401.

Niyongere, C., Ndayihazamaso, P., Niko, N., Bizimana, S., Nibasumba, A., Lepoint, P., Kaboneka, S., Sakayoya, E., Jogo, W., Tinzaara, W. and Karamura, E. (2012). Farmers' knowledge of Banana Crop Management As Related to the Control of Banana Diseases in Burundi in Book of Abstracts International Banana Symposium: Banana Improvement, Health Management, Use Diversification and Adaptation to Climate Change. Pg. 49.

Nwachukwu, E.O. and C.I. Umechuruba, (2001). Antifungal activities of some leaf extracts on seed-borne fungi of African yam bean seeds, seed germination and seedling emergence. *Journal of Applied Science and Environmental Management* 5 (1): 29 - 32.

Oerke, E.C. (2006). Crop losses to pests. *Journal of Agricultural Science* 144: 31–43.

Ogechi, N. Agbenin, P.S. and Marley (2006). In-Vitro Assay of Some Plant Extracts against *Fusarium Oxysporum* F. Sp. *Lycopersici* causal agent of Tomato Wilt. *Journal of Plant Protection Research* 46 (3): 215 – 220.

Oladipo, O.G. (2013). Effects of Microbial Heavy Metal Remediation in Soils from Selected Mine Sites in Osun and Ekiti States, Nigeria on Maize Performance. A Ph D. Thesis of the Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile – Ife, Nigeria. Pp 325.

Olayinka, A. (2009). Soil Microorganisms, Wastes and National Food Security. *Inaugural Lecture Series 222 of Obafemi Awolowo University, Ile-Ife, Nigeria.*

Otaru, K. (1996). Fungitoxicity of Neem Extract on some Mycoflora of Cowpea. A B. Sc. Project Work of the Department of Microbiology, University of Ilorin, Ilorin, Nigeria. Pp 33.

Petzoldt, C. and Seaman, A. (2006). Climate Change Effects on Insects and Pathogens. *Climate Change and Agriculture: Promoting Practical and Profitable Responses* III 6 - III 16.

Ravi, I. and Mustaffa, M.M. (2013). Impact, Adaptation and Mitigation Strategies for Climate Resilient Banana Production. In: Climate-Resilient Horticulture: Adaptation and Mitigation Strategies. Pg. 45-52. Publisher: Springer India, Print ISBN: 978-81-322-0973-7, Online ISBN: 978-81-322-0974-4.

Robert, A.S., Ellen, S.H., and Connie, A.N.V. (1984). Introduction of food-borne Fungi. Institute of the Royal Netherlands Academy of Arts Science, Netherlands.

Rozeita, L., Mohamad-Roff, M.N., Tengku, T.M., and Malik, A. (2012). Isolation and Evaluation of Biocontrol Agents From the Phylloplane and Soil Rhizosphere of Banana Plants for Suppressing the Growth of *Fusarium oxysporum* f. sp. *Cubense* in Book of Abstracts International Banana Symposium: Banana Improvement, Health Management, Use Diversification and Adaptation to Climate Change Session 4: Soil and Plant Health. Pg. 63.

Singh, H.N, Prasad, M.M. and Sinha, K.K. (1993). Efficacy of leaf extracts of some medicinal plants against disease development in banana. Letter in Applied Microbiology 17 (6): 269-271.

Srivastava, A.K, Bihari, B., Lal, B. (1997). Studies on biofungicidal properties of leaf extract of some plants. *Indian Phytopathology* 50 (3): 408-411.

Stewart, J. E., Kim, M.-S., James, R. L., Dumroese, R. K., and Klopfenstein, N. B. (2006). Molecular characterization of *Fusarium oxysporum* and *Fusarium commune* isolates from a conifer nursery. Phytopathology 96:1124 - 1133.

Stroll, G. (2001). Natural crop protection in the Tropics (First published in 1986) Published by Margraf Publishers Scientific Books. Published online by Seed to Seed (2001).

Thangavelu, R., Gobi, M. and Mustaffa, M.M. (2012). Field Evaluation of Antagonistic Microbes for the Suppression of Fusarium Wilt Disease of Banana in Book of Abstracts International Banana

Symposium: Banana Improvement, Health Management, Use Diversification and Adaptation to Climate Change Session 4: Soil and Plant Health. Pg. 69.

Tjamos, E. C., and Beckman, C. H. (1989). Vascular Wilt Diseases of Plants: Basic Studies and Control. Springer-Verlag, Berlin.

Tripathi, L. (2005). Biotechnology for Improvement of Banana Production In Africa. Presented at the 9th International Conference on Agricultural Biotechnology: Ten Years After. Organized by the International Consortium on Agricultural Biotechnology Research (ICABR), Italy.

Tripathi, L., Mwangi, M.,Aritua, V., Tushemereirwe, W.K., Abele, S. and Bandyopadhyay, R. (2009). Xanthomonas Wilt: A Threat to Banana Production in East and Central Africa. *Plant Disease* by the American Phytopathological Society Plant Disease 93 (5) 440 – 451.

Verma, V.C. and Kharwar, R.N., (2006). Efficacy of Neem leaf extract against its own fungal Endophytic *Curvularia lunata*. *Journal of Agricultural Technology* 2: 329 – 335.

Viljoen, A. (2010). Protecting the African Banana (*Musa* spp.): Prospects and Challenges. Proceeding on International Conference on Banana & Plantain in Africa. Eds.: T. Dubois *et al*. Actual Horticulture. 879: 305 – 314.

Viljoen, A. (2012). Fusarium Wilt of Banana: A Global Perspective. Book of Abstracts in International Banana Symposium: Banana Improvement, Health Management, Use Diversification and Adaptation to Climate Change Session 5: Banana pests and diseases/ Fusarium wilt Pg. 75.

Challenges of Food Insecurity Due To Climate Change (Flood Disaster) In the South Eastern Region of Nigeria: Need for Home Economics Extension Workers

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ABSTRACT
The purpose of the study was to examine the impact of flood disaster due to climate change on food security of flood disaster victims in Anambra and Imo States of Nigeria. A sample of 120 people drawn from 34 local government areas of the affected communities was selected using simple random sampling. A Structured questionnaire was used as the instrument for data collection, using a design time survey design. The results revealed that there was food insecurity as a result of destruction of the crops by flood and lack of land to cultivate since most of the lands were flooded. This resulted to malnutrition, hunger, and poverty. It was revealed that though Home Economics extension workers, the problem of food insecurity could be reduced in these areas. Based on these findings recommendations were made, among which was that the government should use Home Economics Extension Workers to distribute food and drugs to the affected areas to improve their health and food security.

Keywords: food insecurity, climate change, flood disaster, Home Economics Extension Workers

INTRODUCTION

Background to the Study

Climate change is marked by global warming which is the increase in average surface temperature of the earth. Global warming could be seen as the gradual heating of the earth due to green house gases. This gradual heating leads to climate change and rising sea levels (Vyigue, 2008). These rising sea levels could lead to flood disasters.

Going back as far as 160,000 years ago past record of climate change indicates a close correlation between the concentration of green house gases in the atmosphere and global temperature. The United State Environmental Agency (2009) stated in its report that some greenhouse gases such as Carbon dioxide occur naturally and are emitted to the atmosphere through natural processes and humans activities and other green house gases (e.g. fluorinated gases) are created solely through human activities. Human activities both in agriculture and industrial sectors lead to the emission of increasing qualities of heat-trapping molecules into the atmosphere. These molecules are known as green house gases. Smith (2002) opined that during the 1980's, Scientist, government, and the public became concerned about the possibility that the world may be getting warmer.

The United Nations Environment Programme established an inter-Governmental panel on Climate Change (IPCC) to study the issues and make recommendations. Its first Assessment was published in 1990 in 1996, the IPCC published it Second Assessment and concluded that climate change is occurring and that it is highly probable that human activities are important causes of the change. The IPCC has reached several important conclusion. These are:

- The average temperature of the earth has increased 0.3 – 0.6^{o}c (0.5 – 1.0^{o}f) (1999 was the warmest year record) and Sea level has risen to 10-25cm (4-10 inches) in the last 100 years.
- There is a strong correlation between the increase in temperature and amount of green house gases present in the atmosphere.
- Human activity greatly increases the amount of these green house gases.

Regional Climate Changes will likely be very different from changes in the global average. Differences from the region to region could be in both the magnitude and rate of climate change. Just as the climate change in the south-eastern region of Nigeria, the most devastating natural disaster is flood. Flood is a phenomenon that sometimes has devastating effect on human livelihood. The impact of flood is more pronounced in the low-lying areas due to rapid growth in population, poor governance, decaying infrastructure and lack of proper environmental planning and management (Odufuma, Adedeji and Bongwa, 2012).

Indeed, the amount of economic damage caused by flood affects a large population of people in low-lying coastal zones or other areas at risk of flooding and extreme weather condition was largely on flood insecurity particularly on the South-Eastern regions of Nigeria.

Food insecurity is the most broadly used measure of food deprivation. The USDA defines food insecurity as "consistent access to adequate food is limited by a lack of money and other resources at times during the year (Texas food bank Network (2013). The acceptable short term for food insecurity is "hunger" or at risk of hunger. Food insecurity exists when all people do not at all times have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (FAO 2012).

CAUSES OF CLIMATE CHANGE AND FLOOD DISASTER

An explanation often put forward is that several gases in the atmosphere are transparent to light but absord infrared radiation. These gases allow sunlight to penetrate to atmosphere and he absorbed by the earth's surface. This sunlight energy is reradiated as infrared radiation (heat) which is absorbed by the gases. This is because the effect is similar to what happened in a green house the glass allows light to enter but retards the loss of heat. These gases are called green house gasses and the warming thought to occur from their increase is called the green house effect. The most important green house gasses are carbon dioxide (Co_2), Chlorofluoro Carbon (Primarily (Cl_3f and C_2 f_2) methane (CH_4) and Nitrous oxide (N_2o).

The table below shows the major green house gases and their characteristics:

Gas	Atmospheric Concentration (ppm)	Annual Increase (Percent)	Lifespan years	Concentrate Global warming %	Principle sources
Carbon dioxide (fossil fuels) (biological)	355	.4	50 200	55	Coal, oil, natural gas deforestation
Chlorofluo carbons	0085	2.2	50-102	24	Foams, gerosels refrigerator soluent
Methans	1.714	.8	12-17	15	Wet land, rice, fossil, fuel, limestone
Nitrous oxide	.31	.25	120	6	Fossil fuels, fertilizers, deforestation

Source: Word Meteorological Organization.

The U.S Environmental protection Agency (EPA) 2009, listed the principal GHGS that enter the atmosphere because of human activities as follows:

i) Carbon dioxide (CO_2)
ii) Methane (CH_4)
iii) Nitrous oxide (N_2O)
iv) Fluorinate Gases

Rising sea level and flooding: one major cause of flood disaster is the rising sea level. The there is much rain the sea level tends to rise forward this will lead to flooding. In Nigeria with July and August 2012, there was rainy season which resulted to seasonal flash flood. The flash floods are sometimes lethal, especially in the rural areas or overcrowded slums, where drainage does not exist at all.

Another cause of flooding in Nigeria was the release of water from Laydo dam in Northern Cameroon by the Cameroonian authorities, which led to the submerging of many riverine settlements in some states in Nigeria which led to overflooding of farm lands and destruction of farm produce/ Agricultural produce that has caused food insecurity in the nation.

Challenges of flood disaster on food insecurity

Nigeria has being experiencing rainy season and flooding but the 2012 has been worse than earlier years. Many parts of the country experienced serious floods as a result of the heavy rain at the end of August and the beginning of September 2012. The Nigeria authorities contained the initial excess run-off through contingency measures, but during the last week of September water reservoirs have over-flown and authorities were obliged to open dams to reline pressure in both Nigeria and neighbouring Cameroon and Niger, leading to destroyed river banks and infrastructure, loss of property and livestock and flesh floods in many areas especially the South-Eastern States of Anambra, Imo, Abia, Enugu and Ebonyi States. By 29th September, the flood had affected 134, 371 people, displaced, 64,473 were injured and 148 killed (FRC, 29th September, 2012) and many farm land destroyed which had the greatest threat and the challenges of climate change on food security and on the agricultural produce. Ensuring food security at the national level is a high priority because it provides the link between production and availability of food for the areas affected by the flood disaster. Warming measures, communication and adequate policy on food security will be appropriately delt with. That is why this paper focuses on the need of Home Economics extension worker on the challenges of flood disaster due to climate change on the South-Eastern regions of Nigeria.

Von (2008) identified climate change as one of the major causes of food insecurity as result of low agricultural output, high food prices and others. This cause is attributed to lower crop yields as a result of adverse weather conditions. FAO (2009) stated that climate change impacts the four key dimensions of food security, availability, stability, accessibility and utilization. Availability of agricultural product is affected by climate change directly through its impact on crop yields, soil fertility and water holding properties.

The resulting of challenges of flood disaster on food security are:

a. **Food insecurity**: This is high in developing countries which the South-Eastern region of Nigeria as Abia, Anambra, Imo, Enugu, and Ebonyi is inclusive but not totally absent in the developed countries. It can be categorized as either famine and hunger. The chronic food insecurity could be translated into high degree of vulnerability to famine or hunger. Food insecurity is seen when

i) Healthy foods are expensive than unhealthy foods
ii) Fishes die and rivers polluted
iii) Lack of money to purchase foods
iv) Indigenous foods are not accessible etc.

b. Malnutrition/ Nutrient deficiencies: food insecurity have a significant effect on the nutritional status of those who are food insecured. The most vulnerable groups are the women, pregnant women, children and the aged. Many deficiency conditions consequently appears infectious diseases then because the immune system cannot function properly. Inadequate nutrition provokes health problems in the greatly increase death risk especially on children.

c. Poor standard of living: food insecurity will affect the nations work force which leads to underdevelopment, health, social, psychological and behavioural consequences which will eventually lead to poor standard of living.

d. Lack of accessibility and affordability of food because they are faced with poverty and cannot afford the foods that will supply them with the right nutrient. Increased food prices is a challenge to food access especially for low-income and the vulnerable populations.

The Place Of Home Economics Extension Worker

A Home Economics Extension worker is one who visits people in different areas and organizes a programme to educate the masses on different issues of life with much emphasis on the home, environment, health, nutrition etc for a more meaningful living.

With emphasis on Climate change, flood disaster and food insecurity, the Home Economics extension worker should collaborate with the national committee on flood relief and rehabilitation to support the government's relief and rehabilitation to see that the funds allotted to these states are utilized efficiently. The Home Economics extension workers should endevour to see that they inculcate into the people how to make use of the available food resources to feed adequately as to avoid malnutrition of the family members especially the children who are most vulnerable to diseases and infections. Food insecurity, food deficits or shortages are major issues in climate change, and addressing ways to ensure that these issues could be minimized to some extent are the possible major challenges that all countries are concerned with.

Statement of Problem

During the incidence of the flood disaster many saw their means of livelihood washed away. It was unknown that over 5,000 farmlands were washed away, it was reported that over 3,200 hectares of rice plantation were washed away. The hardest-hit were the fishes, pigs and crop such as cassava and rice farmers. These effects made many experts believe that a food crisis characterized by the escalation of poverty, food scarcity and the rise in food prices is imminent especially on the areas affected by flood disaster if prompt action is not taken. Secondly, due to large-scale reduction in the supply of home-grown agricultural produce, a famine is lurking (Obasi, 2012).

Purpose of Study

The general purpose of the study was to examine the challenges of food insecurity due to climate change (flood disaster) in the south-eastern region of Nigeria. Need for Home Economics Extension worker and specifically to:

1. Identify the causes of climate change (flood disaster).
2. Identify the challenges of food insecurity due to climate change (flood disaster).
3. Identify the role/need for Home Economics Extension Worker in food insecurity.

Reserch Questions

The following questions were formulated to guide the study:

1. What are the causes of climate change (flood disaster)
2. What are challenges of food insecurity due to climate change (flood) disaster?

3. What are the role/need of Home Economics extension worker towards food insecurity?

METHODOLOGY

The research design that was used for this study was a descriptive survey design, a descriptive survey research design is one in which a group of people or items are studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group (Floyed 2002).

Area of Study

The area of the study was the South-Eastern regions of Nigeria which comprises of five state such as Anambra, Abia, Imo, Enugu and Ebonyi States. These areas have big rivers in them and most of their lands are in low-lying areas.

Population and Sample

The population of the study consisted of all the 34 major local government as in the five states in the south-eastern region of Nigeria. The house-holds that are vulnerable to flood disaster seven (7) local government areas were randomly selected using simple random sampling. From the seven local government areas of affected eighteen people from the affected communities were chosen making it a total of 120 households consisting of civil servants and business men/women.

Instrument for Data Collection

The instrument used for data collection was structured questionnaire developed by the researcher. It was made up of two sections. Section A was demographic information from the respondents, while Section B was made up of questions on issues to address by the study.

Data Collections & Analysis

Copies of the questionnaire were administered to the respondents at their various locations. The information were completed questionnaires were analysised using Mean.
Normal values were assigned to a four point scale thus:

Strongly Agree	-	SA	= 4
Agree	-	A	= 3
Disagree	-	DS	= 2
Strongly disagree	-	D	= 1

Where x = sum of the nominal values
X = mean
N = Number of respondents

$$\text{Mean } \frac{4 + 3 + 2 + 1}{4} = \frac{10}{4} = 2.5$$

Therefore items with up to 2.50 and above were regarded as agreed while below 2.5 were rejected/disagreed.

Validity of Instrument

The instruments were validated by five experts from the college. It was subjected to face and content validity. They suggestions/corrections were used in the final draft.

RESULTS

The data from the study were analysed based on the research questions.

Research question 1 – What are the causes of climate change (flood disaster)?

Table 1

S/N	ITEMS	SA	A	D	SD	N	X	REMARK
1.	Rising sea levels causes flood	32	60	124	30	120	2.05	Disagree
2.	Too much rain fail	88	210	48	4	120	2.91	Agree
3.	Release of dam	44	228	30	6	120	3.02	Agree

Most of the respondent responded positively to the item except the item No. 1 that has disagreed.

Research question 2 –What are the challenges of food insecurity due to flood disaster?

S/N	ITEMS	SA	A	D	SD	N	X	REMARK
1.	Farmlands/ crops are destroyed	80	180	60	10	120	2.75	Agree
2.	There is food insecurity	152	150	36	14	120	2.93	Agree
3.	Waters are polluted and fishes die	80	210	36	12	120	2.81	Agree

In table 2, the respondents agreed that the items in the research questions were the challenges of food insecurity due to flood disaster in the areas of the study.

Research question 3 – What are the roles/needs of the Home Economics extension workers towards food insecurity?

S/N	ITEMS	SA	A	D	SD	N	X	REMARK
1.	The Home Economics Extension works inculcates into the vulnerable household how to make use of the available resources to food well	120	210	40	2	120	3.03	Agree
2.	They will help in efficient distribution of foods to the affected areas	120	120	44	28	120	2.6	Agree
3.	They should collaborate with the government to see that aids is being given to the affected areas	116	92	40	7	120	2.95	Agree

From the table above it was observed that the respondents responded positively to all the items which indicated that Home Economics extension have role to play in food insecurity of the areas affected by flood disaster as a result of climate change.

DISCUSSION

From the information derived from the analysis, below were the findings;

1. Food insecurity could arise due to climate change (flood disaster) among the areas carried out the study.
2. Among the areas carried out the study they were faced with poverty, malnutrition, hunger etc. due to food insecurity.
3. That burning fuels as natural gas, coal, oil and gasoline raises the level of carbon dioxide in the atmosphere and carbon dioxide is a major contributor to global warming which leads to climate change. Wise utilization of energy can help to reduce the demand for fossil which reduces global warming that could lead to food insecurity.

CONCLUSION

Climate change (flood disaster) leads to food insecurity and food insecurity leads to hunger, malnutrition, poverty, death etc. Therefore, to avoid all these and have food security the anthropogenic causes of global warming which results to climate change should be prevented. Since food insecurity will lead to food crisis.

RECOMMENDATIONS

To eliminate food insecurity in the research areas the following recommendations were made:

1. The government should use the Home Economics extension workers to distribute foods and drugs to the affected areas.
2. The government and Non-governmental organizations should make food secured to the affected areas by giving them aids.
3. The government and the individuals should endeavour to avoid those anthropogenic causes of global warming which could result to climate change and food insecurity.

REFERENCES

Obasi, T (2012); Food Crisis: Implication for agric and food security in Nigeria Businessday: www.businessday online.

Nigeria; The Flood disaster caused by Cameroon Dam Source- Leadership September 2012- 2013 All Africa.com

FAO (Food and Agricultural Organization) 2009, climate change and bioenergy challenges for food and agriculture, FAO, Rome, Italy, <http/www.fao.org/fileadmin/templates/lusg/docs/issues_appers/HLTF2050-Climate.pdf7

Food insecurity and causes. Wikipedia (2009) food security.

Global warming facts (2011). Global warming facts/info/assets/files/50 tips.

Von,B.(2008): Effects of Climate Change on Agriculture www.agitrade.org/events /documents/paper vonvrown abrcelone

Wikipedia (2009), food security envikipedia.org/miki/food security.

Chemical Composition and Antioxidant Capacity of Some Selected Underutilised Bean Seeds Varieties

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ABSTRACT

The effect of climate change on plant biodiversity, thereby affecting the number of such plant foods varieties for use in solving food insecurity cannot be overemphasized. Four varieties of cooked underutilised bean seeds (*Cajanus cajan, Sphenostylis stenocarpa, Phaseolus lunatus 1, and Phaseolus lunatus 2*) which are rarely consumed were evaluated for proximate and mineral compositions using standard analytical methods. Antioxidant activity and total phenolic content of the aqueous extracts of the seed flours were determined using Ferric-ion Reducing Antioxidant Potential (FRAP) assay and Folin Coicalteu method respectively. Percentage moisture of the samples ranged from 9.24 – 9.96; crude protein 20.79 – 22.72; fat 5.19 – 5.65; crude fibre 3.26 – 7.91; ash 3.37 – 5.94; with high metabolisable energy. Essential minerals such as K, Ca, and P were present at significantly high levels ($p < 0.01$) while the Na-K and Ca-P ratios for the samples were less than 1 indicating their suitability as diets for diabetic patients and food formulation for bone formation in children. Antioxidant activity of the samples ranged from 424.0 – 1295.7 mgGAE/100g while the total phenolic content ranged from 2740 – 5400 micromole GAE/g suggesting that the consumption of the bean seeds can be utilized as scavengers of free radicals produced by environmental pollution and essential body metabolic reactions. It is hoped that the inclusion of these underutilized bean seeds varieties in the diet will be a relief to the burden placed by the adverse effect of seasonal climatic changes on agriculture, thereby increasing food security.

INTRODUCTION

The impact of food security on the populace as a result of climate change on the quality and quantity of agricultural products is increasing in most countries of the world. About, 870million people remain hungry as the world is increasingly faced with a double burden of malnutrition which affect more than 1.4billion people (FAO, 2012). The burden of feeding a growing global population is made heavier by this adverse effect of climate change on food production. Currently, the world population is projected to swell from 6.8billion to 9.1billion by 2050 (Nwanze, 2009) with most of the growth in the developing countries.

In order to avert this trend, urgent action needs to be taken in solving the effect of the food insecurity brought by the drastic change of climate and the resultant incidence in diseases. To this end, plant foods reported to be major sources of nutrients and provision of optimum health (Dougall 2013) need an in-depth research.

As such some selected underutilised bean seeds (*Cajanus cajan,Sphenostylis stenocarpa, Phaseolus lunatus 1,and Phaselous lunatus 2*) were evaluated for nutritional potentials and antioxidant capacity. These are legumes reported to have nutritive and medicinal values (ref.) the four selected bean seeds are known to form part of nigerian diet in various forms. However, the limitation of long cooking hours due to hard shell is a major drawback. It is hoped that the results of this study will provide the much needed information as to the potentials of the underutilised seeds as vital sources of natural antioxidants which are reported as scavengers of free radicals thereby reducing the occurrence of chronic and degenerative disease ref.

MATERIALS AND METHODS

***Collection of the samples*:** The bean seeds were purchased from local markets located in Iworoko – Ekiti, in Ekiti State, Nigeria.
***Preparation of the samples*:** Five hundred grams of the bean seeds were weighed and subjected to cooking. Pigeon pea and African yam bean seeds were soft and presumed suitable for consumption after 2hrs while that of Lima bean seed 1 and Lima bean seed 2 took about 3hrs. The samples were oven dried and powdered for subsequent analysis.

***Proximate analysis*:** The samples were analysed for proximate compositions according to the method of AOAC (1990). The analysis of the samples was carried out in triplicates.

***Mineral analysis*:** Potassium and sodium were determined using a flame photometer (FP, model 140) and KCl and NaCl were used to prepare the standards. Phosphorus was determined by spectrophotometer. All other minerals were determined by atomic absorption spectrophotometer (Perkin- Elmer Model 403, Norwalk CT). All determinations were done in triplicates and the minerals were reported in mg/100 g.

Antioxidant Activity (AA): Antioxidant activity was determined using Ferric-ion Reducing Antioxidant potential (FRAP) assay method. (Chan *et al*, 2007). The results were expressed as mg Gallic acid equivalent (mg GAE/100g sample).

***Total phenolic content (TPC)*:** Total phenolic content (TPC) was determined using Folin-Coicalteu method (Singleton *et al.* 1996). Analyses for each sample were determined in triplicates and their results were expressed as Gallic acid equivalent (micromole GAE/g).

RESULTS AND DISCUSSION

Table 1 presents the results of the proximate analysis of the cooked bean seeds. The seeds contain 9.24 – 9.95 % moisture, 20.79 – 22.72 % crude protein, 5.19 – 5.65 % fat, 3.37 – 5.94 of % ash, 3.26 – 7.91 % fibre and 49.18 – 56.11 % Carbohydrate by difference. *Sphenostylis stenocarpa* was found to have the highest value of moisture (9.95%) with the *Pigeon pea* having the lowest value (9.24%). The lower moisture content is an advantage in prolonging the shelf-life. The highest value for crude protein and fat were found in *Phaseolus lunatus* 2 with 22.72% and 5.65% respectively. However, the value is higher than that reported by (Audu and Aremu, 2011) in cooked *Phaseolus vulgaris* but lower in fat when compared with it. *Cajanus cajan* was found to have the highest value in ash and crude fibre with 5.94% and 7.91% which is slightly higher than that reported in raw *Cajanus cajan* seeds reported by (Akande *et al,* 2010, Audu and Aremu, 2011, Fasoyiro *et al,* 2010, and Etuk *et al,* 2002). The carbohydrate and the metabolisable energy were found in higher values for *Phaseolus lunatus* 1 with 56.11% and 1512.36KJ/100g. The values obtained are higher than those reported in raw and processed *Vigna subterranea* reported by (Aremu *et,al,* 2010).

Table 1: % proximate composition of some selected underutilized leguminous seeds

Components	Sample A	Sample B	Sample C	Sample D	Mean	(±) Sd	%Cv
Moisture Content	9.24(±0.04)	9.95(±0.11)	9.70(±0.02)	9.52(±0.02)	9.60	0.30	3.31
Crude Protein	22.52(±0.50)	20.79(±0.25)	21.23(±0.5)	22.72(±0.49)	21.82	0.95	4.35
Fat	5.22(± 0.01)	5.19(± 0.02)	5.34(±0.01)	5.65(±0.01)	5.35	0.21	3.93
Ash	5.94(± 0.05)	3.37 (± 0.02)	4.37(±0.02)	4.00 (±0.14)	4.42	1.09	24.66
Fibre	7.91(± 0.01)	6.19 (± 0.08)	3.26 (±0.01)	5.14(± 0.01)	5.63	1.95	34.64
Carbohyrate	49.18(±0.51)	54.54(±0.54)	56.11(±0.5)	52.98(±0.41)	53.20	2.97	5.58
Metabolisable Energy(Kj/100g)	1412.08	1472.64	1512.36	1495.95	1473.26	43.92	2.98

LEGEND
± S.D = Standard deviation in parenthesis
CV = Co-efficient of Variance
Sample A – *Cajanus cajan* (Pigeon pea)
Sample B - *Sphenostylis stenocarpa* (African Yam bean)
Sample C – *Phaseolus lunatus* (Lima Bean 1)
Sample D – *Phaseolus lunatus* (Lima Bean 2)

Table 2 presents the results of the mineral compositions of cooked bean seeds. The most abundant mineral were phosphorus with 465.32mg/100g found in *Phaseolus lunatus* 2 while the least abundant mineral was found in manganese with 0.64mg/100g in *Sphenostylis stenocarpa*. These values compared favorably with some reported values of raw and processed *Vigna subterranea* reported by (Aremu and Ogunlade, 2010). Other essential minerals in the samples ranged from 37.8 – 46.54 calcium, 4.50 – 4.77 sodium, 10.54 – 13.87 potassium, 28.76 – 38.81 magnesium, 2.30 – 3.06 zinc, 2.40 – 2.58 iron and 1.00 – 1.30 copper. The ratios of Na-K and Ca-P were less than 1 suggesting their suitability for hypertensive patient (Ogunlade *et al,* 2005).

Table 2: Mineral composition of some selected underutilised leguminous seeds

MINERALS (mg/100g	SAMPLE A	SAMPLE B	SAMPLE C	SAMPLE D	MEAN	(±) SD	% CV
Na	4.77	5.03	4.50	4.76	4.77	0.22	4.61
K	10.54	2.13	11.35	13.87	11.97	1.42	11.86
Ca	46.52	45.64	44.95	37.88	43.75	3.96	9.05
M	32.58	30.74	28.76	33.81	31.47	0.20	6.99
Zn	2.30	2.68	3.02	3.06	2.77	0.35	12.64
Fe	2.40	2.58	2.57	2.53	2.52	0.08	3.17
Cu	1.13	1.00	1.05	1.30	1.12	0.13	11.61
Mn	0.65	0.64	0.69	0.71	0.67	0.03	4.48
Pb	N.D	N.D	N.D	N.D	N.D	N.D	N.D
P	385.61	432.33	378.76	465.32	415.51	40.86	9.83
Na/K	0.45	0.41	0.40	0.34	0.4	0.05	12.5
Ca/P	0.12	0.11	0.12	0.08	0.11	0.02	18.18

LEGEND
± S.D = Standard deviation in parenthesis
CV = Co-efficient of Variance
Sample A – *Cajanus cajan* (Pigeon pea)
Sample B - *Sphenostylis stenocarpa* (African Yam bean)
Sample C – *Phaseolus lunatus* (Lima Bean 1)
Sample D – *Phaseolus lunatus* **(**Lima Bean 2)

Table 3 presents the Antioxidant Activity (AA) of the samples. The results ranged from 424.0 mgGAE/100g in *Sphenostylis stenocarpa* (African yam bean) to 1298.7 mgGAE/100g in *Phaseolus lunatus* 1 (Lima bean 1). However, this present study revealed that cooked underutilised leguminous bean seeds such as *Cajanus cajan, Sphenostylis stenocarpa, Phaseolus lunatus 1, and Phaseolus lunatus 2* are good for consumption when compared with the antioxidant capacity of some selected fruits (0.93 – 4.61) Trolox equivalent ml as reported by (Ogunlade *et al*. 2011)

Table 3: Antioxidant Activity of some selected underutilised leguminous seeds (mgGAE/100g).

SAMPLES	C1	C2	C3	Mean	(±)S.D	CV%
A	928	956	944	942.7	14.05	1.490
B	412	436	424	424.0	12.00	2.830
C	1276	1320	1300	1298.7	22.03	1.696
D	1048	1064	1056	1056.0	8.00	0.758

LEGEND
± S.D = Standard deviation in parenthesis
CV = Co-efficient of Variance
Sample A – *Cajanus cajan* (Pigeon pea)
Sample B - *Sphenostylis stenocarpa* (African Yam bean)
Sample C – *Phaseolus lunatus* (Lima Bean 1)
Sample D – *Phaseolus lunatus* **(**Lima Bean 2)

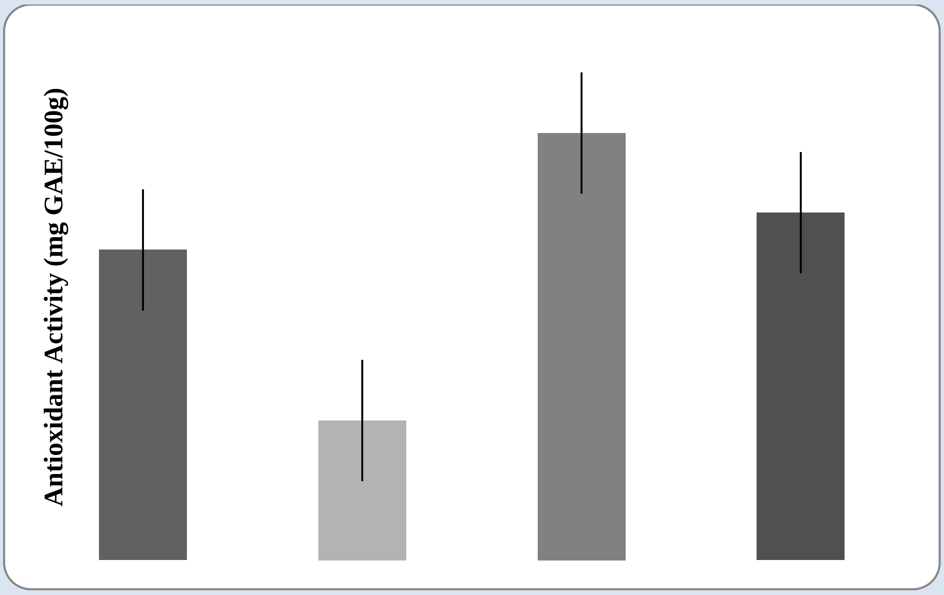

Figure 1: Antioxidant Activity of some selected underutilised leguminous seeds (mgGAE/100g).

LEGEND
± S.D = Standard deviation in parenthesis
CV = Co-efficient of Variance
Sample A – *Cajanus cajan* (Pigeon pea)
Sample B - *Sphenostylis stenocarpa* (African Yam bean)
Sample C – *Phaseolus lunatus* (Lima Bean 1)
Sample D – *Phaseolus lunatus* (Lima Bean 2)

Table 4 presents the Total phenolic content (TPC) of the samples. The results ranged from 2740 micromoles GAE/g in *Sphenostylis stenocarpa* (African yam bean) to 5400 micromole GAE/g in *Phaseolus lunatus* (Lima bean 1). The values were found in lower concentration when compared with those reported by (Velioglu *et al,* 1998) in selected fruits, vegetables, and grain products.

Table 3: Total phenolic content of some selected underutilised leguminous seeds (micromoleGAE/g).

SAMPLES	A1	A2	A3	Mean	(±)S.D	CV%
A	3772	3800	3780	3784	14.42	0.38
B	2740	2728	2572	2740	12.00	0.44
C	5384	5428	5388	5400	24.33	0.45
D	4896	4868	4900	4888	17.44	0.36

LEGEND
± S.D = Standard deviation in parenthesis
CV = Co-efficient of Variance
Sample A – *Cajanus cajan* (Pigeon pea)
Sample B - *Sphenostylis stenocarpa* (African Yam bean)
Sample C – *Phaseolus lunatus* (Lima Bean 1)
Sample D – *Phaseolus lunatus* (Lima Bean 2)

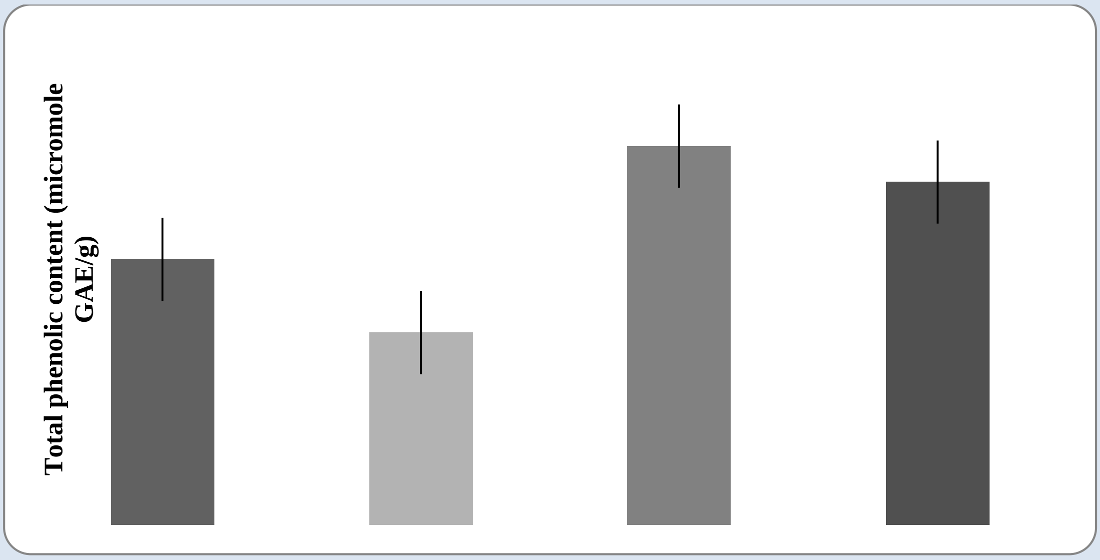

Fig 2: Total Phenolic content of some selected underutilised leguminous seeds (micromoles GAE/g)

LEGEND
± S.D = Standard deviation in parenthesis
CV = Co-efficient of Variance
Sample A – *Cajanus cajan* (Pigeon pea)
Sample B - *Sphenostylis stenocarpa* (African Yam bean)
Sample C – *Phaseolus lunatus* (Lima Bean 1)
Sample D – *Phaseolus lunatus* **(**Lima Bean 2)

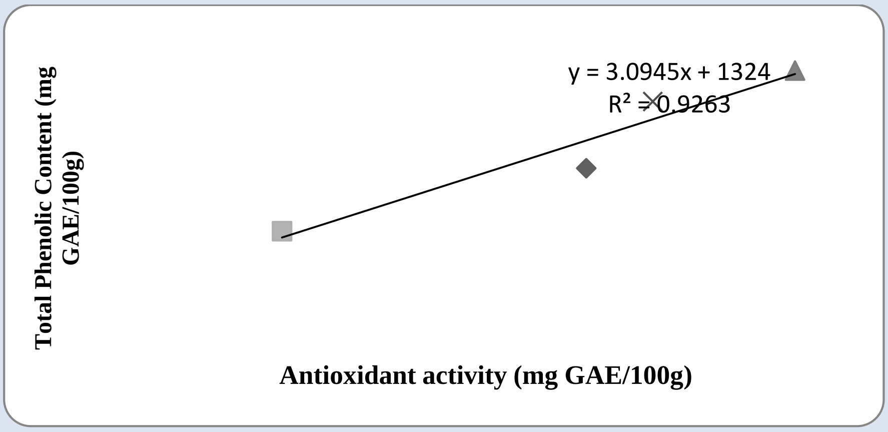

Figure 3: Relationship between the Antioxidant activity and total phenolic content of some selected underutilized leguminous bean seeds

CONCLUSION

The presence of the chemical compositions and high antioxidant capacity suggest that the intake of these bean seeds needs to be encouraged as they are rich sources of nutrients and minerals that are capable of ensuring good health with the high antioxidant capacity of all the samples suggest that they are readily available dietary sources of antioxidants which can alleviate symptoms associated with chronic and neurodegenerative disease. It is hoped that the current estimated climate change that could put more than 63 million people at risk of hunger by 2020 could be alleviated through agriculture by planting and consuming these underutilised leguminous bean seeds.

REFERENCES

Akande K.E, Abubakar M.M, Adegbola T.A, Bogoro S.E and Doma U.D (2010). Chemical Evaluation of the Nutritive Quality of Pigeon pea [*Cajanus cajan (L.)*Millsp.] *International Journal of Poultry Sciences 9 (1): 63-65.*

AOAC, (1990) Official methods of analysis 15th ed. Washington: Association of Official Analytical Chemist.

Audu S.S and Aremu M.O, (2011) Nutritional composition of raw and processed pinto bean (*Phaseolus vulgaris L.*) grown in Nigeria. *Journal of Food, Agriculture & Environment Vol.9 (3&4): 72-80*

Aremu M.O, Ogunlade I, Osinfade B.G and Okopi S.O. (2011). Some biochemical evaluation of raw and processed bambara groundnut (*Vigna subterranean L.*). *Int.J.Chem.Sci. Vol 4 No 1, ISSN: 2006-3350*

Chan, E. W.C, Lion, Y.Y and Chew, Y, L (2007); Antioxidant activity of camellia sinesis leaves and tea from a looking plantation in Malaysia J. *Food chemistry.* 102, 1214-122.

Etuk E.B and Udedibie A.B.I (2002). Substitution value of toasted Pigeon pea (*Cajanus cajan*) seed meal for Soybean meal amd maize in Broiler Starter Diets. *Int. J. Agric, Rural Dev.,3: 92-97.*

Food Agriculture Organisation.(2012). Globally almost 870 million chronically undernourished New hunger report.

Fasoyiro S.B, Akande S.R, Arowora K.A, Sodeko O.O. Sulaiman P.O, Olapade C.O and Odiri C.E.(2010). Physico-chemical and sensory properties of Pigeon pea (*Cajanus cajan*) flours. *African journal of Food Science vol .4(3), pp. 120-126.*

Kanayo F. Nwanze (2009). The Links Between Food Security And Climate Change.

Ogunlade I, Oni A, Osasona A.I (2011). Comparative analysis of antioxidant capacity and total phenolic content of some selected fruits in Ekiti State, Nigeria.NISEB Journal 11,4,329-334.

Singleton,V.,Orthofer,R. and Lamuela,R.(1996).Analysis of total phenols and other oxidative substrate by means of Folin-Coicocalteu reagent In L.Parker(Ed.) oxidants and antioxidants part A.Methods in enzymology 299,152-178.

Velioglu Y. S, Mazza G, Gao L, and Oomah B.O.(1988) Antioxidant activity and total phenolic content in selected fruits, vegetables, and Grain products. *J. Agric. Food Chem. 46,* 4113- 4117.

Climate Change Adaptation through increased Agricultural Productivity: Natural Products as Growth Enhancer in Cultured Clarias *Gariepinus* Production

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ABSTRACT

The use of natural products is one of the most promising methods of preventing fish diseases and improving growth as an alternative to the drugs, chemicals and antibiotics currently used in fish culture. A 56 day study was conducted to evaluate the effect of dietary inclusion of *Tetracera potatoria* root extract (TP) and *Psidium guajava* leaf extract (PG) on growth and haematological parameters of African catfish, *Clarias gariepinus.* One hundred and twenty juvenile with initial weight of 30 ± 0.3 g were randomly distributed into plastic tanks (45 L) at 10 fish /tank and replicated twice. Experimental animals were fed with commercial fish feed (42% crude protein) at 5% body weight twice a day. Group 1 animals served as control without inclusion of extract, groups 2 and 3 had 250 mg/kg and 500 mg/kg inclusion of TP, groups 4 and 5 had 250 and 500 mg of PG, respectively, group 6 animals had 600 mg/kg inclusion of vitamin C. The weight of the animals were recorded weekly for the period of the experiment while PCV, Hb, RBC WBC, differential WBC count, and weight of viscerals were determined at the end of the experiment. MCH, MCHC, MCV, viscerosomatic and hepatosomatic indices were afterwards calculated from these parameters. The mean weight gain (54.5g/fish), final standard length and the viscerotropic index were significantly different ($p<0.05$) across the group and the highest values were recorded in fish supplemented with 250 mg/kg TP. The highest percentage survival of 100% was recorded in groups 2, 3 and 6 animals. There was no significant change in the blood parameters of fish across the group. It can be concluded that the natural extracts had no toxic effects on the fish but they can serve as natural growth promoters in aquaculture production hence lead to increased productivity.

Keywords: *Clarias gariepinus*, growth enhancer, productivity, climate change, adaptation

INTRODUCTION

The international community faces great challenges in the coming decades including reining in global climate change, ensuring food security for the growing population, and promoting sustainable development. Changes in the agriculture sector are essential to meeting these challenges. Agriculture provides the main source of livelihood for the poor in developing countries, and improving agricultural productivity is critical to achieving food security as well as most of the targets specified under the

Millennium Development Goals (Rosegrant et al. 2009). One adaptation to climate change is through improved technologies so as to increase productivity.

Aquaculture is the growing and cultivation of different species of fish including other aquatic animals for the purpose of feeding, decoration, ornamental and for advance research. This branch of agriculture has become very important being that they are good source of protein, vitamins, oil e.t.c. (Chamberlain, 1993). Aquaculture fish production has been increased significantly over the past few decades which has led to intensive fish culture practices where stressors like overcrowding, transport, handling, size grading and poor water quality are common problem. *Clarias gariepinus* is the most cultured fish in Nigeria and indeed Africa (Soosean et al., 2010). Since the last three decades, clariid species has been considered to hold great interest for fish farming in Africa and Nigeria in particular. The fishes having wide geographical spread, a high growth rate, resistance to handling and stress and well appreciated in a wide number of African countries (Clay, 1979). Aquaculture fish production has been increased significantly over the past few decades which has led to intensive fish culture practices where stressors like overcrowding, transport, handling, size grading and poor water quality are common problem. It has been widely demonstrated that farmed fish are more susceptible to various pathogenic microbes in intensive farming. (Soosean et al., 2010).

In order to improve health conditions in the rearing of aquatic organisms, several alternatives such as improved husbandry, nutrition, and water quality; optimal stocking density; and use of vaccines, probiotics and immunostimulants have been proposed (Prasad and Mukthiraj, 2011). An immunostimulant is a substance that elevates non-specific defence mechanisms and specific immune response if the treatment is followed by vaccination or infection (Siwicki et al, 1988).

In recent years, there has been growing interest in the field of herbal medicines research and search for promising potential area of investigating of immunomodulatory agents from natural products. Herbal drugs are believed to enhance the natural resistance of the body against infection and their immunomodulatory activities have been reported in numerous plants (Upadhyay, 2010). *Tetracera potatoria* Afzel, family Dilleniaceae is known as liane a eau in France and water tree in Sieerra-leone (Burkil, 1985). It is found in wooded areas of Senegal, Southern part of Nigeria, Central and Eastern Africa (Dalziel, 1937) also known as Awo-Ekun in Nigeria. The leaves of the plant boiled in its own sap are used for the treatment of gastrointestinal sores (Burkil, 1985). Adesanwo et al., (2003) reported the antiulcer activity of the methanolic extract of the root of *Tetracera potatoria*. *Psidium guajava* is a tropical shrub tree whose leaf is reputed to cure diarrhea, hypertension, cancer etc and can serve as antioxidant (Gutierrez et al, 2008). This study examined the effects of *Tetracera potatoria* and *Psidium guajava* on the growth and immune response of catfish fingerlings as a means of increasing productivity.

MATERIALS AND METHOD

The experiment was conducted at the Faculty of Agriculture, Department of Animal Sciences Wet laboratory, Obafemi Awolowo University Ile-Ife Osun State located in the South West Nigeria. Fingerlings of Clarias gariepinus were bought from hatcheries in

Lagos State, and were transported in plastic containers and on arrival at the experimental site were immediately transferred into a bigger container and allowed to remain for at least three hours to allow them recover from transportation stress and acclimatize to their new environment. The *Clarias gariepinus* fingerlings were acclimated to experimental condition for 14 days at 27^{o}C ± 1.5^{o}C prior to the feeding trial.

Preparation of Plant Extract and Fish Feed

Fresh roots of *Tetracera potatoria* were purchased at Bode Market, Ibadan in Southwestern Nigeria while fresh leaves of *Psidium guajava* were harvested from Obafemi Awolowo University, Ile-Ife. The samples were authenticated at the herbarium unit of the Department of Botany, Obafemi Awolowo University, Ile-Ife where voucher specimen were deposited. The roots and leaves were air-dried and ground to powder forms after drying using hammer mill. Powdered and weighed samples of plant samples were extracted in 100% methanol by soaking for 72 hours. The resulting crude methanolic extracts (MeTP and MePG) were then concentrated under reduced pressure at 35^{o}C in a rotary evaporator to obtain the solid samples which was weighed and stored in the desiccator for pharmacological studies.

The extracts were reconstituted with distilled water to dissolve and carefully mixed with olive oil after which they were used to coat the feed. Thereafter, the feed was air-dried and assigned to an experimental treatment. This method is known as surface coating.

Experimental fish and feeding:

At the end of the acclimatization period, a total of 120 fingerlings were (mean initial weight 2.7±0.3 g) assigned into 6 groups (T1, T2, T3, T4, T5 and T6) and replicated twice.

- T1 Control,
- T2 Vitamin C 500mg/kg bw
- T3 *Tetracera potatoria* 250mg/kg bw,
- T4 *Tetracera potatoria* 500mg/kg bw,
- T5 *Psidium guajava* 250mg/kg bw and
- T6 *Psidium guajava* at 500mg/kg bw.

The fish were kept in 45L rectangular plastic tanks. Each culture treatment was fed with durante (2mm) floating diet, a complete dry catfish food containing 45% of protein, 14% fat, 1.6% of calcium, 1% potassium, 7.6% Ash, 2.5% fiber, 60 ppm minerals and vitamins A 5000iu/kg, D 750mg/kg, E 150 mg/kg, and C 100mg/kg. Each experimental diet was randomly assigned to duplicate tanks. The fingerlings were fed 5% of their body weight with the respective diet twice daily, morning (8.00am – 10.00am) and evening (4.00pm – 6.00pm). During the trial, the water temperature was maintained at 29.0±2.0°C and Dissolved oxygen ranged from 3.10-6.13mgL-1. The experimental unit was under a natural light and dark cycle. The sampling of fish for weight and length measurement was done by reducing the volume of water with a rubber siphon before the fish is collected. The weighing was done per treatment and on a weekly basis. On weighing days, the fishes were not fed in the morning until the whole exercise was completed and fed in the late afternoon. The feeding trials lasted for eight weeks (56 days).

Statistical Analysis:

Data obtained were subjected to one way Analysis of Variance (ANOVA) and the mean were separated using Duncan multiple range test. SAS package was used for this analysis.

RESULTS AND DISCUSSION

Table 1: Effect of *Tetracera potatoria* and *Psidium guajava* on hematological parameters of catfish fingerling

	Control (T1)	Vit. C (T2)	Tp250mg/kg (T3)	Tp500mg/kg (T4)	PG250mg/kg (T5)	PG500mg/kg (T6)
PCV (%)	22.20 ± 2.0^{ab}	26.40 ± 2.2^{a}	26.20 ± 1.2^{a}	24.90 ± 1.2^{a}	23.7 ± 1.6^{ab}	18.5 ± 1.6^{b}
HB (g/dl)	7.29 ± 0.7^{ab}	8.69 ± 0.7^{a}	8.67 ± 0.4^{a}	8.22 ± 0.4^{a}	8.14 ± 0.5^{a}	6.09 ± 0.5^{b}
RBC(x10^6/l)	2.25 ± 0.1^{c}	2.47 ± 0.2^{bc}	3.19 ± 0.2^{a}	2.98 ± 0.3^{ab}	3.02 ± 0.2^{ab}	2.54 ± 0.2^{c}
WBC(x10^3/l)	14.38 ± 2.1^{a}	13.34 ± 1.8^{a}	14.00 ± 0.9^{a}	10.98 ± 1.0^{abc}	11.12 ± 0.9^{ab}	13.64 ± 1.3^{a}
PLATELET(1000/mm^2)	7.4 ± 0.5^{b}	8.1 ± 0.7^{b}	13.64 ± 1.4^{a}	7.6 ± 0.4^{b}	7.8 ± 0.5^{b}	5.8 ± 0.5^{c}
MCV(fl)	92.5 ± 13.0^{a}	85.7 ± 14.8^{a}	85.8 ± 8.9^{a}	86.9 ± 6.0^{a}	84.6 ± 7.3^{a}	76.6 ± 7.6^{a}
MCH (pg)	32.4 ± 3.1^{a}	34.8 ± 2.2^{a}	28.6 ± 3.0^{a}	28.5 ± 1.9^{a}	27.6 ± 2.4^{a}	26.5 ± 2.7^{a}
MCHC (pg)	33.0 ± 0^{a}	33.0 ± 0^{a}	33.0 ± 0^{a}	33.0 ± 0^{a}	33.0 ± 0^{a}	33.0 ± 0^{a}
LYMP (%)	68.0 ± 1.6^{b}	65.5 ± 1.0^{b}	74.6 ± 0.2^{a}	61.2 ± 0.6^{c}	76.3 ± 2.7^{a}	71.0 ± 2.9^{ab}
NEUT (%)	30.9 ± 1.6^{b}	34.1 ± 0.2^{ab}	23.9 ± 0.2^{c}	37.9 ± 0.6^{a}	22.5 ± 2.6^{c}	28.0 ± 2.9^{b}
MONO (%)	1.2 ± 0.1^{a}	1.4 ± 0.2^{a}	1.4 ± 0.2^{a}	1.3 ± 0.2^{a}	1.3 ± 0.1^{a}	1.1 ± 0.1^{a}

Key: (PCV) Packed cell volume, HB-hemoglobin, RBC- red blood cell, WBC- white blood cell, MCV- Mean corpuscular volume, MCH- Mean corpuscular haemoglobin, MCHC- Mean corpuscular haemoglobin concentration, LYMP- Lymphocyte, Neut- Neutrophil, MONO- monocyte. Means with different superscript are significantly different at $p<0.05$

Table 2: Effect of *Tetracera potatoria* and *Psidium guajava* on growth parameters of catfish fingerling

Parameters	Control (T1)	Vit. C (T2)	TP250 (T3)	TP500 (T4)	PG250 (T5)	PG500 (T6)
Initial weight(g)	30	30	30	30	30	25
Final weight(g)	75	65.5	84.5	71.5	71.3	45.55
Mean weight gained(g)	45	35.5	54.5	51.5	41.3	20.55
% Weight Gained	150	118.3	181.65	138.3	136.5	82
% Survival	80	100	100	100	100	100

Table 3: Effect of *Tetracera potatoria* and *Clarias gariepinus* on mean body weight and length of Clarias gariepinus.

	BW(g)	Length(cm)
Control (T1)	440.0 ± 39.5^{b}	20.3 ± 1.2^{ab}
Vit .C (T2)	470.0 ± 32.1^{b}	19.5 ± 0.7^{b}
Tp250mg/kg (T3)	611.25 ± 47.68^{a}	21.76 ± 0.68^{a}
Tp500mg/kg (T4)	517.5 ± 34.35^{b}	20.46 ± 0.71^{ab}
PG250mg/kg (T5)	458.1 ± 28.5^{b}	19.6 ± 0.6^{b}
PG500mg/kg (T6)	321.2 ± 15.2^{c}	16.6 ± 0.4^{c}

Means with different superscript are significantly different at $p<0.05$.

Table 4: Effect of *Tetracera potatoria* and *Psidium guajava* on mean weight for Visceral, Liver, Heart, Testes, Egg, Viscerosomatic Index (VSI), Hepatosmatic Index (HSI) and Gonadosomatic Index (GSI).

	Control (T1)	Vit. C (T2)	Tp250mgkg- (T3)	Tp500mgkg (T4)	PG250mg/kg (T5)	PG500mg/kg (T6)
Visceral	6.9 ± 0.9^{b}	4.0 ± 0.8^{c}	9.7 ± 1.2^{a}	7.8 ± 1.01^{ab}	9.7 ± 0.8^{a}	3.8 ± 0.4^{c}
Liver	0.9 ± 0.21^{abc}	0.5 ± 0.1^{bcd}	1.28 ± 0.32^{a}	1.05 ± 0.19^{ab}	0.7 ± 0.09^{b}	0.3 ± 0.07^{c}
VSI	9.4 ± 0.71^{ab}	6.7 ± 0.53^{c}	10.4 ± 1.15^{a}	8.59 ± 0.58^{abc}	8.6 ± 0.46^{abc}	7.0 ± 0.34^{c}
HSI	1.1 ± 0.28^{a}	0.8 ± 0.17^{a}	1.21 ± 0.2^{a}	1.12 ± 0.15^{a}	0.9 ± 0.1^{a}	0.6 ± 0.1^{b}
GSI	1.5 ± 0.45^{a}	0.2 ± 0.15^{c}	1.26 ± 0.2^{ab}	0.40 ± 0.09^{bc}	0.7 ± 0.2^{b}	0.3 ± 0.02^{c}

Means with different superscript are significantly different at $p<0.05$.

There was a significant increase ($p<0.05$) in the PCV, HB and RBC of fish administered with TP250 with PCV of 26.20±1.2, hemoglobin count of 8.67±0.4 and RBC of 2.54±0.2 while there was a significant decrease in the PCV, HB and RBC of fish fed with PG500 with values of 18.50±1.6, 6.09±0.5 and 2.54±0.2 respectively when compared with the control group (Table1). The significant reduction in RBC and Hb content on exposure to *Psidium guajava* extract at 500mg/kg bw- caused anaemia in *C. gariepinus* fingerlings, the decline of MCV suggests that anaemic effect could be attributed the destruction of the erythrocytes or inhibition of erythrocyte production, similar trends in RBC in fishes exposed to various medicinal plants and toxicants have been observed and reported by other workers (Adeyemo 2005, Kori Siakpere et al .,2009, Gaafar et al., 2010, Ololade and Oginni 2010). The increase in haematological values recorded in fish in *Tetracera potatoria* group could be due to the presence of betulinic acid which is a constituent of *Tetracera potatoria*, a similar result was obtained in rats (Oyebanji et al, 2011). There was a general increase in weight gain in the course of the experiment with the highest growth performance observed in fish fed on 250mg/kg of *Tetracera potatoria* with mean weight gain of 54.5g and mean length of 21.76cm. The higher values obtained in this group could be due to the presence of growth stimulants or constituents in *Tetracera potatoria* namely flavonoids, alkaloids, tannins and phlobatannins (Oyebanji et al, 2011).

The fish in the treatment groups had 100% survival rate meaning that the exposure of *C. gariepinus* fingerlings to the plant extracts did not cause outright mortality.

Although *Psidium guajava* at 500mg/kg bw^{-} had effect on the physiology of the fish by significant reduction in growth rate as well as negative changes in haematological parameters, this is in agreement with the work of Ayuba et al., 2012.

Fish fed diet with *Tetracera potatoria* (250mg/kg) had the highest hepatosomatic and viscerosomatic indices than the rest of treatments, this may be due to enhanced development of liver and spleen which are the main blood forming organs in fish (in addition to the fore-kidney) this is similar to the result recorded by Yasser et al., 2010 where wormseed plants and chamomile fed to catfish enhanced the hepatosomatic and splenosomatic indices.

In conclusion, *Tetracera potatoria* and *Psidium guajava* inclusion into feed of *Clarias gariepinus* fingerling has a growth enhancing effect, and is therefore recommended as a means of check mating effect of climate change in aquaculture by increasing productivity.

REFERENCES

Adesanwo, J.K; Ekundayo, O., Oluwole, F.S., Olajide, O.A., Van Den Berge, A.J. and Findlay J.A (2003). The effect of Tetracera potatoria Afzel and its constituent- betulinic acid on gastric acid secretion and experimentally-induced gastric ulceration. Nigeria Journal on Physiology. Sci. 22:21-25.

Adeyemo, O. K. (2005). Haematological and Histopathological effects of cassava Mill Effluent in Clarias garienpinus. African Journal of Biomedical Research. 8: 179-183.

Ayuba, V.O., Ofojekwu, P.C. and Musa, S. (2012). Haematological Response and Weight Changes of the African Catfish *Clarias gariepinus* Exposed To Sub Lethal Concentrations of *Datura innoxia* Root Extract PAT ; 8 (2): 134-143

Burkill, H.M. (1985): The useful plants of West Tropical Africa. 2nd Edition. Royal Botanic Gardens, Kew. 1:650-652.

Dalziel, J.M (1937): The useful parts of West Tropical Africa. London: Crown Agent Publication

Gaafar, A.Y., El-Manakhly, E.M., Soliman, M.K., Soufy, H., Mona, S. Z., Mohammed, S.G. and Hassan, S.M. (2010). Some pathological, biochemical and haematological investigations on Nile Tilapia (Oreochromis niloticus) following chronic exposure to edifenphos pesticide. Journal of American Science. 6 (10): 542 – 551.

Kori-Siakpere, O., Ogbe, M.G. and Ikomi R.B.. (2009). Haematological response of the African cat fish (Clarias garienpinus) (Burchell, 1822) to sub-lethal concentrations of potassium permanganate scientific research and essay 4 (5):457 – 466.

Ololade, I.A. and Oginni, O. (2010). Toxic stress and Heamological effects of nickel on Clarias gariepinus fingerlings. Journal of Environmental Chemistry and Ecotoxicology.2(2):14-19

Oyebanji, B.O and Saba, A.B. (2011). Phytochemistry and in vitro anti-oxidant activities of Stellaria media, Cajanus cajan and Tetracera potatoria methanolic extract. Journal of Medicinal plant research Vol. 5(30), pp. 6622–6627

Prasad, G and Mukthiraj, S (2011). Effect of Methanolic extract of Andrographis paniculata (Nees) on Growth and Haematology of Oreochromis mossambicus (Peters).World J. Fish and Marine Sci. 3 (6): 473-479

Rosegrant et al. 2009. Building climate resilience in the agriculture sector. Manila, Philippines and Washington, D.C.: Asian Development Bank and International Food Policy Research Institute.

Siwicki, A.K. and M. Korwin-Kossakowski (1988). The influence of levamisole on the growth of carp (Cyprinus Carpio) larvae. Journal of Applied Ichthyology 4: 178-181.

Soosean, C. Marimuthu, K., Sudhakaran, S and Xavier, R. (2010). Effect of mangosteen (Garcinia mangostana L.) extracts as a feed additive on growth and hematological parameters of African catfish (Clarias gariepinus) fingerlings. Eur Rev Med Pharmacol Sci.14(7):605-11

Upadhaya, S.N., 1997. Therapeutic Potential of Immunomodulatory Agents from Plant Products. 1st Edn., Narosa Publishing House, New Delhi, pp: 149-150.

Yasser M. A, Osama A. S and Saleh F. S. (2012). Study on the Effect of Wormseed Plants; Artemisia cina L. and Chamomile; Matricaria chamomilla L. on Growth Parameters and Immune Response of African Catfish, Clarias gariepinus. Journal of Fisheries International Volume: 5: 1 Pp 1-7

Climate Change and Food Security: Adaptation Strategies and Mitigation Measures in Nigeria

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ABSTRACT

Climate change is caused by the release of billions of tons of carbon dioxide (Co_2) and other heat trapping gases known as Green House Gases into the atmosphere. This results in the depletion of ozone layer leading to increase in the earth's surface temperature due to direct heating of the earth's surface by the sun. This paper discusses the impact of climate change on food security. Climate change impacts on food security in a number of ways. Climate change is impacting on oceans, seas, lakes and rivers and on the animals and plants that are found and/or cultured in them. In Nigeria, thousands of people and their families whose livelihood depend on fishing and aquaculture are affected by climate change as fish become less abundant because many migrate to other areas due to extreme weather events, droughts and the warming of waters. Furthermore, climate change results in low agricultural productivity increase in agricultural pests and diseases, hunger and starvation and in extreme cases death. Various adaptation strategies for coping with the effects of climate change on food security are discussed among which are: use of more

efficient crop varieties, more efficient irrigation and watershed management, efficient use of climate data and forecasts, through early warning systems, changing planting dates, and introducing irrigation into current rain fed systems.

INTRODUCTION

Climate change is the biggest environmental problem of our time that is threatening the existence of man and the environment. It is a major threat to agricultural system and food security in many countries in sub-Saharan Africa (Nigeria inclusive). Climate change or global warming refers to all changes in climate as a result of natural variations and human activities. Natural variation is due to increase in the concentration of carbon dioxide and other heat trapping gases (such as methane, ozone, nitrous oxide, carbon monoxide and water vapour) in the atmosphere. These heat trapping gases are known as Green House Gases (GHG) and occur naturally in the troposphere. The greenhouse gases prevent the direct heat of the sun from heating the surface of the earth but allow sufficient heat to keep the earth warm enough for survival of life. The increased emission of carbon dioxide into the atmosphere results in the depletion of the ozone layer and this leads to increase in the earth's surface temperature due to direct heating of the earth's surface by the ultra-violet radiation of the sun. Climate change is also caused by human activities such as large scale deforestation, wide-spread use of land, over-population, reduced reliance on organic fuels and accelerated uptake of fossil fuels. These activities lead to increased emission of Green House Gases into the atmosphere (troposphere) which in turn increases the average surface temperature of the earth.

Climate change is a threat to food security because of its impacts on the agricultural system. Agricultural production in most Sub-Saharan African Countries (Nigeria inclusive) is dependent on weather. Climate change has a direct impact on the productivity of physical production factors such as soil's moisture and soil fertility and this affects farming outputs which in turn impacts negatively on food security. In other words, the food security of a nation depends on the stability and sustainability of sufficient food from the agricultural sector. This paper seeks to provide answers to the following disturbing questions about climate change and food security. What is climate change? Is Nigeria vulnerable to climate change? How does climate change impact on food security in Nigeria? What are the mitigation measures and adaptation strategies for coping with the impact of climate change on food security in Nigeria? The paper concludes that the development of appropriate policy instrument that will effectively address adaptation challenges to climate change is inevitable if Nigeria must attain her much desired goal of insuring food security for her teaming population of 167million

WHAT IS CLIMATE CHANGE?

Over the past 100 years, the earth's average surface temperature has risen by 0.74^{o}celsius. This rise in the temperature of the earth has brought some changes in the global weather pattern by affecting natural resources and balance of nature, upsetting seasonal cycles, disrupting the ecosystem and water supply, causing sea levels to rise, affecting agricultural productivity and food security. The Inter-governmental Panel on

Climate change defined climate change as statistically significant variations that persist for an extended period, typically decades or longer. It includes shifts in frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature [1]. United States Global Climate Change Programme defined climate change as Extreme reactions of the weather phenomenon which creates negative impact on agricultural resources, water resources, human health, depletion of ozone layer, vegetation and soil, leading to doubling of carbon dioxide concentration in the ecosystem [2]. Some researchers [3], [4] are of the view that global temperature will rise further if the factors implicated in climate change are not urgently addressed. Furthermore, that there are likely to be more instances of extreme weather events (such as floods, landslides, drought, storms, increasing rise in seas levels, increase in environmental degradation, increase in pest and disease infestations of agricultural crops and animals, poor agricultural productivity, poverty, hunger and starvation and food insecurity. The sectors which are considered most vulnerable to climate change are agriculture and food security, water resources and habitat.

VULNERABILITY OF NIGERIA TO CLIMATE CHANGE

Vulnerability is the degree to which a system is susceptible to or unable to cope with adverse effects of climate change including climate variability and extremes [5]. Most countries in sub-Saharan Africa (including Nigeria) are likely to suffer the effects of climate change more than other countries in the world. This is due to their geographical location, low income, low institutional capacity as well as their greater reliance on climate sensitive renewable resources [6]. Nigeria like other countries in Sub-Saharan Africa is highly vulnerable to the impacts of climate change [7]. Many towns and villages in Nigeria lie along the coastal, littoral states of the south and the Northern front line states. These communities are exposed to climate variability or extremes such as shift in temperature, rainfall, storms and rise in sea levels. These changes in weather patterns impact negatively on agricultural activities and food security in Nigeria. Furthermore, Nigeria is particularly vulnerable to climate change because of her over dependence on rain-fed agriculture, wide-spread poverty, unemployment and weak capacity. Climate change, therefore, is a major threat to the agricultural system and food security. The six geopolitical zones in Nigeria are vulnerable to climate change. The degree of vulnerability to climate change in the six geopolitical zones in Nigeria varies from zone to zone. The South-South and South-West geopolitical zones for example, are mainly affected by sea level rise and deforestation-induced change, the south-east zone is affected mainly by erosion, flooding and land degradation, the North-central is affected by changes due to deforestation and over-grazing, the North-East by drought, desertification and heat-stress and the North-West is also affected by drought, desertification and heat stress [8]. An assessment of some aspects of Nigeria's vulnerability to climate change carried out by [9] using a wide range of data available at National and Regional levels reveals that vulnerability varies across the country with the North-East and North-West zones of Nigeria being more vulnerable to climate change than the south-west and the south-east. The North Central zone, has a relatively more favorable condition and this could be attributed to the presence of earth dams. The Earth dams could have influenced the volume of rainfall in the North-Central Zone hence they have a better prospect for enhanced livelihood than the North-East and North-West Zones of Nigeria. The findings of the study further revealed that the critical vulnerability factors in the South East Zone include delayed onset of rains, early retreat of rains, unsteady growing season and other extreme climate events, such as large scale distribution of acid soils, extensive gully erosion, and few water reservoirs to support irrigation. Furthermore, many parts of Anambra and Enugu States of Nigeria are ravaged by sheet and gully erosion. Some of the worst-hit areas include the Agulu-Nanka axis, the areas around Nkisi River, Amawbia and Ozubulu areas of Anambra State. The Northern part of Nigeria is also seriously affected by climate change. In the Sahel regions of Northern Nigeria, invasion of sand is a threat to human activities and food security. Farmlands and houses are frequently submerged or buried annually by sand from the Sahara desert [10]. The encroachment of the Sahara desert on once fertile land used for food production is a serious threat to food security in Nigeria. Thus, the most vulnerable regions are the desertification prone areas in the Northern part and the erosion prone areas in the southern parts of Nigeria. The vulnerable communities are farmers, fishers, pastoralists, hunters, the elderly, women, children and very poor people.

IMPACT OF CLIMATE CHANGE ON FOOD SECURITY IN NIGERIA

Agricultural production in Nigeria is rain-fed hence it is dependent on weather. Climate change is a serious threat to agricultural production and food security. Food security refers to availability and accessibility to enough food by all people at all times for an active and healthy life. A country is considered food secure when its population does not live in hunger or fear of starvation. Food security is important in any consideration of wealth and economic sustainability of a nation. The economy of Nigeria depends heavily on the agricultural sector though her development funds are derived from petroleum, oil and gas exploitation. Furthermore, estimates from the 1991 National population census in Nigeria indicate that 69% of the population engages in agricultural activities and 40% of the nation's Gross Domestic Product (GDP) is derived from the agricultural sector [11]. Climate variability and extremes impacts more on the agricultural sector than any other sector. These impacts are manifested in changes in frequency and intensity of rainfall, droughts, floods, changes in soil moisture and nutrient, increase in pests and diseases of crops and livestock, desertification, land degradation, heat stress, rise in sea level and erosions. These adverse weather events constitute important challenges to crop and livestock production, fish farming and hunting in Nigeria. Climate variability and extremes impact on food security in Nigeria in the following ways:

Effect on Crop Production

Climate change can adversely affect crops at any stage of production starting from cultivation through growing period to harvest. When crops are adversely affected by water shortage (insufficient rainfall), or heat stress (excessive high temperature) crop yield becomes poor and there is increased risk of hunger and starvation. As temperature increases and rainfall patterns become more unpredictable, crop yields drop significantly. Extreme weather events such as thunderstorms, heavy winds and floods devastate farm lands causing crop failure and serious agricultural losses and this impact negatively on food security. Variations in rainfall patterns in Nigeria also affect crop production in varying ways depending on location. However, even if there is sufficient rain, its irregularity can affect yields adversely. In other words, if the rains arrive late or fail to arrive during the crucial growing stage of the crops, yields will definitely be affected and this in turn impacts on food security. Changes in crop development and phonology due to climate change can cause shortening or lengthening of crop cycles and this can lead to decreases or increases in productivity [12]. Variations in temperature and rainfall expose crops to new crop pests and diseases that flourish only at specific temperatures and humidity. These crop pests and diseases pose new risks for food safety, food security and human health.

Effect on Livestock Production

Live stock production system in Nigeria is vulnerable to climate change. A decrease in rainfall especially in the Sudan Sahelian Zone in Northern Nigeria leads to a reduction in available pasture land, a decline in the available surface water and an increase in the salinity of water resources available to animals. These adverse environmental conditions affect livestock production and availability of animal species as food. Some species may not be able to adapt quickly enough to the changing environment and an alternative habitat may not be readily available for them to move into, hence such species may be threatened by an increase risk of extinction. Increase in temperature and shortage of water have adverse effect on livestock production though this effect is not uniform across agro-ecological zones. This means that varying environmental conditions have varying effects on livestock depending on the agro-ecological location. Furthermore, changes is weather conditions of a place usher in new pests and diseases of livestock and pose new risks to food production, food safety and food security.

Effect on Fish Farming and Aquaculture

Fish farming is an important source of revenue and employment in Nigeria. Climate change is having an impact on oceans, seas, lakes and rivers and on the animal and plants that are found and are cultured in them. Climate change is affecting millions of people in Africa (Including Nigeria) whose livelihood depends on fishing and aqua culture. This is because some fish resources are becoming less abundant while important species move to other areas where they are less accessible to fish farmers due to water shortage and changes in the temperature of the water. Changes in-key environmental variables such as temperature, salinity, wind speed and direction, ocean currents and strength of upwelling due to climate change sharply alter the abundance, distribution and availability of fishes in the country [12]. Furthermore, changes in ocean dynamics lead to changes in migrating patterns of fish and possibly reduce fish landing especially in coastal fisheries.

Aquaculture practices are threatened by increased extreme weather events, droughts and warming of waters. All these impact negatively on food security and on livelihood as it becomes more difficult for many fishing communities to provide fish for feeding their families or make a living, from fish farming. Coastal communities are displaced by rising sea levels and forced to find new places to live and new ways to earn a living. All these directly or indirectly affect the livelihoods of fish farmers, their immediate families, their dependants and food security in Nigeria. It also affects the revenue sustenance of those who work or trade on fishery resources. Fishery resources are highly sensitive to marine environmental changes. Although fishes had always coped with these changes, future climate changes will likely be so extreme that it may be difficulty for them to cope with. Hence, identification of proper mitigation measures and adaptation strategies is a high priority to ensure continued food security in Nigeria.

Effects on Forestry and Hunting

The forest reserves in Nigeria are not left out in the threat posed by climate change. Climate change affects agriculture and forestry through higher temperatures, elevated carbon dioxide concentration, precipitation changes, increased weeds and increased pests and diseases of plants. All these adversely affect food production and food security in Nigeria in diverse ways. Deforestation whereby forests are cut down faster than they are replaced is a major contributor to climate change. Deforestation accounts for 20 percent of the world carbon emissions because trees absorb carbon dioxide as they grow and use them for the synthesis of organic food substances. If there are fewer trees left to absorb carbon dioxide then carbon dioxide will build up in the atmosphere. Various agricultural activities, industrialization, increase in population do not only damage the earth's ability to absorb carbon dioxide but often cause an additional problem by producing emissions of their own. Furthermore, cutting down of forest vegetation for whatever reason makes the wild life to relocate to new habitat. This affects hunters who depend on hunting of these animals for livelihood. Consequently, deforestation affects food securities as meat becomes less available to the masses.

Mitigation Measures and Adaptation Strategies in Climate Change

Climate change is perhaps the most serious threat to the fight against hunger and starvation, malnutrition, poverty and diseases in Africa (Nigeria inclusive). Climate change is global but its adverse effects are felt mainly by developing countries, especially those in Africa due to their low coping capabilities. As the planet warms, rainfall patterns shift and extreme events such as droughts, floods, erosions and forest fires become more frequent. Tragic crop failures and reduced agricultural productivity results in food insecurity. Consequently, there is increased hunger and starvation, poverty, malnutrition and diseases in Africa. It is projected that due to climate change, crop yield in Africa may fail 10-20% by 2050 or even up to 50% [13]. This is because agriculture in Africa is predominantly rain-fed, hence depends on the vagaries of weather. Climate change impoverishes Africa by retarding economic growth and undermining sustainable development. There is need therefore to seek for ways of coping with the adverse effects of climate change. Two main categories of measures taken to address climate change are: mitigation and adaptation.

What is Mitigation?

According to IPCC mitigation refers to activities aimed at reducing green house gases emission directly or indirectly. This can be achieved either by avoiding GHG emissions or capturing those gases before their release into the atmosphere or by trapping GHG already present in the atmosphere by increasing carbon dioxide sink such as forests and use of carbon capture and storage (CCS). Reduction of emission of Green House Gases (GHG) can be achieved by avoiding deforestation and forest degradation, use of other technological devices and dissemination of new technologies such as use of LED lamp, and improved cook stoves.

Mitigation Measures

Mitigation measures aim at reducing loss of life and property by lessening the impact of disasters. It is taking action now-before the next disaster to reduce human and financial consequences later. It entails analyzing risk, reducing risk and insuring against risk. The recent flood disaster in Nigeria in 2012 had far reaching human, financial, economic, health and social consequences on Nigerians. Many farm lands and agricultural products were washed away by flood, property worth billions of naira was destroyed, many communities were sub-merged in the flood and thousands of people were rendered homeless. Effective mitigation entails an understanding of local risks especially the risks that would be faced by rural farmers should such disaster reoccur and how best to reduce the effect of a reoccurrence of such disaster. Mitigation measures are necessary to reduce the rate and magnitude of climate change. Some suggested mitigation measures to cushion the effect of climate change include:

i. Construction of wide drainage channels for flood control and clearing all drainage ways for easy flow of water.
ii. Dissemination of information about climate change in local dialects at the grass root.
iii. Campaign against over stocking of livestock and over grazing of a piece of land as a way of avoiding land degradation.
iv. Use of gingles, advertisements and bill boards to disseminate info about climate change to all parts of the country.
v. Mounting of robust enlightenment campaign before and during disasters through the use of community radios and other indigenous communication systems like: Use of town criers, gongs, and bells to announce to the people about an impending disaster.

What is Adaptation?

Adaptation refers to adjustments in practices, processes or structures in response to projected or actual changes in climate with the goal of maintaining the capacity to deal with current and future changes and/or take advantages of new opportunities that may be presented. Adaptation includes activities that are taken before impacts are observed (anticipatory) and after impacts have been felt (reactive). It is any response to improve an outcome [14]. Adaptation also refers to the decisions that people, communities, businesses, institutions and governments take to prepare for and respond to a changing climate. In addition to mitigation measures being developed to combat climate change, adaptation to the anticipated climate change is essential. While mitigation is necessary to reduce the rate and magnitude of climate change, adaptation is essential to reduce the damages from climate change that cannot be avoided.

The Nigerian agricultural sector of the 21st century is facing two main challenges, namely: the need to increase the nation's food supply as well as adjusting to variation in climate. In most African countries including Nigeria, agriculture is practiced across a broad range of climates and environmental conditions, hence the country need to develop many adaptation options that will meet the different conditions of the different ecological locations of the nation. Adaptation therefore is any response that improves an outcome. Adaptation to impact of climate variations on food security entails direct changes in the agricultural system. Adapting to climate change or climate variations in recent weather patterns is crucial for agricultural productivity in most developing countries in sub-Sahara Africa especially Nigeria.

Types of Adaptations

There are two basic types of adaptation, autonomous adaptation and planned adaptation. **Autonomous adaptations** occur more or less on their own; that is automatically without outside investment or policy intervention. In autonomous adaptation, farmers recognize climate shifts or climate variation and reacts in ways that offsets expected losses. For instance, farmers could react to changing precipitation patterns by changing crops, using different planting/sowing dates and different harvesting date.

Planned adaptation measures are conscious policy options, investments or response strategies, often multi-sectorial in nature and aimed at altering the adaptive capacity of the agricultural system. A lot of adaptation options have been tried on the different areas of agriculture. Some yielded positive results while the effects of the rest are still being observed.

Adaptation Strategies to Climate Change

There are two approaches to adaptation to climate change namely:

i. Extant measures and ii. Ex post responses.

Extant measures are actions taken in anticipation of a given climate realization. Ex post responses are measures undertaken after the event is realized. Extant adaptation strategies to climate variability (climate change) are strategies centred or based on diversification. This is based on the fact that a given climate event may have differential effects on different crops and activities in a given year. Hence farmers diversify their farm activities in various ways such as: farmers growing rainfed crops in a drought-prone environment may choose to diversify the location of their farm plots so as to benefit from the high spatial variability of rainfall, grow a variety of crops with different sensitivity to climate, diversify income sources into non-farm enterprises that are less sensitive to climate, maintain flexibility in decisions about when crops are to be planted and farmers could insure their harvests against failure.

Ex post adaptation strategies are strategies adapted to reduce or decrease crop or welfare losses once climate events have been realized

Such ex post adaptation strategies include:

- utilizing cash reserves or stored grain to start all over.
- borrowing from formal or informal credit markets or family
- selling assets such as livestock to use the money to start all over again.
- migrating elsewhere in search of job in non-affected regions.
- replanting fast maturing varieties after the growing season has started if early season planting fails.
- planting trees in rows to serve as wind breakers and to check erosion.
- irrigating where possible if rainfall is meager.
- using better and wider drainage channels to check floods and erosions.

However, not all strategies are available to all farmers, nor are all available strategies always successful in buffering food security against a variable climate. In wealthier countries, farmers rarely go hungry as a result of drought, flood or other adverse climate events. This is because of the existence of social safety nets and functioning financial markets or can receive help from the government to maintain livelihoods during bad times. In like manner, consumers in rich countries spend only a small percentage of their income on food; hence they are not very sensitive to the food price increases that often accompany droughts or floods. In poor countries (Nigeria inclusive) both extant and ex post adaptation strategies can be used to reduce climate associated losses to some degree. However, the poorest households are unable to withstand the effects of climate variability and this usually have dramatic and devastating consequences as was the case in the drought-related famines in the Sahel and Horn of Africa in the 1980s. The negative impacts of climate variability on economic livelihoods and food security in Nigeria is enormous helping farmers to better adapt to climate variability should be the main concern of government.

SUGGESTED ADAPTATION STRATEGIES FOR COPING WITH THE IMPACTS OF CLIMATIC CHANGE ON FOOD SECURITY IN NIGERIA

Nigeria has a weak adaptive capacity hence her adaptive capacity need to be strengthened to cope with damages caused by climatic change. Many farmers in Nigeria usually become completely helpless when any harvest fails or a disaster occur. Two cases in point are the Sokoto flood disaster in 2010, and the 2012 flood disaster that swept over several states in Nigeria. In each of these two cases flood swept away many farmlands and many houses were sub merged, livestock and property worth millions of naira were destroyed and thousands of people were rendered homeless. This disaster left many local farmers economically devastated as they had no significant alternative source of livelihood. Furthermore, the food security of the nation was seriously threatened as food was not available and affordable to the masses. Hunger and starvation, malnutrition, poverty and health problems were on the increase and in severe cases loss of life. In the light of the above, some adaptation strategies that will enable Nigerians cope with the impact of climate change on food security were highlighted in this paper. The recommended strategies may simply be an improvement of an already existing practice in the community or completely new strategies to the community. They are as follows:

i) Use of Accurate and Timely Weather Forecasting

Timely and accurate weather forecasting is crucial for improving crop performance and yield. There is need to develop human capacity and appropriate infrastructure for weather forecast and dissemination of information about weather. This will enable the farmers to know when and where to grow their crops and the types of crops to grow given the weather conditions at the time. In this way, food production is improved and food security is assured.

ii) Use of Agricultural Extension Services

Agricultural extension officers are trained to link farmers with scientific methods of improving farm operations as well as providing relevant weather information based on local and indigenous knowledge about adaptive practices. Farmers should therefore utilize the services of the agricultural extension officers for improved crop yield.

iii) Use of Efficient Irrigation Infrastructures

To eliminate crop failure due to drought and increased evaporation efficient irrigation system should be adopted. It enables farmers to extend their farming into the dry season and not to depend solely on rain-fed agriculture. In this way food production will increase and become more available and affordable by many Nigerians.

iv) Growing of Drought Resistant Variety of Crops

This strategy could be adopted in drought-prone areas where water stress may be a limiting factor. Switching to new crops that are drought tolerant e.g. cassava and maize is very rewarding because it increases agricultural productivity.

v) Growing more cover crops to Protect the Soil from Erosion and Leaching

Cultivating spreading crops like potatoes, melons and groundnut in the farming cycle help to curb loss of top soil through erosion and leaching of food nutrients by heavy down pours.

vi) Planting of early maturing varieties like maize and cassava especially when the first crops planted at the beginning of the planting season has failed.

vii) Increasing and upgrading storage facilities to preserve crops for longer periods and prevent the destruction of crops by insect pests and excessive heat of the sun. When crops are well preserved, then food availability is ensured for longer period.

viii) Control of pest, insects and birds to ensure increased crop yields and high market value of agricultural products.

CONCLUSION

This paper upholds that climate change is real and that Nigeria is highly vulnerable to climate change. Climate change is impacting negatively on food security in Nigeria as shown by low agricultural productivity. A large number of Nigerians are still malnourished, hungry, starving and poor and have various health problems due to food insecurity caused by climate change. Nigeria needs to adopt some adaptation strategies that will enable her cope with the challenges of climate change to ensure food security in the country. To achieve this, there is urgent need for climate change policy at both National, state and local government levels in Nigeria. It is hoped that if the suggestions as made in this paper are effectively pursued, the country's vulnerability to climate change will reduce appreciably and Nigeria's food security will be greatly enhanced.

RECOMMENDATIONS

The following recommendations are proffered as ways of coping with the impacts of climate change on food security in Nigeria.

1. Government should set up temporary relief camps or settlements for flood victims or temporarily displaced people.
2. Financial support (loans) should be given to farmers affected by disasters caused by climate change to enable them start off again.
3. Government should establish a National climate change commission to handle issues related to climate change.
4. Climate change issues should be infused into the curricula at the various levels of the education systems to enable learners gain knowledge and understanding about climate change. This, it is hoped will enable learners avoid acts that promote climate change in Nigeria.
5. Laws forbidding bush burning and large scale deforestation should be promulgated as a way of checking land degradation and carbon dioxide emission.
6. Climate change adaptation should be mainstreamed into Nigeria educational system to create sufficient knowledge and awareness about climate change among the youths.
7. Government should stabilize gullies and erosion site through better methods of erosion control.
8. Government should improve the monitoring and evaluation of agricultural activities with realistic and measurable indicators to enhance food security in Nigeria.
9. Government should help farmers to secure agricultural insurance and loans in situations of disaster to enable them take off again.
10. Farmers should be encouraged to engage in other businesses other than farming so that incase of disaster, they will still have something else to fall back on.

REFERENCES

[1] Intergovernmental Panel on Climate Change (IPCC) (2007). Impact, Adaptation and Vulnerability. Contribution of Working Group I of the Intergovernmental Panel on Climate Change (Third Assessment Report). London: Cambridge University Press.

[2] United State Global Change Programme *Global Climate Change Impacts in the United States, Global Climate Change Chapter.* Retrieved on 2/05/2013 from http://downloads global change. gov. usimapacts /pdfs /global.pdf.

[3] Butt,T.A. McCari, B.A. Angerer, J. Dyke, P.T. & Stuth, J. W. (2005). The economic and Food Security Implications of Climate Change. *Male Journal of Climate Change* 6(8) 355 – 378.

[4] Ole, M., Cheikh, M. Anette, R. & Awa, D. (2009). Farmers Perception of Climate Change and Agricultural Strategies in Rural Sahel. *Journal of Environmental Management* 4(3) 804 – 816.

[5] Intergovernmental Panel on Climate Change (IPCC) (2001). Impact, Adaptation and Vulnerability. Contribution of Working Group II of the Intergovernment Panel on Climate Change to the (Third Assessment Report). London: Cambridge University Press.

[6] Eboh, E. (2009). Implications of Climate Change for Economic growth and sustainable development in Nigeria. *Enugu Forum Policy Paper 10. African Institute for Applied Economics, Nigeria.*

[7] Nigerian Environmental Study Team (NEST) (2004). Climate Change and Nigeria: A guide for Policy Makers. The publication of the Nigeria Environmental Study Team (NEST). Ibadan Nigeria 12 – 20.

[8] Ozor, N. (2009). Understanding Climate Change: Implications for Nigerian Agriculture Policy and Extension. *Paper Presented at the National Conference on Climate Change and the Nigerian Environment. Organized by the Department of Geography,* Nsukka: University of Nigeria.

[9] Adesina, A. & Odekunle, T. O. (2011). Climate Change and Adaptation in Nigeria: Some Background to Nigeria's Response II. *International Conference on Environmental and Agricultural Engineering.* 15 (2), 74 – 80.

[10] Ogbo, A. I & Onyedinma, A. C. (2012). Climate Change Adaptation in Nigeria: Problems and Prospects. *Sacha Journal of Environmental Studies* 2(1) 130 – 145.

[11] Ijeoma, Stanley (2012). Nigeria and Climate Change Adaptation. International Society of Sustainability Professionals Insight 1 – 6.

[12] Ifeanyi-Obi, C. C., Etuk, U. R. & Jike-Wai O (2012) Climate Change, Effects and Adaptation Strategies: Implications for Agricultural Extension System in Nigeria. *Greener Journal of Agricultural Science* 2(2) 53 – 60.

[13] Anyadike, R. N. C. (2009). Climate Change and Sustainable Development in Nigeria; Conceptual and Empirical Issue. Enugu Forum Policy Paper 10. African Institute for Applied Economics, Nigeria.

[14] Reilly, J & Schimmelpfenning D. (2000) Irreversibility, Uncertainty and Learning: Portraits of adaptation to long-term climate change, *Climatic Change* 45(1) 253 – 278.

Climate Change and Food Security in Kogi State

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ABSTRACT
This study highlighted the effect of climate change on food security and how to maintain food availability and accessibility resulting to food security in times of climate change. This paper focused on the challenges to achieving food security, managing risks and how to adapt to climate change to maintain food security. It will provided information on the way out, the relationship between climate change and food security, and ways of dealing with the new threat during climate change to sustain food security. Six local government areas in Kogi State were used for the study, (i.e. those flood affected areas - Ibaji, Bassa, Lokoja, Odoru, Koton-Karfi and Omala). A structured questionnaire was used to collect information on climate change and food security. The results showed 61% of the respondents chose early planting for yams, cassava, sweet potatoes and maize 25%, chose irrigation for rice, maize and vegetables. 14% respondents chose rainy season for planting maize, yam, rice, beans, cassava and sweet potatoes. The findings will strengthen the vulnerable rural people and also help them to cope with this threat to food security. It also sensitize rural people in agricultural sector to adapt and be able to contribute to food security in the face of climate challenge. This paper suggested to Kogi State Government to educate the vulnerable poor rural dwellers on monitoring weather, improving scientific understanding of climate change and providing timely weather information for all actors in the food system.

Key words: Climate change, food security

CLIMATE AND ITS MEASUREMENT

Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location; weather refers to the day-to-day functions in these conditions at the same location. The variables that are commonly used by meteorologists to measure daily weather phenomena, are air temperature, precipitation (e.g rain, sleet, snow and hail), atmospheric pressure and humidity, wind, sunshine and cloud cover (FAO, 2007).

Climate is a particularly important driver of food system performance at the farm end of the food chain, affecting the quantities and types of food produced and the adequacy of production- related income.

The Concept of Climate Change

According to Ogbo, *et al.,* (2013) climate change refers to any change in climate overtime, whether due to natural variability or as a result of human activity. It can also be seen as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (Pany *et al.,* 2007).

Climate change is the drastic alteration in the natural components of the atmospheric environment with the resultant adverse responses (Aina, 2013), it is the shift in weather variations or patterns involving overall and unprecedented changes in weather patterns, which may include unusual challenges in rain yield or precipitation, temperature, density or cloud look.

According to FAO, (2007) there is no internationally agreed definition of the term “climate change”. For internationally agreed terminology on climate and climate changes, climate change can be referred to:

i. Long-term changes in average weather conditions.
ii. All changes in the climate system, including the drivers of change, the changes themselves and their effects.
iii. Human – induced changes in the climate system.

Climate Variability

There is also no agreement on how to define the term “climate variability”. Climate has been in a constant state of change throughout the earth’s 4.5 billion- year history, but most of these changes occur on astronomical or geological time scales, and are too slow to be observed on a humale scale. Natural climate variation on these scales in sometimes referred to as “climate variability” as distinct from human- induced climate change (McCarthy, 2001).

Causes of Climate Change

There is a global consensus about the causes of climate changes is instigated by human activities (Aina, 2013). A chief contributor is the global over- dependence on the use of fossil fuels to meet energy needs.

The use of fossils leads to the release of green house gases (GHGs), mainly produced from natural gas, fossil fuels constitute the primary source of energy to the world economy, and have been utilized in power generation, transportation, agriculture, manufacturing, land use and other activities.

Nigeria relies more on the use of generators to generate household and industrial electricity supplies most vehicles depend heavily on petroleum or diesel, as kitchen appliance depend on gas or kerosene that precipitate and form cloud. All these sources of human and economic activities that emit sizeable yield carbon dioxide and other deleterious gas (Fegbemi and Idoko, 2009).

The agricultural sector and the mode of land processing are also contributors to climate change. Land use processes, deforestation and bush burning also contribute to climate and atmospheric purity. Deforestation reduces the quantity of plantation that could have consumed carbon dioxide (CO_2) emissions in the atmosphere through photosynthesis. The less the coverage area of plants on earth, the more the volume of carbon dioxide (CO_2) yield forming clouds. Bush burning is mere rampant in the less developed agro-economics. Farmers engage in bush burning deforested plants and weed due to lack of modern technology for quick fermentation. In the process, more CO_2 is released into the air. The CO_2 emission from all sources are therefore saturated in the earth's atmosphere and consequently resulting into thicker cloud layers with adverse consequences on climatic and weather conditions (Aina, 2013).

The Concept of Food Security

Herren, (2010) defined food security as existing when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life. Commonly, the concept of food security is defined as including both physical and economic access to food that meets peoples dietary needs as well as their food preferences. In many countries, health problems related to dietary access are ever increasing threat, because malnutrition and food borne are double burden.

Food Security is Built on three Pillars:

- Food availability: Sufficient quantities of food available on constant basis.
- Food access: Having sufficient resources to obtain appropriate foods for a nutritious diet.
- Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water (Wikipedia, 2012).
- Food security refers to the availability of food and one's access to it: A household is considered food- sure when occupants do not live in hunger or fear of starvation. It is a measure of resilience to future disruption or unavailability of critical food supply due to various risk factors including droughts, shipping disruptions, fuel shortages, economic instability, war etc.
- Food security assessment is divided into the self – sufficiency rate and external dependency rate as this divides the largest set of risk factors.

Although some countries may desire a high self-sufficiency rate to avoid transport risks, this may be difficult to achieve especially for wealthy countries, generally due to higher regional production costs. (Wikipedia, 2010) conversely, high self – sufficiency without economic means of subjecting the vulnerable to product risks.

Wikipedia, (2012) defines three facets of food security: food availability, food access is having sufficient resources, both economic and physical, to obtain appropriate foods for a nutritious diet. Food use is the appropriate use base on knowledge of basic nutrition and care, as well as adequate water and sanitation. FAO, (2009) adds a fourth facet: the stability of the first three dimensions of food security over time is also very important

CLIMATE CHANGE AND FOOD SECURITY

Agriculture is important for food security in two ways. It produces the food that people eat; and it provides the primary source of livelihood for 36 percent of world's total workforce. In the heavily populated countries of Asia and the pacific, this population still make their living from agriculture (ILO, 2007).

- Climate change will affect all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Its impacts will be both short terms, resulting from more frequent and more intense extreme weather events, and long term, caused by changing temperatures and precipitation patterns.
- People who are already vulnerable and food insecure are likely to be the first affected. Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock. People living on the coasts and floodplains and in mountains, drylands and the Arctic are most at risk.
- As an indirect effect, low-income people everywhere, but particularly in urban areas, will be at risk of food insecurity owing to loss of assets and lack of adequate insurance coverage. This may also lead to shifting vulnerabilities in both developing and developed countries.
- Food systems will also be affected through possible internal and international migration, resource- based conflicts and civil unrest triggered by climate change and its impacts.
- Agriculture, forestry and fisheries will not only be affected by climate change, but also contribute to it through emitting greenhouse gases. They also hold part of the remedy, however; they can contribute to climate change mitigation through reducing greenhouse gas emissions by changing agricultural practices.
- At the same, it is necessary to strengthen the resilience of rural people and to help them cope with this additional threat to food security. Particularly in the agriculture sector, climate change adaptation can go hand-in-hand with mitigation. Climate change adaptation and mitigation measures need to be integrated into the overall development approaches and agenda.

The above background information on the interrelationship between climate change and food security are ways to deal with the new threat. It also shows the opportunities for the agriculture sector to adapt, as well as describing how it can contribute to mitigating the climate challenge (FAO, 2008).

MATERIALS AND METHODS

Structured questionnaires were distributed and used to collect information on climate change and food security in Kogi State. Six hundred (600) respondents were used for the study. Six local government areas in Kogi State that were mostly flood affected were used for the study, and one hundred respondents were used for each of these areas (Ibaji, Bassa, Lokoja, Odoru, Koton-Karfi and Omala). These are the riverine areas in Kogi State.

Data Analysis:
Percentage would be used in the analysis of data collected.

Results

Table 1: The Level of Human Activities Responsible for Climate Change in Kogi State.

Options	No. of Respondent (No.)	Percentage (%)
Improper sewage disposal	420	70
Bush burning	85	14
Digging of pond	60	10
Deforestation	35	6
Total	**600**	**100**

Table 1 shows 70% respondents indicated that improper sewage disposal was responsible for climate change in Kogi State, 14% of respondents indicated bush burning, 10% respondents stated that digging of fish pond was responsible for climate change while 6% respondents chose deforestation as responsible for climate change.

Table 2: The Most Serious Adverse Condition that Contribute to Climate Change in Kogi State

Options	No. of Respondent (No.)	Percentage (%)
Flood	514	86
Drought	10	2
Erosion	56	9
Sea level rises and posing challenges	20	3
Total	**600**	**100**

Table 2 shows that 86% of the respondents indicated that flood was most serious adverse condition that contributed to climate change in Kogi State while 2% respondents chose drought as the least adverse condition that has influence on climate change.

Table 3: The Category of People that Mostly Affected by Climate Change (Flood) in Kogi State

Options	No. of Respondent (No.)	Percentage (%)
Urban	31	6.8
Riverine Settlers	266	44.3
Poor vulnerable	103	17.2
Farmers/fishermen	190	31.7
Total	**590**	**100**

Table 3 shows that 44.3% respondents that the riverine settlers were most affected by flood while the urban settlers were least affected by flood.

Table 4: The Way Forward for Addressing Food Security and Climate Change

Options	No. of Respondent (No.)	Percentage (%)
Integrated climate risk management	25	4.2
Diversifying their sources of food and income	350	58.3
Government policies to tackle climate change	15	2.5
Providing timely weather information	210	35
Total	**600**	**100**

Table 4 shows the way forward for food security and climate change.

Table 5: What are the government/agencies efforts to help to reduce the risk associated with climate change.

Options	No. of Respondent (No.)	Percentage (%)
Adaptation/responding to the risk of climate change	90	15
Educating and monitoring of weather	200	33.3
providing food aid	210	35
Intensify food and agriculture	100	16.7
Total	**600**	**100**

Table 5 shows the government/agencies efforts to reduce the risk of climate change.

Table 6: Suggested methods suitable for planting during climate change

Options	Crops	No. of respondents (No)	Percentage (%)
Irrigation	Rice maize vegetable	150	25
Rainy season	Maize, yam rice, beans cassava	84	14
Early planting	Yam, cassava sweet potatoes maize	366	61
Total		**600**	**100**

DISCUSSION

The flood emergencies have affected the economic and lives of the people in Kogi State. Flood has made transportation system difficult when roads and bridges were eroded away by water for days. Motorists and passengers were stranded, waiting for day, the volume of water would reduce before their passage.

Many farmers along the riverine were greatly affected by the flood. Many of them lost their lives when they where trying to secure their food produce like rice, yams and cassava, were washed away by water. Children of these farmers were out of school at these periods and also malnourished due to not having access to enough food and many lost their children in the process. The government and some individuals had to step in for intervention even though was not carried out as proposed.

Production of food and other agricultural commodities may keep peace with aggregate demand, but there are likely to be significant changes in local cropping patterns and farming practices.

There has been a lot of research on the impact that climate change might have on agricultural production, particularly cultivated crops.

Acclimatization is essentially adaptation that occurs spontaneously through self- directed efforts. Adaptation to climate change involves deliberate adjustments in natural or human systems and behaviours to reduce the risk to peoples lives and livelthoods. Mitigation of climate change involves actions to reduce greenhouse gas emissions and store carbon in the short term to develop choices that will lead to low emissions in the long term. Acclimatization is a powerful and effective adaptation strategy, which means getting used to climate change and learning to live comfortably with it.

CONCLUSION

The potential impact of climate change on food security must therefore be viewed within the larger framework of changing earth system dynamics and observable changes in multiple socio-economic and environmental variables.

A number of strategies can be utilize to meet the challenges of climate change and for transforming the state and nation's agricultural sector for the purpose of ensuring food security. These strategies are a combination of informative, adaptive, behavioural and innovative technological methods. Informative strategy entails impacting knowledge to farmers and general public at large about knowing certain things on climate change. Most people lack knowledge about the causes and consequences of climate change.

RECOMMENDATION

- Investment incentives should be made available by federal government in order to attract foreign investors to the agricultural sector of the economy.
- Investment in water control projects involving construction of dams and irrigation works.
- Provision of information about the spatial impact of natural hazards connected to climate change is pertinent. There is need to develop procedures to integrate high level quantitative climate risk assessment into the spatial planning process as well as identification of options and articulation.

REFERENCES

Aina, P.O. (2012). Climate Change and Food Security: The Challenge of Transforming Agriculture in Nigeria. Being Text of the Lecture Delivered at Ikorodu Division Resource Development Group (IDRG).

Fegbemi, S. and Idoko, C. (2009). "40 Million Nigerian Youths Unemployed – Plans Summit on Youth Unemployment – 80% Nigerian Graduates Unemployable – Education Minister".

Food and Agricultural Organization (2007) of the U.N. Retrieved.

Food and Agricultural Organization (2008). "Food Security and Agricultural Mitigation in Developing Countries. Options for Capturing Synergies". Rome. Available at: www.fao.org.fao.org.

Food and Agricultural Organization (2009). Enabling Agriculture to Contribute to Climate Change. Submission by FAO to UNTCCC. Rome Available at: http://unfccc.in/resource/docs/2008/smsn/igo/036.pdf

Herren, H.R. (2010). Moving in the Right Direction. In: Food Security, Creating an Affordable, Sustainable, Economically Sound and Socially Acceptable Food Future for Everyone, London Available at www.feedingthefuture.ev.intergovernmental Panel to Climate Change.

Ilo (2007). Ilo – Gender – requitable rural employment. http://wwwfao. ilo.org/fao-ilo-gender/en.

McCarthy, J.J., Canzian, O.F., Leary, N.A., Dokken, D.J., White, K.S. (Eds) (2001). Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third

Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) Cambridge: Cambridge University Press.

Ogbo, A., Ndubuisi, E.L., Wilfred, U. (2013). Risk Management and Challenges of Climate Change in Nigeria. J. Hum. Ecol., 41(3) 221 – 235.

Pany, M.I., Canzian, O.F., Palutikof, J.P., Vander, L.P.J. Hanson, C.E. (Eds) (2007). Climate Change Impacts Adaptations and Vulnerability: Contribution of Working Group II to Fourth Assess Report.

Wikipedia (2010): Two Commonly Used Definition of Food Security From UN's from Food and Agricultural Organization (FAO) and the United State Department of Agriculture (USDA).

Wikipedia, (2012) "Global Hunger Index" Wikipedia, the free Encyclopedia.

Change and Food Security in Nigeria

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ABSTRACT

Climate change is a worldwide phenomenon and could have serious deleterious consequences. The increasing flooding in the coastal and non-coastal regions of Nigeria is indicative of the expected effect of climate change. The drought of the 1970s that swept most of the Sahel region of Africa left the region, including Nigeria, with serious water resources issues. The consequences of that are the low agricultural output, limited water supply and inadequate water reserve for power generation which the region is associated with. Landslides especially in erosion prone areas lead to loss in available land space for agriculture. Increase in desertification leads to more droughts which encourage locusts and white flies infestation. This will in turn affect food and water supply. Deforestation as a result of relocating of people from the flood affected areas of the coast and change in land use in the coast may have drastic effect on agricultural output and livelihood. Wildlife is also affected with possible effect on the entire food chain. Hunger-related deaths could increase if grain productions do not keep pace with population growth in an unfavourable climatic environment. The last quarter of 2012 experienced unprecedented floods which ravaged many parts of Nigeria rendering tens of thousands of fellow

Nigerians homeless, and causing massive destruction of property, farmlands, and infrastructure across the country. For an example no fewer than 15 communities in Oguta LGA of Imo state was ravaged by an unusual flood caused by the overflowing Oguta Lake. Many farmers in Nigeria had committed suicide due to loss of farm produce .It was regrettable that most people affected by the flood were poor farmers and artisans that hardly make ends meet on daily basis .Climate change adaptations can have significant impact on farm productivity. This paper shows that climate change affects farmers and food supply which can lead to food insecurity.

Key words: climate change, food security, Nigeria

INTRODUCTION

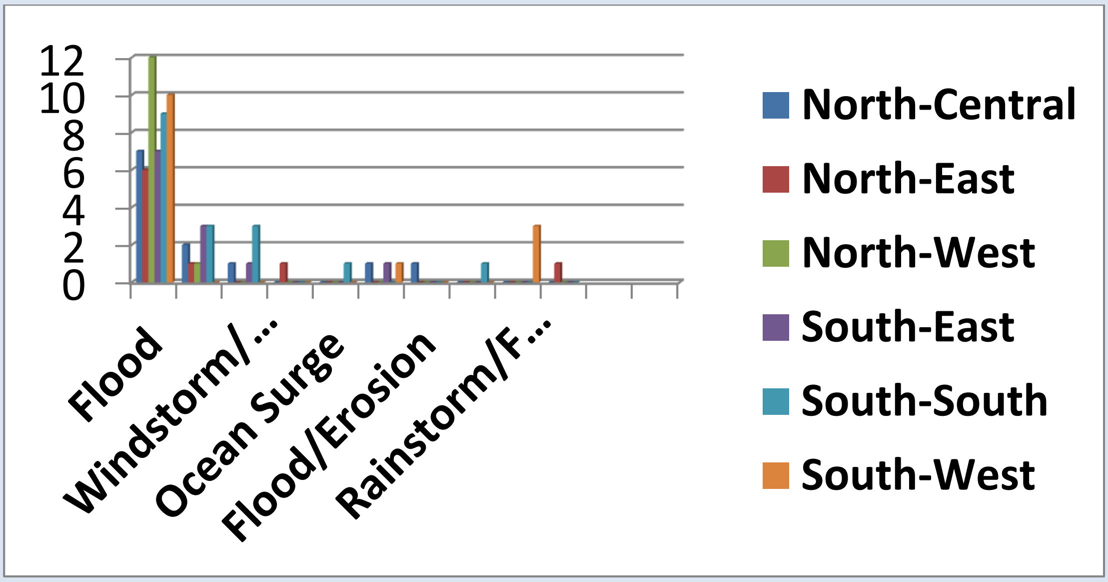
In Nigeria there had been incidence of flood affecting farmland and food supply over a period of time. There are 36 states and FCT in Nigeria and each of them had experienced some form of climate change affecting food security. The level of vulnerability of natural and anthropogenic hazards is unacceptably high in Nigeria, especially among local communities. These are people whose livelihoods depend mainly on nature and the ecosystem which are highly susceptible to the impacts of climate change. They built their homes and situated their farms in flood-prone areas. This is because of their famous socio-economic status and lack of knowledge. Awareness of the social networks, lack of access to education, health care, agricultural services, grossly undermine their capacity to cope with the effects of climate change. The houses are structurally inadequate and unable to withstand flood and windstorm (NEMA 2010).The recent climate change and global warming if left unchecked will cause adverse effect on livelihood in Nigeria, such as crop production, livestock production, fisheries, forestry and poor harvest activities. This is because rainfall regimes and patterns were altered. Floods devastate farmlands and there would be increase in temperature and humidity which increases pests population. Global warming has influenced agricultural productivity leading to declining food production (kurukulasuriya and Mendelssohn, 2006; Lobell et al: 2008).

Population, income, and economic growth could all affect the severity of climate change impacts in terms of food security, hunger and nutritional adequacy. Nigeria as a nation, has also recorded its own experience of the negative impacts of climate variability in flooding in 2010, 2011 and 2012. In 2012 flooding occurred in 23 states of the federation, affecting 7,705,398 people, displaced 2,157,419 caused the death of 363 and destroyed 597476 houses. An estimate of ₦2.6trillion Naira was lost and resulted in unprecedented ecological damage. The 2012 flood was a glaring testimony to the growing intensity of climate change related disasters in Nigeria and indeed the West African sub-region. Extreme weather conditions, including excessive rainfall, severe windstorm, heat wave and drought have become more frequent with adverse effect on economy, environment, food security, lives and livelihoods. This study is to investigate the effects of climate change on food supply which can lead to food insecurity.

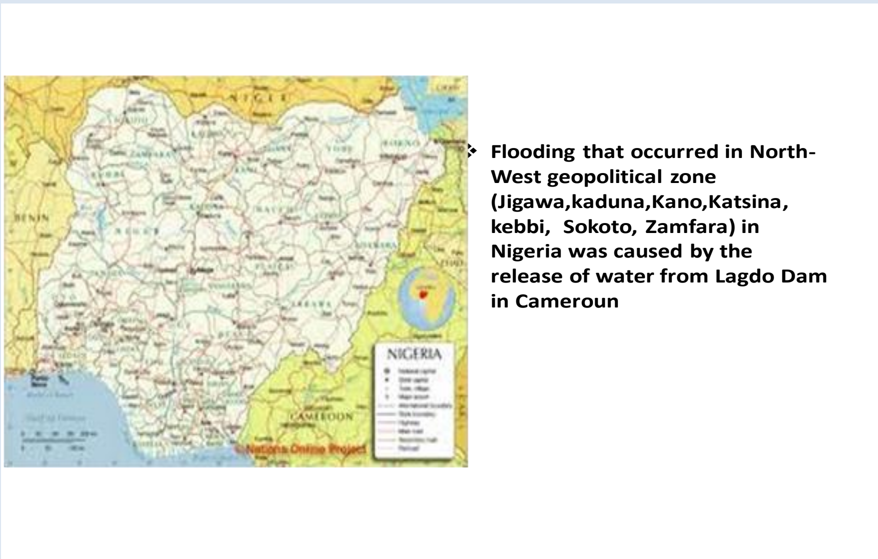
SOURCES OF DATA COLLECTION

The study was carried out by the use of secondary and primary data obtained from various sources including National Emergency Management Agency (NEMA) Annual Reports and Newsletter, Dailies and by distribution of questionnaires to flood affected victims. There were also personal interviews with the affected victims.

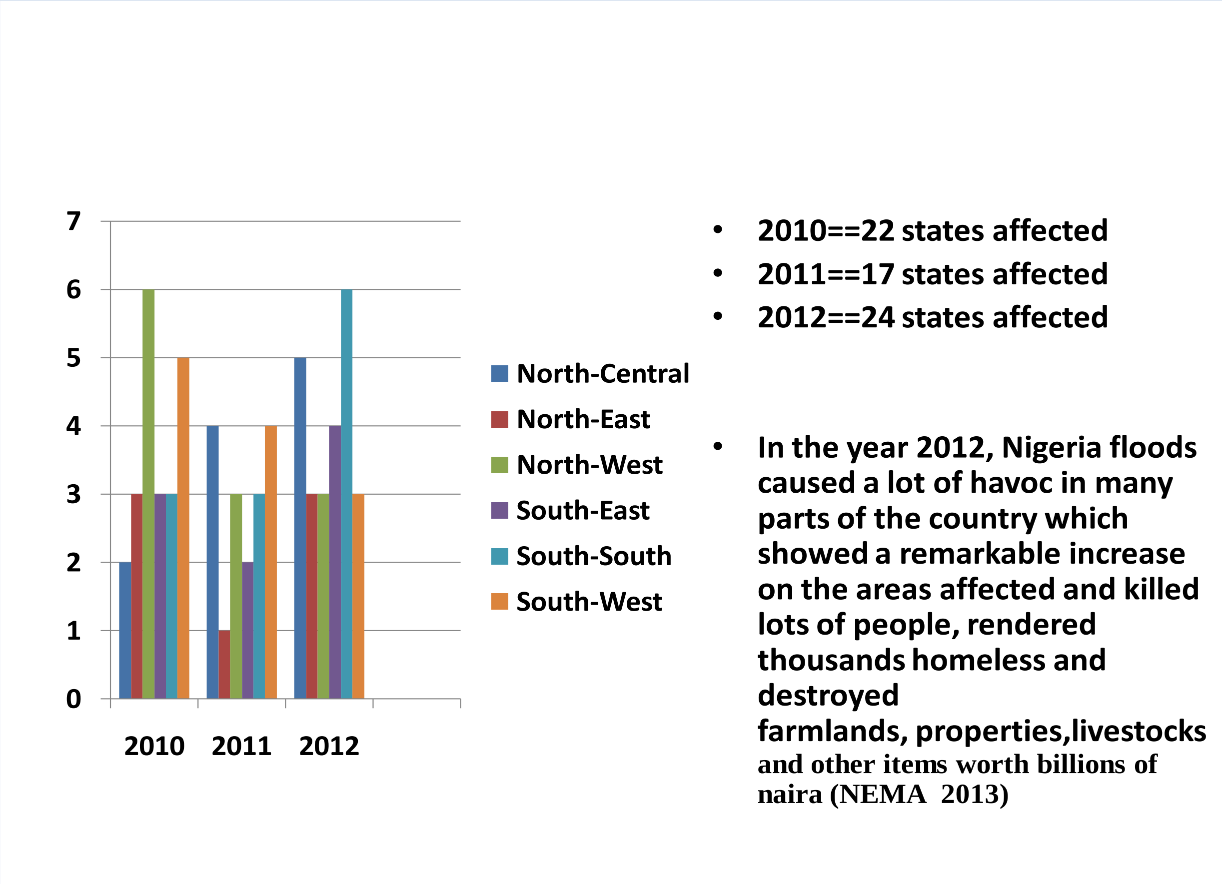
EFFECT OF CLIMATE CHANGE ON DIFFERENT GEOPOLITICAL ZONE IN NIGERIA BETWEEN THE YEAR 2010-2012



EFFECT OF CLIMATE CHANGE IN NORTH-WEST ZONE IN NIGERIA BETWEEN THE YEAR 2010-2012



NUMBER OF STATES AFFECTED BY NATURAL DISASTERS IN NIGERIA IN RELATION TO A PERIOD OF 2010-2012



EFFECT OF NATURAL DISASTERS

Expectedly, effect of flooding, windstorm, drought, heavy torrential rainfall, landslide in the six geopolitical zones of Nigeria in 2010, 2011 and 2012 resulted in displacement of communities, destruction of residential houses, loss of lives and livestock, farmlands and properties worth millions of Naira were destroyed, infrastructure like bridges were damaged and low agricultural yield. The negative impact of climate change badly affected women and children.

Primary data collected from questionnaires and personal interviews from these communities: Ohita ; Okoti-Odekpe; Odo Rubber; Iyiowa Odekpe; Umuoba Anam; Aguleri, Igbariam; Ndo Aguleri; Anam Umueze; Nmiato Anam all in Anambra state of Nigeria experienced floods, pest invasion, which led to hunger, lack of foodstuff, farm camp destruction, lost of lives and livestock.

RELIEF INTERVENTION

Agencies like NEMA networked with other stakeholders: State Emergency Management Agencies; Red Cross Society; Some NGO's and CBO's; affected local government officials; opinion leaders/traditional rivers of the affected communities; Nigeria Security and Civil

Defense Corps and Police distributed building materials, food stuff and houses hold items/clothing to flood affected victims in 2010 and 2011

In 2012 Nigeria floods caused a lot of havoc in many parts of the country which showed a remarkable increase on the areas affected and killed scores of people, rendered thousands homeless and destroyed billions of Naira worth of farmlands, property and other items that made Federal Government of Nigeria to institute 36-member presidential committee on food relief and rehabilitation. The government also released ₦17.6bn for flood victims which were distributed in accordance with the categories that were based on assessment. Category A: which included Oyo, Kogi, Benue, Plateau, Adamawa, Delta, Bayelsa & Anambra states got ₦500 million each. Category B: which comprised Jigawa, Kano, Bauch, Kaduna, Niger, Nasarawa, Taraba, Cross river, Edo, Lagos, Imo states got ₦400 million each;
Category C: consisting of Kwara, Kashra, Gombe, Ogun. Ondo, Ebonyi, Abia & Rivers states got ₦300 million each; Category D involved Sokoto, Kebbi, Zanifara Yobe, Enugu, Ekiti, Osun, Akwa Ibom, Borno & FCT states got ₦250 million each. Agencies were allocated funds as follows: Ministry of Works ₦2.6 million; National Emergency Management Agency ₦1.1 billion; Ministry of Environment ₦350 million; National commission for refugees ₦150 million; Technical committee on flood impact Assessment ₦100 million (National Broadcast, 2012).

CONCLUSIONS AND RECOMMENDATIONS

The issue of climate change and its resultant effect on mankind has become a global phenomenon. Climate changes are major factors influencing variations in crop yields, production, soil utilization and conservation.
The effects of climate change prone to Nigeria are flooding, windstorm, heavy torrential rainfall and drought which showed a remarkable increase in the number of disaster incidence in 2012. The 2012 flooding in some parts of the country has partly caused by the release of water from the Kiri Dam in Adamawa State and from Lagdo Dam in Cameroun. Nigeria has been under constant threat from the Dams in Cameroun, but effort to construct receiver Dams that would absorb excess water released from Cameroun has been scanty. Despite yearly budgets, Nigerians are yet to see the impact of the Dams if they have been constructed. The country experienced more floods, stronger windstorm, especially among the local communities. These are people whose livelihoods depend mainly on nature and eco-system which are highly susceptible to the impacts of climate change.
It is observed that absence of response strategies to both short and long term climate change including climate variability has significant effect on the agricultural production which in several ways has direct impact on food production. Excessive flooding which occurred in the major parts of Nigeria as a result of excessive rainfall between June and Sept 2012, resulted in soil erosion which led to losses of crops, productive assets and properties such as farmlands and farm equipments.

Damages to roads resulted to difficulty in accessibility to markets, basic services and equally hampered economic activities.

It is hereby recommended that houses should not be built along waterways or flood prone areas; persons at risk should be evacuated from flood prone areas to safer location; dumping of refuge in gutter/water channels should be avoided; drainages and water ways should be cleared; early warming alerts must be adhered to; weather forecasts on both electronic and print media should be taken seriously. There should be sufficient fund for the zones to enable them carry out laudable programmes to manage disaster in all its ramifications.States and local governments should participate actively in all programmes geared towards making their society disaster resilient. There is need to create awareness for the zones to enhance sensitization and strengthen disaster management practices at the grassroots. Proper storage of harvested crops to avoid losses should be ensured.

REFERENCES

Agada A. (2012): The Rage of flood: The world poverty day: Poverty worsens as flood renders 42 million Nigerians homeless. Vanguard, Wednesday, October 17 p.9

Akinsuyi Y. and Sanni T. (2013): 31 States to experience devastating flood - This day Thursday, August 22 p. 1

Amaize E. (2012): The Rage of flood: Ex-militants donate N52.7 m to victims in Nigeria delta. Vanguard Wednesday, October 17 p.8

Anucha E. (2012): Flood displaces 100,000 persons in Rivers: Sacks over 90 communities Daily Sun, Monday, October 15 p.6

Atta A (2012): Flood babies: Triplets, 2 sets of twins, 4 others born in one week, 2000 pregnant women set to deliver. Expert warns on imminent epidemic, famine Sunday Sun, October 14 ,p.5

Edike T. (2012): Over 5,000 Kogi flood victims now refugees in Enugu. Vanguard, Monday October 1 p. 13

Ekpunobi D. (2013): Flood displaces 200 in Nkpor Daily Sun, Tuesday, July 23 p.7

Etim .W. (2012): Bayelsa … Groaning under the ravaging water. The Guardian, Sunday, October 14 p. 5

Folaranmi F. (2012): Jonathan Visits Bayelsa flooded communities, assures rehabilitation Daily Sun, Monday, October 15 p.6

Kurukulasuriya, P & Mendelsohm, R.(2006): A Ricardian analysis of the impact of climate change on African cropland CEEPA Discussion paper No. 8. Centre for Environmental Economic and policy in Africa, University of Pretoria.

Lobell, D.B, and Burke M. B et al (2008): Prioritizing Climate change adaptation needs for food security in 2030" Science 319 (5863): p. 607-610

Maigida E. (2010): Department of relief and rehabilitation. In: NEMA (2010) Annual Report p.44- 56

Maigida E. (2011): Department of relief and rehabilitation. In: NEMA (2011) Annual Report p.64- 74

National Emergency Management Agency (2013): NEMA donates materials to displaced persons in Kaduna. NEMA Newsletter Vol 5 No 15 p.3.

News Agency of Nigeria (NAN 2013): 20 corpses unearthed by flood in Kano.

News Agency of Nigeria (NAN 2013): Nasarawa Government begins construction of drainages in flood prone areas in Lafia.

Odum F. (2012): FG plans food distribution, employs satellite to monitor flood: The Guardian, Sunday, October 14, p.9

Ogugbuajah .C. (2012): More donations for victims as floods recede, The Guardian Tuesday November 6 p.8

Ogugbuajah C. (2012): More donations for victims as floods recede, The Guardian, Tuesday, November 6, p.8

Okah E. (2012): Coping with the flood: Sunday Sun October 14 p.16

Okoro J (2013): Mudslide Wipes out Family of 8 .Daily Sun ,Friday September 6 p.6

Onwuchekwa D. (2012): As crocodiles, scorpions, invade Anambra homes: Community laments sharp rise of food crops Sunday Sun October 14 p.11

Taiwo – Obalonye J. (2012): As victims turn roadside beggars. Daily Sunday, Monday October 15, p.6

Taiwo – Obalonye J. (2012): Flood victims go haywire, force Jonathan to change itinerary in Yenogoa, Daily Sun Monday, October 15 p.6

Tope Templer Olaiya (2012): Rage of the floods: City file; The Guardian, Sunday, October 14, p.4

Ujumadu V. (2012): Flood sacks corps members in Anambra. Vanguard, Monday, October 1 p.13

Climate Change and Productivity of Women Farmers in Anambra East Local Government Area of Anambra State, Nigeria: Implication for Food Security

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ABSTRACT

The study was an investigation into the effect of climate change on output and productivity of women farmers in Anambra East Local Government Area of Anambra State. Structured questionnaire was the instrument for data collection. A total of thirty respondents were sampled and questionnaire administered to them. Data were analysed using descriptive statistics of frequency distribution and percentages. The result showed that irregular rainfall patterns (such as torrential rainfall, short duration rainfall, and excessive rainfall) affected the yield and output of the women farmers. Torrential rainfall caused some crops to lodge, prevented storage of farm products and blowing off roofs of

animal buildings. Short duration rainfall at the onset of rains adversely affected the crops grown at the beginning of the season; making crops to wilt. However, it aided the sun-drying of crops harvested the previous year (positive effect). Excessive rainfall caused flooding that destroyed farmlands, increased the incidence of fungal and viral diseases and pests. Improved agricultural technology by government is necessary to cope with climate change. It is recommended that short duration, drought resistant and high yielding crops and animal should be developed through research and made available to farmers to ensure food security.
Keywords: climate change, productivity, women farmers, food security

INTRODUCTION

Nigerian agriculture is predominantly rain-fed and hence inherently dependent on the vagaries of weather. Increasing climatic variability is having profound impact on agriculture (Spore, 2012). Climate change had resulted to changes in rainfall pattern, rising sea level, high temperatures, increase in rainfall intensity, flash floods – submergence of farmers field and in some cases drought. This has drastically impacted on agricultural productivity (IFC, 2010). The impact could be measured in terms of soil erosion, sea level rises, crop growth, availability of soil water, incidence of pests and diseases and decrease in soil fertility (Adejuwon, 2006). Direct effects of climate variable such as air, temperature, humidity, wind speed and other climate factors influence animal performance such as growth, milk production and reproduction. Climate can also affect the quantity and quality of feedstuffs such as pasture, forage, grain and the severity and distribution of livestock diseases and parasite. Hence, the totality of agricultural sector is considered by examining agricultural productivity. Developing countries are seriously affected by climate change. For instance, during higher temperatures, the poor countries especially those already experiencing food insecurity in tropical and sub-tropical areas are more likely to experience output decline. Drought induced by changes in climate (i.e. warmer climate) is making some tree species to disappear especially in the Sahel region (Spore, 2012). According to study conducted by the University of California USA, rainfall in the Sahel has dropped between 20-30 percent in the 20th century producing the world most severe long-term drought. At some sites, average temperature rose by 0.8 degree Celsius – causing trees to be shifted south wards towards wetter areas. This shift in the vegetation zones could have a severe impact on the lives of the sahel population who depend on trees for maintaining soil fertility firewood, hut poles, food and other essentials of life.

In Nigeria, rainfall is by far the most important element of climate change and water resources potential in the country (Adejuwon, 2006). The location, characteristics, and size of Nigeria gives rise to a variety of climates ranging from tropical rainforest climate along the coast to the sahel climate in the northern parts of the country, each being different by its’ annual precipitation, sunshine and other climate elements (FGN,1997). The north east region of Nigeria is increasing becoming an arid environment at a very fast rate per year occasioned by fast reduction in the amount of surface water, flora and fauna resources on land. Consistent reduction in rainfall leads to a reduction in the natural regeneration rate of land resources. This makes farmers to exploit previously undisturbed lands leading to depletion of the forest cover and increase on sand dunes deposits in the northern area of Nigeria largely known for high rainfall is currently confronted by irregularity in the rainfall such as off season rains and temperatures is gradually increasing in, the guinea savannah zone of the country. As further explained by United Nations Framework convention on climate change (UNFCCC,2007), the effect of climate change implies that the local climate variability which people have previously experienced and adapted to is changing and this change is observed in a relatively great speed. Thus, the resultant effect causes changes on the growth and yield of crops and livestock. In Anambra state, the change in climate has also affected human lives, livestock and crops in recent time. Between August and October 2012, many parts of the State were submerged. The towns that were affected include: Ogbaru, Ossomala, Odekpe, Okija, Ogidi, Anam, Aguleri-otu, Umuleri etc. For example, a farmer in Ogbaru, who had up to 3,000 birds, lost them to flooding.

Statement of the Problem

Climate is the primary important factor in agricultural production in Nigeria since agriculture is mostly rain-fed. The economy and food supply are closely linked to climate. Fluctuations in the climatic conditions can exert serious pressure on the agricultural systems, patterns of production, productivity and income. This is because agricultural production remains the most source of livelihood for most rural communities in developing countries and, in particular, the sub-saharan Africa. Weather variation, the incidence of pest and diseases and a host of other less obvious factors cause productivity and farming yields to fluctuate unpredictably (Enete and Achike, 2008). Thus, farmers are contending with variations in climate and achievement of optimum yield so as to secure a suitable net farm income for increased food supply. Women farmers, especially in the study area, are becoming more vulnerable to the changes in weather than men because they supply most of the labour needed in the farm as well as own their farms. In 2012, due to excessive rainfall, many communities in the study area were flooded; destroying many farmlands, livestock, properties and human lives. This has a bearing on the productivity and income of the women farmers. Now, how can these farmers achieve increased productivity and food security in the face of changing climatic conditions? It is against this backdrop that the study seeks to analyse the effect of climate change and on the productivity of women farmers in Anambra East Local Government Area.

Objective of the Study

The overall objective of the study was to analyse the effect of climate change productivity of women farmers in Anambra East Local Government Area of Anambra State, South-east Nigeria. Specifically, the objectives includes to:

i. describe the socioeconomic characteristics of women farmers and
ii. analyse the effect of irregular rainfall pattern on the productivity of women farmers in Anambra East Local Government Area.

METHODOLOGY

Area of Study
The study area was Anambra East Local Government Area. It is sharing boundary with Anambra West Local Government, Onitsha North Local Government Area, Ayamelum Local Government Area and Awka North Local Government Area. It is made up of six towns namely: Aguleri, Umuleri, Igbariam, Nsugbe, Nando and Umuoba Anam. The soil is well-drained clay-loam and a number of crops thrive well in the area. These crops include garden egg, fluted pumpkin (*telfairia sp*), tomatoes, potatoes, maize, yam, rice etc. There are also a number of livestock farmers in the area of which women also engage in. Anambra East Local Government is situated near the popular "Omambala" river (an offshoot of River Niger) from where the name is derived. Farmers living along the river in the area also engage in artisanal fishing.

Sampling Procedure
Simple random sampling was the method adopted to select the respondent farmers. Four towns out of six towns were randomly s elected for the study. They include, Aguleri, Umueri, Igbariam and Nando. In each town, six women farmers were randomly s elected. Because of the peculiar nature of Igbariam town that hosts the "Igbariam farm settlement, another six women farmers were randomly selected from the farming community of the farm settlement. On the whole, a total of thirty respondent farmers were sampled for the study. A well-structured questionnaire was the instrument for data collection. Through the help of two enumerators residing in the study area, the questionnaire was administered personally to the respondents. A total of thirty copies questionnaire were administered and all of them were validly returned.

Method of data analysis
Descriptive statistics such as frequency distribution and percentages were used to analyse the socio-economic variables and climatic variables on the productivity of women farmers. The climatic variables analysed here was rainfall patterns of the respondent farmers.

RESULTS AND DISCUSSIONS
The results were presented in tables in line with the objectives.

Table I: Socio-economic characteristics of Women Farmers

Socioeconomic variables	Frequency	Percentage
Age (years)		
20-30	1	3.33
31-40	9	30.00
40-50	16	53.33
51-60	4	13.34
61-70	-	-
Total	30	100.00

Highest Educational Level		
No formal education	8	26.67
Primary education	12	40.00
Secondary education	8	26.67
Tertiary education	2	6.660
Total	**30**	**100.00**
Years of farming experience		
1-5	-	-
6-10	4	13.33
11-15	6	20.00
16-20	17	56.67
21-30	1	3.33
31-40	2	6.67
Total	**30**	**100.00**
Marital Status		
Single	-	-
Married	20	66.66
Divorced	2	6.67
Widowed	8	26.67
Total	**30**	**100.00**
Family size		
1-5	18	60.00
6-10	11	36.67
11-15	1	3.33
Total	**30**	**100.00**
Farming Type		
Animal	6	20.00
Crop (mixed)	24	80.00
Livestock	1	3.33
Sole cropping	9	30.00
Combined (crops/animal/livestock)	-	-
Fish farming	-	-
Total	***40**	***133.33**
Farm size		
Less than 0.1ha	-	-
0.1 – 0.5 ha	1	3.33
0.6 – 1.0 ha	14	46-67
1.1 – 1.5 ha	12	40.00
1.6 – 2.0 ha	1	3.33
2.1 – 2.5 ha	2	6.67
Total	**30**	**100.00**

Source: Field Survey, 2012

* Multiple responses

Table 1 Shows that 3.33%, 30.00%, 53.33% and 13.34% of the respondents had age of 20-30years, 31-40years, 41-50years and 51-60years respectively. Thus, most of the women farmers lies between the age range of 31-60years, This is an indication that most respondent farmers were young and active age for production and are that the women farmers have sufficient energy to work in their farm hence, the output and productivity will be high. The relevance of age distribution of farmers lies in the fact that agriculture in the rural communities relies heavily on the use of human power. Also productivity of a farmer is expected to increase with age as the farmer becomes older and acquires more experience in farming. After some years when old age sets in, the productivity of the farmer will begin to diminish until he/she is no longer able to farm (Atagher, 2012).

Also, it revealed that about 73% of the farmers had formal education. Thus, on the average, farmers in the study area had attempted at least a primary education. The need for education cannot be over emphasis since the level of education not only increases his productivity but also enhances its ability to understand evaluate and adapt to new production techniques if the farmer is well educated, it will enable him to access new information on how to manage her farm, improve productivity and expand her farming activities. (Atiri, 2011). The distribution of respondents according to farming experience shows that 13.33% of the women farmers have been farming for 6-10years, another 20% have been farming for 11-15 years, 56.67% have been farming for 16-20years, about 3.3% to have been farming for 21-30years and 6.67% have been farming for 31-40years. This means that farmers have the necessary experience in agricultural production. The number of years a farmer spent in farming gives an indication of the practical knowledge gained, so that when it is channeled properly, can lead to higher productivity and higher standard of living for the farmer and its household. However experience can sometimes become a limiting factor to improvement in production as farmers become conservative, refuse to change and take advantage of new ideas on production (Atagher, 2012). Therefore, farmers with higher years of experience in farming should also watch out for new innovations that can improve productivity. The table revealed that most women farmers were married and they constitute about 66.6%, of while about 6.67% were divorced and about 26.6% were widowed. No respondent sampled was single. This implied that agricultural production was very much practiced by married people who can also involve their family members in farming to cater for their daily requirements of food. The distribution of respondents according to family size shows that 60%, 36.67% and 3.33% of the respondent farmers have family sizes of 1-5, 6-10, and 11-15 respectively, a large family size could imply a more supply of cheap farm labour especially in Nigeria where farming is dependent upon human labour; except for a family size which is made up of young children and old members of the family. However, large family sizes tends to draw more on family income such that little amount of money is saved for investment in farming (Baba and Wando 1998). It also revealed that 20%, 80% 30% and 3.3% of the respondent farmers were involved in animal production, mixed cropping, sole cropping and livestock production systems respectively.; although, most respondents farmers were mainly engaged in both crop and animal production, as indicated by their multiple responses. Thus, one can concluded that majority of the women farmers studied were actively engaged in crop and animal production systems so as to enable them achieve greater productivity. Furthermore, the table shows that 3.33%, 46.67%, 40%, 3.33% and 6.67% of the respondent farmers have farm sizes ranging from 0.1-0.5 hectares, 0.6-1.0 hectares, 1.1.-1.5 hectares, 1.6-2.0 hectares and 2.1-2.5 hectares respectively. The results show that majority of the respondent farmers are either small or medium –scale farmers.

Table 2: Effect of irregular rainfall patterns on agricultural production

A. Too short rainfall	**Frequency**	**Percentage**
Wilting of crops	9	30.00
Delays farm operation	17	56.67
Does not allow to grow some crops twice a year	15	50.00
Lack of moisture to support plant growth	1 8	60.00
Enhances the sun-drying of some crops	13	43.33
Insufficient water in the rives to allow dry season farming	8	26.67
Hinders artisanal fishing	2	6.67
Total	***82**	***273.64**
B. Excessive rainfall (over 2,500mm/year)		
Hinders timely harvesting	15	50.00
Makes weed to grow much in the farm	25	83.33
Sprouting of maize cob stand while still in the field	4	13.33
Breeds fungal diseases	9	30.00
Reduces the storability of agricultural products	7	23.33
Processing such as drying becomes difficult	20	66.66
Livestock production becomes risky	4	13.33
Others	-	-
Total	***84**	***279.98**
C. Torrential rainfall		
Farm structures and animal roof blown off	1	3.33
Lodging of crop plants especially maize	8	26.67
Destruction of farm crops	29	96.67
Others	2	6.66
Total	***40**	***133.33**

*Multiple responses

Table 2 shows that 30% of the respondent farmers believed that short rainfall duration during the onset of rain (April/May) in 2012, brought about wilting of crops such as maize, yam, cocoyam etc. About 56.67% agreed that short rainfall duration delayed farm operations, 50% of the farmers opined that it did not permit growing of some crops twice a year. It was also revealed that short rainfall duration caused lack of moisture for plant growth, enhanced sun drying of some crops, insufficient water in the rivers for dry season farming and hindered artisanal fishing with 60%, 43.33%, 26.67% and 6.67% respectively. On the other hand, excessive rainfall in the area hindered timely harvesting, makes weed to grow much in the farm, caused sprouting of maize cob while still in the field, breeds fungal diseases, reduces storability of agricultural products, makes for difficult processing of products and hinders livestock production with percentages of 50, 83.33, 12.33, 30, 23.33, 66.66 and 13.33 respectively. It also shows that torrential rainfall causes blowing off farm structures and animal roof, lodging of crop plants, destruction of farm crops and reduces fruiting in crops (poor yield) with percentage of 3.33, 26.67, 96.67 and 6.66 respectively. For instance, in December 2011, some parts of southeastern states like Awka in Anambra State, Ugwuoba and Ezeagu in Enugu State witnessed torrential rain and reduced the storing of harvested farm products as well as destroying of some crops in the farm. On the average climate change resulted in declining women productivity in the study area. Agricultural production is very much influenced by the climate especially when it changes from much normal condition to abnormal conditions. A change of climatic condition in the rainforest zone from short duration and low quantities of rainfall to long duration and high quantities of rainfall will cause loss to the particular crops that it supports such as cereals and legumes (Dinar and Mendelsohn, 1999). The resultant effect will be shortage of food and famine in the next season. Generally speaking, the timing of planting operation, the number and type of crops which can be grown, are influenced by the onset of the rainfall regime and duration of the wet seasons.

Climate change and Food security

Climate change affects food and water resources that are critical for livelihood in Nigeria where much of the population especially the poor rely on local supply system that are sensitive to climate variation. Disruptions of existing food and water systems will have devastating implications for rural household livelihoods. Agricultural practice in Nigeria is still predominantly rain-fed and therefore particularly vulnerable to the impact of climate change. The increasing frequency and severity of climate change are likely to cause crop failure, high and rising food prices, distress sale of animals, de-capitalization, impoverishment, hunger and eventually famine (IFAD, 2007). Households will probably try to cope with their cash and food shortage by cutting and selling more firewood thereby exacerbating land degradation and desertification (Madugu, 2009). As the planet warms, floods, and forest fire become more frequent, the resultant effect is poor and unpredictable yields. Farmers will have to face tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases (Zoellick, 2009). Food security threat posed by climate change is greatest for sub-saharan Africa, where agricultural yields and per capita food production have been steadily declining and where population growth will double the demand for food, water and forage in the next 30 years. There is need to adapt to the vagaries of weather in order to feed a population which has reached about 7 billion (Spore, 2012). The severity of rural households' food insecurity is closely tied to the amount and quality of food consumed, since individual farming households and communities are by no means food self sufficient (FAO, 2005).

CONCLUSION

With the increasing rate of erratic rainfall patterns, drought and desertification, drought resistant and short duration high yielding crops should be developed through research efforts and made available to farmers. There is therefore the need for adequate provision of irrigation and drainage infrastructures which, could be regarded as crucial for climate change adaptation. Investment on improved agricultural technology by government and other stakeholders are very necessary for agriculture to crop with climate change. Effective capacity building to strengthen women farmers, especially in the study area, as the most vulnerable group in agricultural production with requisite knowledge and regular, current information related to climate change and agriculture is seriously advocated.

REFERENCES

Adejuwon, J.O. (2006). Food Crop Production in Nigeria: Potential effects of climate change. *Climate Research*. Vol. 32 Pp 229-245.

Atagher, M.M. (2012). The effect of cassava production technology on the productivity and incomes of women farmers in Benue State, Nigeria. A. Ph.D unpublished research findings presented to the Department of Agricultural Economics University of Nigeria, Nsukka.

Atiri, O.A. (2011). Comparative analysis of cost and returns in selected maize varieties production in Osun State. An unpublished M.Sc thesis presented to the Department of Agricultural Economics and Extension, Delta State University Asaba, Campus.

Baba, K.M & Wando, M.A. (1998). Impact of membership of Fadama user Association on resource use, crop yield and farm income; a case study from two local government areas of Niger State, Nigeria. *Journal of basic and applied Science,* 6:7-15.

Chan, K.W. (1991). Predicting oil palm yield based on solar radiation. Second national seminar on agrometeorology. Petaling Jaya, Malaysia.

Consultative Croup on International Agricultural Research (CGIAR, 2000). The Challenge of climatic change: poor farmers at risk. Retrieved from www.cgiar.org.

Darwin, R. (1999). The impact of global warming on agriculture: A Ricardian analysis comment". *American Economic review*. Vol. 89. Pp 1049-1052.

Dinar, A and Mendelsohn, R. (1999). Climate change, Agriculture and developing countries. Does Adaptation matter? *The World Bank Research Observer* 14(2): 277-293.

Food and Agricultural Organisation (FAO) (2005). Impact of climate change, pest and diseases on food security and poverty reduction. Special event background document for the 31st session of the committee on world food security". Rome. 23-26 May, 2005.

International Fund for Agricultural Development (IFAD) (2007). Rural poverty in Nigeria: Agriculture in the Federal Republic of Nigeria. http://www.ruralpovertyportal.org//web/guest.\

International Finance Corporation (IFC) (2010). Smart lessons, real experiences, real development: Adapting to climate change in Bangladesh.Retrieved from www.fao.org

Madugu, N. I. (2009). Nigeria: climate change - a threat to the country's development. http://www.allafrica.com/nigeria.

Spore, (2012). Climate change. *A bi-monthly of magazine of the Technical Centre for Agricultural and Rural Cooperation(CTA)*, Wageningen.

United Nations Framework convention on climate change (UNFCCC, 2007). Climate change impact, vulnerabilities and adaptation in developing countries. Retrieved from http://www/unfccc.int.

Zoellick, R.B. (2009, August 12). A climate smart future. *The Nations' Newspaper*, P. 18

Climate Change Impacts on Agriculture and Forestry Resources Management: Sudan Case Study

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ABSTRACT

There is a compelling scientific consensus that human activity is changing the world's climate. Sudan has a longstanding history of armed conflict. On 9th of January 2005, the Sudanese Government and the Sudan People's Liberation Movement/Sudan People's Liberation Army signed a Comprehensive Peace Agreement (CPA), putting an end to twenty-two years of continuous civil war. When the CPA was signed, there was hope for a prosperous and politically stable Sudan. Instead, there is still war in Darfur and recently a conflict in South Kordofan State. After six years of signing the CPA, the Southern part of Sudan separated from the North and became a new country. Later, as a result of this separation, a conflict happened between the South and the North for the borders between the two countries, and this created a big environmental issue in the conflict areas. The overall objective of this study is to review the factors that cause the climate change in Sudan and its impacts on agriculture and forestry. The study focuses on three key questions: What is Climate Change?; What are the Factors Make Sudan Vulnerable to Climate Change?; What are the Climate Change Impacts on Agricultural and Forestry Resources Management?. Sudan is facing a number of challenges, among these are critical environmental issues including: land degradation, deforestation and the impacts of climate change that threaten the Sudanese people's prospects for long-term peace, food security and sustainable development. In addition, complex but clear linkages exist between environmental problems and the ongoing conflict in Darfur, as well as other historical and current conflicts in Sudan. More than 70% of Sudanese population relies on traditional and subsistence agriculture, the majority of which are dependent on rain-fed agriculture and pastures, and many people's livelihoods are under threat of climate change.

Keywords: Sudan, Climate Change Impacts, Agricultural Resources Management, Forestry Resources Management, Civil Conflicts

INTRODUCTION

Sudan, officially the Republic of the Sudan sometimes called North Sudan, is a country in eastern North Africa (sometimes also considered to be part of the Middle East). It is bordered by Egypt to the north, the Red Sea to the northeast, Eritrea and Ethiopia to the east, South Sudan to the south, the Central African Republic to the southwest, Chad to the west, and Libya to the northwest [http://en.wikipedia.org/wiki/Sudan]. Sudan suffered seventeen years of civil war during the First Sudanese Civil War (1955–1972). Although it originated in Southern Sudan, the civil war spread to the Nuba mountains and Blue Nile by the end of the 1980s, followed by ethnic, religious and economic conflicts between the Muslim Arab northern Sudanese and the mostly animist and Christian Nilotes of Southern Sudan. This led to the Second Sudanese Civil War (1983-2005) [http://en.wikipedia.org/wiki/Second_Sudanese_Civil_War]. The civil war ended with the signing of a Comprehensive Peace Agreement in 2005 which granted autonomy to what was then the southern region of the country. Following a referendum held in January 2011, South Sudan seceded on 9 July 2011.

Sudan's total land area (including South Sudan) amounts to some 2 510 000 km^2. About half of this land is suitable for agriculture, of which about 170 000 km^2 are actually cultivated. The Nile is the dominant geographic feature of Sudan, flowing 3,000 kilometers from Uganda in the south to Egypt in the north. Most of the country lies within its catchment basin. The Blue Nile and the White Nile, originating in the Ethiopian highlands and the Central African lakes, respectively, join at Khartoum to form the Nile River proper that flows to Egypt [http://en.wikipedia.org/wiki/Geography_of_Sudan]. Sudan is blessed with substantial water resources. The Nile water basin contributes most of Sudan's available surface water, transporting over 93 billion cubic meters of water per year on average, though only a fifth of this may be used in accordance with a 1959 water use treaty with Egypt [Higher Council for Environment and Natural Resources, 2007, p. 1]. The Nile divides the country between east and west sides.

The country's soils can be divided geographically into three categories. These are the sandy soils of the northern and west central areas, the clay soils of the central region, and the laetrile soils of the south. Less extensive and widely separated, but of major economic importance, is a fourth group consisting of alluvial soils found along the lower reaches of the White Nile and Blue Nile rivers, along the main Nile to Lake Nubia, in the delta of the Qash River in the Kassala area, and in the Baraka Delta in the area of Tawkar near the Red Sea in Ash Sharqi State. Agriculturally, the most important soils are the clays in central Sudan that extend from west of Kassala through Al Awsat and southern Kordofan. East of the Blue Nile, large areas are used for mechanized rain-fed crops. West of the White Nile, these soils are used by traditional cultivators to grow sorghum, sesame, peanuts, and (in the area around the Nuba Mountains) cotton [http://en.wikipedia.org/wiki/Geography_of_Sudan]. Sudan lies within the tropical zone between latitudes 3° and 22° North and longitude 22° to 38° East. Mean annual temperatures vary between 26°C and 32 °C across the country. Rainfall, which supports the overwhelming majority of the country's agricultural activity, is erratic and varies significantly from the northern to southern ranges of the country. The unreliable nature of rainfall, together with its concentration in short growing seasons, heightens the vulnerability of Sudan's rain-fed agricultural systems. The most extreme temperatures are found in the far northern part of the country, where summer temperatures can often exceed 43°C and sandstorms blow across the Sahara from April to September. These regions typically experience virtually no rainfall. In the central area around and just south of Khartoum, average annual temperatures are around 27°C, with rainfall averaging about 200 mm/year and rarely exceeding 700 mm/year [Higher Council for Environment and Natural Resources, 2007, p. 2]. Overall, the country's land and water resources can be classified into the following major ecological regions, as described below:-

- Arid and semi-arid ecosystems: These areas in the northern and central parts of the country; they represent over 50% of total area with about 125 million hectares;
- Savannah ecosystems (clay): These areas are typified by low rainfall and the prevalence of clay soils; they represent about 5% of total area with about 12 million hectares;
- Savannah ecosystems (sand): These areas are typified by low rainfall and the prevalence of sandy soils; they represent about 3% of total area with about 8 million hectares;

MATERIALS AND METHODS

The main sources of information for this study would be the available literature related to Sudan and climate change..

Definitions of Terminology

What is Climate Change?

Climate includes patterns of temperature, precipitation, humidity, wind and seasons. ***"Climate change"*** affects more than just a change in the weather it refers to seasonal changes over a long period of time. These climate patterns play a fundamental role in shaping natural ecosystems, and the human economies and cultures that depend on them. Because so many systems are tied to climate, a change in climate can affect many related aspects of where and how people, plants and animals live, such as food production, availability and use of water, and health risks.

For example, a change in the usual timing of rains or temperatures can affect when plants bloom and set fruit, when insects hatch or when streams are their fullest. This can affect historically synchronized pollination of crops, food for migrating birds, spawning of fish, water supplies for drinking and irrigation, forest health, and more. Some short-term climate variation is normal, but longer-term trends now indicate a changing climate. A year or two of an extreme change in temperature or other condition doesn’t mean a climate change trend has been "erased.” [http://www.ecy.wa.gov/climatechange/whatis.htm].

The most general definition of ***climate change*** is a change in the statistical properties of the climate system when considered over long periods of time, regardless of cause. Accordingly, fluctuations over periods shorter than a few decades, such as El Niño, do not represent climate change. The term “El Niño” sometimes is used to refer specifically to climate change caused by human activity, as opposed to changes in climate that may have resulted as part of Earth's natural processes. In this sense, especially in the context of environmental policy, the term *climate change* has become synonymous with anthropogenic global warming. Within scientific journals, *global warming* refers to surface temperature increases while *climate change* includes global warming and everything else that increasing greenhouse gas levels will affect [http://en.wikipedia.org/wiki/Climate_change#Terminology]. ***Climate change*** is a change in the average pattern of weather over a long period of time, typically decades or longer. ***Climate change*** may be due to natural processes such as volcanic eruptions and changes in solar activity, or may be caused by human activities such as increases in greenhouse gases as is currently the case [Fawcett, Amalia, 2010, p. 6]. ***Climate change*** is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). ***Climate change*** is caused by factors that include oceanic processes (such as oceanic circulation), variations in solar radiation received by Earth, plate tectonics and volcanic eruptions, and human-induced alterations of the natural world; these latter effects are currently causing global warming, and ***"climate change"*** is often used to describe human-specific impacts.

What is Global Warming?

Global warming is the rising average temperature of Earth's atmosphere and oceans since the late 19th century and its projected continuation. Since the early 20th century, Earth's average surface temperature has increased by about 0.8°C (1.4 °F), with about two thirds of the increase occurring since 1980. Warming of the climate system is unequivocal, and scientists are more than 90% certain that most of it is caused by increasing concentrations of greenhouse gases produced by human activities such as deforestation and the burning of fossil fuels. These findings are recognized by the national science academies of all major industrialized nations [http://en.wikipedia.org/wiki/Global_warming].

It is clear from the above mentioned definitions about climate change and global warming that, the climate change is not exactly the same like global warming, but they are closely related, and some people use the terms interchangeably. Global warming causes climates to change. "***Global warming"*** refers to rising global temperatures, while "***climate change***" includes other more specific kinds of changes, too. Warmer global temperatures in the atmosphere and oceans leads to climate changes affecting rainfall patterns, storms and droughts, growing seasons, humidity, and sea level. Also, while "***global warming***" is planet-wide, "***climate change***" can refer to changes at the global, continental, regional and local levels. Even though a warming trend is global, different areas around the world will experience different specific changes in their climates, which will have unique impacts on their local plants, animals and people. A few areas might even get cooler rather than warmer.

Why is climate change a concern?

Weather and climate extremes affect every sector of society, including agriculture, public health, water, energy, transport, tourism and overall socio-economic development [WMO, 2009, Fact Sheet #1]. All across the world, people are taking action because climate change has serious impacts, locally and globally. For example, in 2007, scientists from the International Panel on Climate Change (IPCC) predicted that warming oceans and melting glaciers due to global warming and climate change could cause sea levels to rise 7-23 inches by the year 2100. Worldwide, densely populated coastal communities and infrastructure that supports them would be affected (such as city buildings and homes, roads, ports and wastewater treatment plants). Some would be flooded or more vulnerable to storm damage. In flat terrain, the shoreline could move many miles inland. Other effects are also serious. In some places, floods and/or drought could become more frequent and more severe. Even seemingly less dramatic local changes in temperature, precipitation and soil moisture could severely impact many things important to human life and all life around us, including:

- natural ecosystems
- agriculture and food supplies
- human health
- forestry
- water resources and availability
- energy use
- transportation, etc.

Many people are concerned that we are losing time to make a difference. Climate change and its effects may be irreversible. Life could become very difficult for some populations—plant, animal and human. Species, cultures, resources and many lives could be lost. Worldwide, people are paying serious attention to climate change.

FACTORS MAKE SUDAN VULNERABLE TO CLIMATE CHANGE

Low Rainfall

The vast country encompasses the full range of meteorological diversity – semi-arid in the north, and savannah in the central regions. Nevertheless, drought has been the dominant threat throughout. Data from weather monitoring stations records that average rainfall has decreased significantly over the last 60 years, accompanied by an increase of variability, especially in the north and west part of Sudan. Decreasing annual rainfall and increased rainfall variability are contributing to extreme dry spells and periods of drought in many parts of Sudan. Sudan, along with other countries in the Sahel belt, has suffered several long and devastating droughts in the past few decades, the UNEP (2007) assessment pointed out. The most severe drought occurred in 1980-1984, and was accompanied by widespread displacement and localized famine. The drought is threatening the existing cultivation of about 12 million hectares of rainfed mechanized farming and 6.6 million hectares of traditional rainfed lands; pastoral and nomadic groups in the semi-arid areas of Sudan are also affected [Balgis Osman, et.al, 2005, p. 4].

Average rainfall in Sudan varies greatly by region. Darfur has experienced below-normal annual rainfall for several years increasing tensions over scarce water resources and pasture. Vast swamp regions in Sudan also affect the water stability in the country as they greatly increase the amount of evaporation that occurs annually (roughly three times as much water evaporates due to the swamps as is annually available for use). Annual rainfall has been declining for some time, which has led to weak economic performances. In addition, the civil wars left large areas contaminated with unexploded ordnance and targeted natural resource destruction, such as trees that were deliberately cut down. Further, more than five million internally displaced persons contributed to environmental damage and resource scarcity [Christian Webersik, 2008, p. 2].

Climate scenario analyses conducted as part of the preparation of Sudan's First National Communications indicated that average temperatures are expected to rise significantly relative to baseline expectations. By 2060, projected warming ranges from 1.5°C to 3.1°C during August to between 1.1°C to 2.1°C during January.3 Projections of rainfall under climate change conditions also show sharp deviations from baseline expectations. Results from some of the models show average rainfall decreases of about 6 mm/month during the rainy season. The most vulnerable groups would be traditional rain-fed farmers and pastoralists, groups least resilient to climate-related shocks [Balgis Osman Elasha, et.al, 2005, p. 4]. Projections indicate that climate change will also impact water resources. Reduced groundwater – either through decreased precipitation or increased temperatures and evaporation – would have serious repercussions. Drought will increase if these trends continue, without efforts to adapt.

Vulnerability to climate change is accentuated by the dependence of more than 80% of the population on rain-fed agricultural livelihoods. In its first climate change report in 2003, the Sudan government predicted a significant long term decline in the yields of staple millet and sorghum, due to shorter growing seasons imposed by higher temperatures. Subsequent studies relating to winter crops in the River Nile State for 1994-2005 support this predicted trend. UNEP report [2007] stated that "An estimated 50 to 200 km southward shift of the boundary between semi-desert and desert has occurred since rainfall and vegetation records were first held in the 1930s. This boundary is expected to continue to move southwards due to declining precipitation. The remaining semi-desert and low rainfall savannah which represent some 25 percent of Sudan's agricultural land are at considerable risk of further desertification. This is forecast to lead to a significant drop (approximately 20 percent) in food production.

Climate change poses significant challenges to a developing country like Sudan, not only will many of its important ecosystems and natural resources be adversely affected, but its farmers and pastoralists – spread over thousands of villages from northern desert regions to southern forests – will face increasing difficulty in wresting their livelihoods under conditions of rising heat stress. and recurrent drought. The UNEP report [2007] also listed the erosion of natural resources caused by climate change as among the root causes of social strife and conflict.

Civil Conflicts

Conflict, in its turn, is taking its toll on the environment. UNEP report [2007] pointed out that the fighting in Darfur was often characterized by a 'scorched earth' campaign, carried out by militias over large areas, which not only resulted in a significant number of civilian deaths, but the widespread destruction of villages and forests, and the displacement of victims fleeing to camps for protection, food and water. The UNEP report [2007] stated that:

"The scale of historical climate change, as recorded in Northern Darfur, is almost unprecedented: the reduction in rainfall has turned millions of hectares of already marginal semi-desert grazing land into desert. The impact of climate change is considered to be directly related to the conflict in the region, as desertification has added significantly to the stress on the livelihoods of pastoralist societies, forcing them to move south to find pasture,".

UNEP report [2007] has also identified categories of natural resources that have been linked to the various conflicts in Sudan: oil and gas reserves; Nile water; hardwood timber; rangeland and rain-fed agricultural land, and the associated water points. The UN agency also considers the pastoralists versus agriculturalists theory simplistic. "The rural ethnic and livelihood structures of Sudan are so complex and area-specific that any summary of the issue of resource competition on a national scale is, by definition, a gross simplification. For instance, traditional pastoralist and agricultural societies in Sudan are not always clearly separated: in many areas, societies (families, clans and even whole tribes) practice a mixture of crop-growing and animal-rearing." The report divides the groups into predominantly sedentary crop-rearing societies/tribes; nomadic livestock-rearing societies/tribes; and owners of, and workers in, mechanized agricultural schemes. The three groups depend all on rainfall for their livelihood. Most of the recorded local conflicts take place within and between the first two groups. The third group - the mechanized farming group - is generally not directly involved in conflict, but has played a very strong role in precipitating it in some states, by uncontrolled land grabs from the other two groups. Throughout Sudan's recorded history, pastoralists resisting the shrinkage and degradation of rangelands have been at the centre of local conflicts: competing with other groups for choice grazing land; moving and grazing livestock on cropland without consent; reducing competition by forcing other pastoralists and agriculturalists off previously shared land.

During Sudan’s twenty-two years of civil war, there was a severe loss of vegetation cover. Following the loss of vegetation cover, large areas of grassland transformed into desert, leaving very little land capable of meeting the grazing needs of livestock. Over the years, livestock has been further threatened by climate variability, as it often produces long periods of droughts. In addition to threatening the availability of grazing resources, drought also results in a lack of fodder crop. In study conducted by Higher Council for Environment and Natural Resources [2007] in the rangelands, 42.9% of the respondents state clearly that the rangelands condition deteriorate significantly both during flood times and droughts, meanwhile 27.1% complain from poor biomass production (fodder) and 21.8% showed that during drought times, water points dry out early. Combined, these factors result in animal mortality increases as well as a decline in milk production. As a result, many animal herders must relocate their livestock in search of green pastures and water. Such mobility often produces tribal conflict, which arise out of competition for remaining rangeland and also when grazing animals encroach on the cultivable lands of resident people.

Population Displacement

As has been mentioned somewhere in this paper, Sudan has suffered two civil wars. The conflict which broke out in Darfur in 2003 has displaced nearly two million people and caused an estimated 200,000-400,000 death. UNEP report [2007, p. 9] stated that, with over five million internally displaced persons (IDP's) and international refugees, Sudan has the largest population of displaced persons in the world today. This massive population displacement has been accompanied by significant human suffering and environmental damage. Areas around the larger displaced camps, particularly in Darfur – are severely degraded and the lack of controls and solutions has led to human rights abuses, conflicts over resources and food insecurity. Although this is not a new phenomenon, the scale of displacement and the particular vulnerability of the dry northern Sudanese environment may make this the most significant case of its type worldwide. In addition to that, the return of southern Sudanese to their homeland following the separation of south Sudan from the north is likely to result in a further wave of environmental degradation in some parts of Sudan.

Indirect environmental impacts of the conflict in Darfur and other parts of Sudan include population displacement. Simultaneously, environmental issues continue to be contributing causes of conflict, most notably competition over oil and gas reserves, Nile waters and timber, as well as land use issues related to agricultural land [http://africatalksclimate.com/info/sudan-country-profile]. Also environmental degradation is one of the driving forces of displacement and, the environment is being further undermined by the sheer number of displaced people and refugees. The environmental impact of a refugee or displacement camp is often high: UNEP researchers in Darfur found that extensive deforestation could be found as far as 10km from a camp; in some the situation was being aggravated by brick-making:

"One large tree is needed to provide the fire to make around 3,000 bricks. In addition, the clay needed for brick-making can damage trees by exposing roots, and also create pits in which water collects and mosquitoes can thrive," the UN agency warned. "It is possible that some camps in Darfur will run out of viable fuel wood supplies within walking distance, resulting in major fuel shortages."

CLIMATE CHANGE IMPACTS ON AGRICULTURE AND FORESTRY RESOURCES

Climate is a key parameter in growing food. It controls the soil moisture level, the amount of sunlight plants receive and the conditions plants are subjected to on a daily basis. Changes in these variables can alter crop yields, affecting food supplies and farmers' livelihoods. Local climate variability and global climate change are rapidly altering the landscape for agriculture and land use, threatening water availability and causing extreme weather in some areas, while expanding growing seasons in other areas. Reliable climate information is needed to guide decisions in the food sector to ensure that food managers can adapt to changing conditions [WMO, 2009, Fact Sheet #4].

Sudan's economy similar to most African nations relies heavily on its agricultural sectors. Agriculture represents roughly 80 percent of the work force and has so for decades. In 1996, agriculture accounted for 48 percent of the country's Gross Domestic Products (GDP). In 2005, this number was reduced to 39 percent as the contribution of crude oil exports has steadily increased since Sudan began exporting this natural resource in 1999. Though the contribution to GDP has decreased by roughly 10 percent, the percentage of the population employed by agriculture has remained at 80 percent. Sudan also boasts the second largest animal population in Africa, which annually contributes substantially to the nation's GDP [Christian Webersik, 2008, p. 2]. A World Bank study in 2009 assessed Sudan to be the country most at risk from the effects of climate change on agriculture. As if endorsing this view, Sudan is currently the location of the World Food Programme's largest operation - providing aid to 11 million people in 2010. May be, the reasons of the presence of World Food Programme in Sudan for other factors – conflicts and displacement persons. However, Traditional subsistence agriculture dominates the Sudanese economy, with over 80% of the population dependent upon crop production and/or livestock husbandry to support their livelihoods. The agricultural sector is dominated by small-scale farmers. Typically, such farmers are living in conditions of persistent poverty and rely on rain-fed and traditional practices. This combination renders them highly vulnerable to climate variability, as evidenced by the widespread suffering in rural areas during past droughts.

Forests are likely to show complex transient responses to rapid changes in climate, the over-cutting of forests is also affecting the environment, especially in Northern Kordofan, through desertification. Forests are the focus of renewed global attention because of their role in climate change mitigation. However, biodiversity loss continues to put forests at risk, diminishing their capacity to adapt to pressures, including climate change. New approached to biodiversity conversions are promising, but they need to be matched by more effective governance and greater financial investment [UNEP, 2011, p. 47]. The year 2009 saw a series of activities in connection with forestry issues. Some of these developments have been part of the institutionalized processes already put into place at the global level. The Thirteenth World Forestry Congress's [WFC-13, 2009] final declaration acknowledged that:

Forests are an invaluable asset for humanity providing livelihoods for billions of people, helping achieve environmental sustainability, and serving as a source of social and spiritual values for peoples, communities and nations. Through their sustainable management, forests can contribute to alleviating poverty, safe-guarding biodiversity, and providing the broad range of goods and services for present and future generations, in the context of a changing climate. However, the Declaration pointed out that though sustainable forest management alone is not enough to address the multitude of challenges nevertheless it contributes to achieving the vital balance between man and nature that is needed for sustainable development. The Declaration further acknowledged that ongoing United Nations processes and other international conventions, such as the Non-Legally Binding Instrument on All Types of Forests, provide useful instructional frame-works for action [Yearbook of International Environmental Law, 2009, p. 446].

ADAPTATION TO CLIMATE CHANGE

Climate change is here now and countries need tools to adapt to the changing climate. While mitigation measures to reduce greenhouse gas emissions and slow global warming are vital, an important and yet more overlooked need is for adaptation. For Sudan, climate change is not merely an environmental issue defined by precipitation and temperature projections. It represents a serious sustainable development problem that affects its citizens who are spread across many vulnerable communities [Higher Council for Environment and Natural Resources, 2007, p. v]. Throughout much of the country, water resources are limited, low rainfall, and drought is common. Compounded by a range of human pressures and civil conflicts, these underlying conditions create a state of vulnerability in Sudan to climate impacts, and a troubling picture of vulnerability to anticipated climate change. Indeed, UNEP's [2007] investigation has shown clearly that peace and people's livelihood in Darfur as well as in the rest of Sudan are inextricably linked to the environmental challenges. Just as environmental degradation can contribute to the triggering and perpetuation of conflict, the sustainable management of natural resources can provide the basis for long-term stability, sustainable livelihoods, and development. It is now critical that both national and local leadership prioritize environmental awareness and opportunities for the sustainable management of natural resources in Sudan.

Adaptation is the ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that moderates harm or takes advantage of positive opportunities. It reflects positive actions to change the frequency and/or intensity of impacts, as opposed to coping strategies that are responses to impacts once they occur. The adaptation can be anticipatory, where systems adjust before the initial impacts take place, or it can be reactive, where change is introduced in response to the onset of impacts that will re-occur and reflect a structural change of state of the system: in climate terms, where new temperature and rainfall patterns emerge. Adaptations vary not only with respect to their climatic stimuli but also with respect to other non-climate conditions, sometimes called intervening conditions, which serve to influence the sensitivity of systems and the nature of their adjustments [Balgis Osman Elasha, et.al, 2005].

Adaptation to climate change is a very compelling subject for the people of Sudan, burdened as they already are with devastating and recurring droughts, as well as severe hardships in the ability to coping with even current climatic variability. As a Least Developed Country and an active Party to the United Nations Framework Convention on Climate Change, Sudan stands ready to cooperate with the international community in reducing its future vulnerability to climate change [Higher Council for Environment and Natural Resources, NAPA, 2007, p. iv]. Sudan's National Adaptation Programme of Action (NAPA) report offers an effective basis for urgent and immediate action to reduce the mounting risks of climate change on the nation's most vulnerable communities.

DISCUSSION AND RECOMMENDATIONS

Climate change is different from other problems facing humanity—and it challenges us to think differently at many levels. We live today in a world that is divided at many levels. People are separated by vast gulfs in wealth and opportunity. In many regions, rival nationalisms are a source of conflict. All too often, religious, cultural and ethnic identity are treated as a source of division and difference from others. In the face of all these differences, climate change provides a potent reminder of the one thing that we share in common. It is called planet Earth. All nations and all people share the same atmosphere. And we only have one. As has been stated in UNDP-Human Development Report [2007/2008, p. 5], " No one country can win the battle against climate change acting alone. Collective action is not an option but an imperative ".

To control and address the situation in Sudan, we need:

- To investment in environmental management,
- Climate adaptation measures;
- Capacity building of national and local government in environmental affairs. Human development itself is the most secure foundation for adaptation to climate change.
- Improving the rangeland and restoring the ecology and eco-system, to avoid further tribal conflict.
- Integrate the principle of sustainable development into policies and programmes and reverse the loss of environmental resources.
- Integration of environmental factors in all development projects.

CONCLUSION

Climate change is real and it is happening in Sudan. The country's long history of civil wars and conflicts, combined with irrational utilization of natural resources have created a range of environmental problems, including population displacements, a lack of governance, land degradation and desertification, deforestation, soil erosion, water pollution, energy scarcity, human health hazards, biological species extinction, decline in soil productivity and loss in sustainability. Conflict-related resource exploitation and underinvestment in sustainable development have been the most severe consequences to date. Most importantly they have added to poverty, which in turn has caused more environmental and health problems. Any discussion of climate change in Sudan must take into account the political context. It is clear from what have been mentioned earlier in this paper that, the critical environmental issues in Sudan are closely linked to the country's social and political challenges. The interrelation of climate change with other factors is complex and evolving. Climate change is projected to affect agriculture, forestry, water resources, and health.

REFERENCES

Balgis Osman Elasha; Elhassan, Nagmeldin Goutbi; Ahmed, Hanafi; Sumaya Zakieldin (2005), "Sustainable Livelihood Approach for Assessing Community Resilience to Climate Change: case studies from Sudan", AIACC Working Paper No.17, August 2005.

Christian Webersik (2008), "Sudan Climate Change and Security Factsheet", United Nations University, Climate Change Facts Sheets Series: 2008/2.

Fawcett, Amalia, "Climate Extreme – How Young People can Respond to Disaster in a Changing World", Plan International and the Children in a Changing Climate Coalition, Australian Aid, 2010.

Higher Council for Environment and Natural Resources (2007), "National Adaptation Programme of Action", Ministry of Environment and Physical Development, Sudan, 2007.

Nations Development Programmes (UNDP), (2007/2008)," Human Development Report 2007/2008 – Fighting Climate Change: Human Solidarity in a Divided World.

United Nations Environment Programme (UNEP), (2007), "Sudan – Post-Conflict Environmental Assessment". UNEP: Nairobi, Kenya, June 2007.

UNEP Year Book, (2011), "Emerging Perspectives on Forest Biodiversity", Emerging Issues in our Global Environment, p. 47.

World Bank Report, (2009), "Sudan the Road toward Sustainable and Broad-Based Growth, Poverty Reduction and Economic Management Unit, Africa Region, December 2009.

World Meteorological Organization (WMO), (2009, Fact Sheet #1), " Climate Information for Reducing Disaster Risk", World Climate Conference (WCC-3) – Better Climate Information for a Better Future, in the period of 31 August – 4 September 2009, Geneva, Switzerland .

World Meteorological Organization (WMO), (2009 , Fact Sheet #4), " Climate Information for Securing Food", World Climate Conference (WCC-3) – Better Climate Information for a Better Future, in the period of 31 August – 4 September 2009, Geneva, Switzerland.

Yearbook of International Environmental Law, (2009), vol. 20, Editors-in-Chief Ole Kristian Fauchald; David Hunter; and Wang Xi

Websites

http://africatalksclimate.com/info/sudan-country-profile/

http://www.irinnews.org/Report/72985/SUDAN-Climate-change-only-one-cause-among-many-for-Darfur-conflict

http://en.wikipedia.org/wiki/Climate_change#Terminology

http://en.wikipedia.org/wiki/Geography_of_Sudan

http://en.wikipedia.org/wiki/Sudan

Crop Substitution as an Adaptation Strategy against Climate Variation in Saki Zone, South Western Nigeria

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ABSTRACT
Climate change has been a major topic of concern to many researchers because it affects every sphere of life, especially crop production. Crop production in Nigeria varies from year to year, mainly because of variations in climatic conditions especially rainfall. Rainfall has been variable for the past few decades, and farmers have been suffering losses during the years of drought. The impact of rainfall on crop yield and possible adaptation strategies were analyzed in this study. It is believed that crop yield is dependent on climate (rainfall), and so the strength of their relationship was tested using correlation and linear regression. The study area was Saki Zone, an area in the northern part of Oyo State in Nigeria. The major occupation in this area is agriculture; the major crops cultivated are maize, cassava and yam. The essence of this study is to make Saki farmers less vulnerable during the years of dryness or drought. When the effect of climate variability on yield of these crops were assessed over a period of eleven years, there was 95% level and 90% strength of relationship between cassava and rainfall; maize and yam had 75% and 83% level and 56% and 69% strength of relationship with rainfall respectively. To mitigate against the effect of climate variability on crops' yield, were Crop substitution as an adaptation strategy was assessed in this study. The study findings show that crop production varies yearly in correspondence to rainfall variation. As a result, during drought, crops with strong relationship with rainfall e.g. maize can be substituted with crops with weaker relationship with rainfall like sorghum and millet. Also, economically, in favourable climatic conditions cassava can be substituted by maize whose yield is not affected by fluctuations in price

Key words: Climate change, Crop substitution, Adaptation strategy, Food security, Food economy

INTRODUCTION

Food production varies from year to year, largely as a result of weather conditions (Iglesias, 2004). Agriculture is sensitive to weather especially in the tropics, thus areas likely to be most vulnerable to climate variability can be spared from its impacts through implementation of appropriate adaptation measures (Eroarome, 2009). Historically, agriculture has shown a considerable capacity to adapt to changing conditions. If climate change is gradual, the adjustment may go widely unnoticed, and the process is one largely of autonomous adjustment (Iglesias, 2009). Many adaptations occur autonomously without the need for conscious response by farmers and agricultural planners. However, it is likely at least in some or most parts of the area that the rate and magnitude of climate change will exceed that of normal change in agriculture and specific technologies and management styles will need to be adopted to avoid the most serious of effects (CGE, 2012). Gommes (1998) stated that variation in climate is one of the main determinants of agricultural production in developing and developed countries alike. He also said it is becoming clear that climate variability is influenced not only by natural factors, but by human activities as well. The "human component" is believed to be responsible for the "climatic change" or the "global warming" which is expected to interact with the "natural component" in a largely unknown way. Higher temperature will produce more intense atmospheric circulation and a faster water cycle.

Objectives of the Study

The aim of the study is to experiment and identify crops that are profitable enough (physically, socially and economically) to substitute or replace the crops that are already being cultivated on a particular piece of land. In order to achieve this, there is need to know the types of crops grown in the area, the size of the farmlands in the study area and know the rate of climate variability in Saki Zone, over a period of 11 years. There is also the need to know the trend of crop yield over the eleven years and measure the effect of climate variability on the yields in order to know the extent of the crops' vulnerability to climate variation and which crop adjust autonomously and which is not surviving. The study will examine the different types of adaptation strategies available and explain the choice of 'crop substitution' and why this chosen strategy is preferred to others, economic and social wise. The study will contribute to knowledge by identification and description of climatic systems in Saki Zone (majorly rainfall variability) and their relationship with crop yields. This can be very useful for better food security planning purpose.

THE STUDY AREA

Saki Zone because of its position in Nigeria is characterized by both climatic conditions of Northern and western Nigeria. It is covered by fertile loamy soils derived mainly from Precambrian hornblende-biotite gneiss. The soils are light and a mixture of laterite and fine-grained loamy and humus materials which support poorer vegetation and the cultivation of cereals like maize, guinea corn and millet as well as roots like yam and cassava. The crops cultivated in the area are maize, millet, sorghum, cowpea, pigeon-pea, groundnut, rice and soybean. The root tubers grown are cassava, yam, sweet potatoes and cocoyam. The vegetables grown are carrot, melon, onion, okro, pepper, sweet pepper, and tomato. The fruits grown are banana, plantain, cashew, citrus fruits, and kolanut (Amao, 2008).

The climate is equatorial and experiences the typical tropical climate of averagely high temperatures, high relative humidity and generally two rainfall maximal regimes – during the rainfall periods of March to October. The Zone experience two major seasons: the wet and dry seasons – with high relative humidity. The dry season lasts from November to March, while the wet season starts from mid-March and ends in October. Average daily temperature ranges between 25°C and 35°C almost throughout the year. The mean temperatures are highest at the end of the hammattan (averaging 28°C) that is from the middle of January to the onset of rains in the middle of March. Even during the rainfall months, average temperatures are between 24°C and 25°C while annual rainfall range varies over the zone from an average of 800mm at the onset of rains to 1,500mm at its peak.

The zone experiences very hot and dry seasons, in its northern part, and wet seasons in the southern part. But over the years the length of the rainy season is decreasing and the plants are becoming increasingly subject to water stress. As a result, crop yield is reducing, and this can lead to crop failure. Water loving crops (e.g. maize) are more vulnerable and tend to die or be unproductive, especially when the wet season is prematurely terminated or fails to start in good time. Considering socio-economic importance, the highest output of a piece of land is of interest and so crop substitution comes on stage as an adaptation mechanism. Crop substitution is changing land allocation to crops in order to stabilize production. It has to do with replacing a failing crop with a successful one in a particular season, whether wet or dry, or planting a crop that is most profitable on the available piece of land in order to maximize returns. An adaptation strategy is a technique, which help crops to adjust to variation in climate. Climate variability is the variation in climatic components over the years.

N.B. Data quoted in this section is obtained from the Oyo State Agricultural Development Programme – OYSADEP.

METHODOLOGY

Data used for this study were obtained from Oyo State Agricultural Development Programme – OYSADEP. The data includes: rainfall data for Saki Zone from 2000 to 2010, production estimates including percentage of plots, percentage of households, cropped area, crop yield and crop production for Saki zone for years 2000 to 2010. OYSADEP is an agricultural body working for the development of agriculture in Oyo State and has an office in Saki. Rainfall data from Saki meteorological station is also used to confirm those collected from OYSADEP. Other information on maps, location and physical features are obtained from the website of Oyo State of Nigeria.

In order to verify the data, the study area was visited during the period under study to authenticate the secondary data. The farms were also assessed and there are some discussions with some farmers, but these were not used directly in this study.

RESULTS AND DISCUSSION

Methods of Crop Cultivation

This is a method or pattern of growing crops in terms of combination and sequence, with time and space together with the use of other factors (such as technology) in order to achieve a given objective with the crops that are grown (Anup, 2012). There are different methods of crop production, they are: Lay system, field system, perennial system, crop rotation, multiple cropping/ intercropping, mono-cropping, cover- cropping, land fallowing, crop substitution and application of fertilizers.

Lay System: This is a system in which grass is planted after arable crops. Animals graze on it, and the farmers allow the field to fallow, while the droppings of animals help to improve soil fertility.

Field or relay System: A system whereby one arable crop is planted after the other before harvesting.

Perennial or Permanent System: This is a situation where permanent crops or some arable cropping remain in the soil for a long time; this includes sugar cane, plantain/banana and any tree crop. The permanent crops can be cocoa, coffee, or kola.

Crop Rotation: This involves either crop or land rotation. It is a system whereby; crop or land is used in a sequential manner in order to achieve some objectives and aims:

(a) To disrupt the life cycle of persistent pests and diseases, by avoiding attack on susceptible crops.

(b) To improve the fertility of the soil. This include the inclusion of legumes in cereals system. The legumes will add nitrogen or improves the soil, while the cereals depict it.

Land rotation is usually allocated with a period of long fallow. Fallow system is the major element in a peasant farming system, it fertilize the soil.

Continuous or Sole Cropping: This system is adapted to the developed countries due to decline in labour and increase in mechanization. With the use of crop production chemicals on the increase, it involves the planting of the same crop (monoculture) on the same area of land for several years.

Intercropping: Also known as multiple cropping; this involves growing more than one crop on a piece of land from time to time, e.g. yearly. Different types are recognized: double cropping, triple cropping, intermingled mix cropping, relay intercrop and multiple storey intercrop.

Crop Substitution: involves re-establishing a plantation initially in use for a crop with another crop

In Saki Zone, of all the above listed crop production methods, continuous or sole cropping is not practiced. Crop rotation (especially land rotation) is on the decrease because of conversion of farmlands to urbanization projects.

Major Crops Grown

Of all the crops that are grown in Saki zone, Maize, cassava, and yam are the major food crops grown throughout the State. This fact is arrived at by:

a. the percentage of plots planted to major crops,
b. proportion of farming Households cultivating these crops
c. Hectare cultivated to these major crops.

The Figure 1 below shows that between 2000 and 2010 an average of 34.34% of the plots was cropped with maize, 33.17% to cassava and 18.37% to yam. Also, the same chart shows the proportions of farming household cultivating these crops. An average of 79.1% of the household cultivates maize, while 69.1% and 52.2% of these households cultivated cassava and yam respectively. In the same vein, the total hectarage cultivated to each of the crops is also presented in the chart.

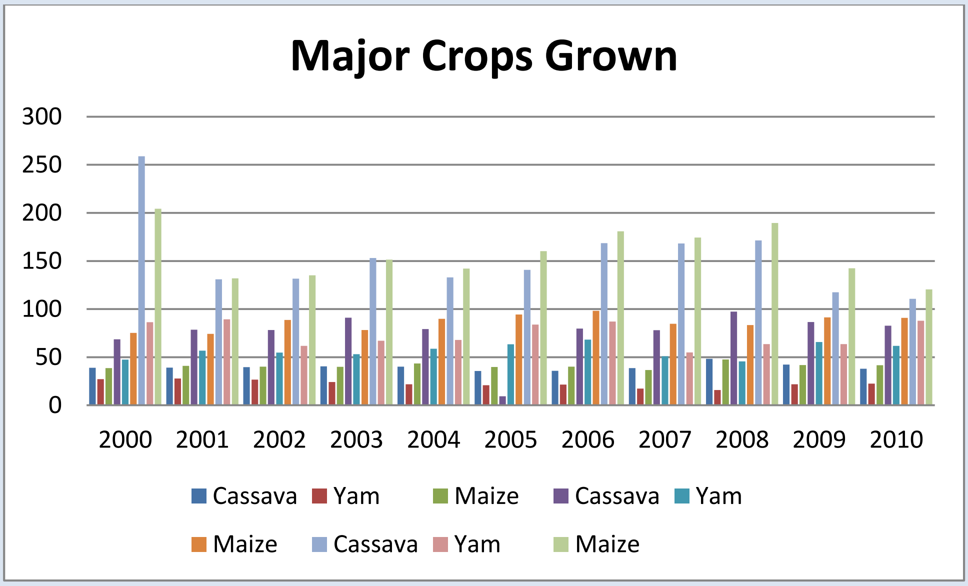

Figure 1 Major Crops Grown Source: OYSADEP

Yield of Various Crops

Crop yield is the total harvested crops. Various methods such as proper cultural practice, sequence of cropping, adoption of elements present on minimal quantity, adoption of water, utilization of adopted varieties and control of pests and diseases can increase it. Factors such as low amount of precipitation, rate of evaporation, soil and specific interaction of climatic factors affects crop yield. Crop growth and yield depend on complex interactions between the crops and several factors and conditions in their environment. They include: soil dept and structure, soil moisture, soil air and slope. The trend of crop yield in the study area is as follow:

Year 2002 recorded the highest yield rate for the three crops under study with 30.61977 MT/HA, while year 2008 recorded the lowest yield value of 15.94056 MT/HA.
Yam's yield was the highest of all the three crops for the 11 years under study. It recorded its highest yield value in 2002 with 18.89 MT/HA and its lowest yield value in 2004 with 9.51 MT/HA.

Cassava is next and its highest recorded yield value was 11.87 MT/HA in 2001 and its lowest yield value is 7.03 MT/HA in 2008. Maize's highest yield value of 1.76 MT/HA was in 2010, while it's lowest yield value of 1.28 MT/HA was in 2007.
NOTE: MT/HA is metric tones/ hectares.

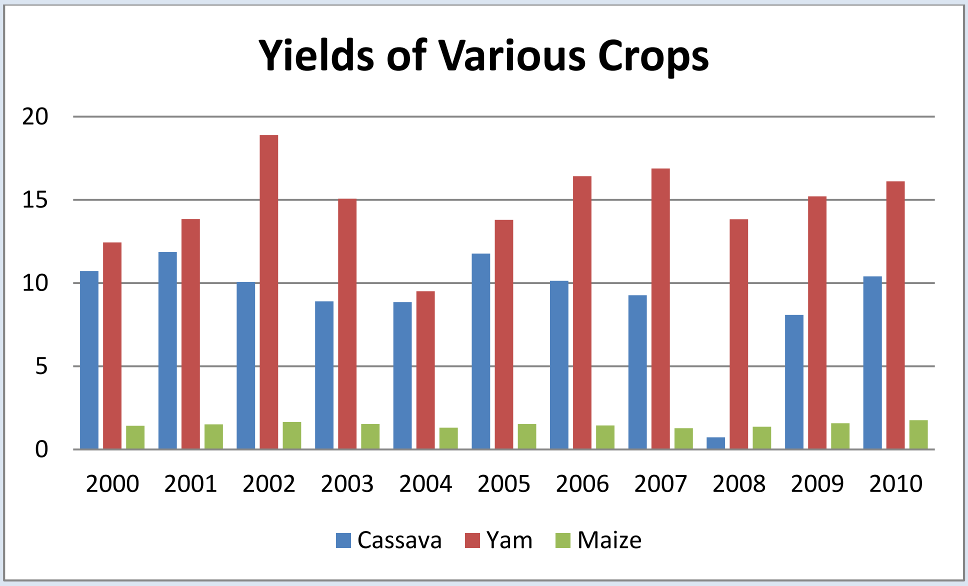

Figure 2 Yields of Various Crops Source: OYSADEP

Rainfall Variation in Saki Zone

Oguntoyinbo (1998) noted that the geographical location, size and shape of West Africa allow it to experience most of the types of weather and climate in the region. The climate of Saki Zone is a microcosm of that of Nigeria – a typical country in West Africa. The rainfall variations are generally accepted to be important because they control to a large extent the calendar of agricultural activities. The times of the start, duration and end of the raining season are especially important to agricultural activities.

It can be noticed from figure 3 that the annual rainfall pattern in Saki Zone varies from month to month and then yearly. The pattern is irregular. For example in the rainfall values for 2000 to 2010, January to December, 2005 and 2001 have the highest rainfall values of 1471.60mm and 1431.30mm respectively with four years interval between them. 2007 and 2003 has the lowest rainfall values of 997.2mm and 981.6mm respectively with four years interval between them as well. The reoccurrence of four years is by chance- coincidental. 2005 has total rainfall weekdays of 98 days, while 2001 has 111 weekdays. The number of days does not determine the volume of rainfall to some extent. The year with the highest number of weekdays is 2004 with 121days, but its rainfall value is 1167.8mm.

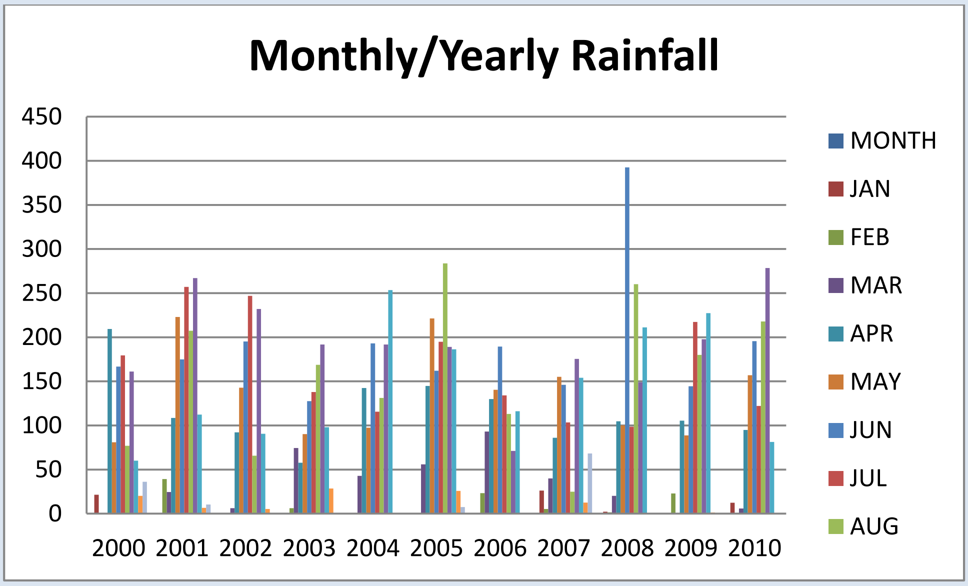

Figure 3 Monthly/Yearly Rainfall Source: OYSADEP

Annual Deviation from Mean.

The mean or average value for the rainfall values of the years under study is 1167.4mm. There are five years with positive deviation from the mean, and six years with negative deviation from the mean. Figure 4 is a chart showing the deviation of rainfall values from the mean. The year with the highest positive deviation from the mean in Saki Zone is 2005 with deviation value of 304.2mm. It is followed by 2001 with value 263.9mm. Other years with positive deviation values are 2008, 2009, and 2004 with deviation values of 173.1mm, 18.0mm, and 0.4mm respectively. The years with negative deviation from the mean in their decreasing order are 2003, 2007, 2006, 2000, 2002, and 2010. Their deviation values are -185.8mm, -170.2mm, -156.8mm, -154.8mm, -90.1 and –1.9 respectively. This is shown in figure 4 below.

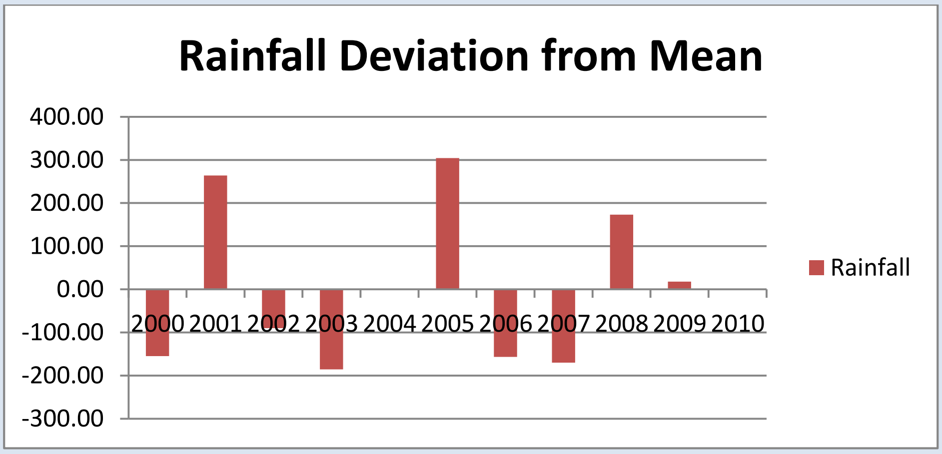

Figure 4 Rainfall Deviation from Mean Source: OYSADEP

Analysis of Crop –Climate Relationship Using Statistical Methods

This study employs statistical methods like deviation from mean (dispersion measures), correlation, and linear regression analysis between the final crop yields and rainfall seasons. Rainfall seasons are used and not annual rainfall because according to Sanderson (1954), plants pay little attention to the calendar. "They germinate, blossom, and ripen their seeds according to the season, not according to the calendar". Also, using the phonological stages as time intervals for processing meteorological data when investigating the influence of climatic variations on agricultural production is more advisable than using the calendar year (Adejuwon 1962). Apart from this, the division of rainfall into the total growing season of crops; pre-sowing, vegetative, flowering and grain filling (or tuber filling as the case may be), will help determine the rainfall of which month is responsible for good crop yield. It was found that fluctuations in rainfall of these seasons combine to reduce the final yield of the crops.

There are broadly speaking, three ways of establishing whether climate-agriculture relationships are in fact significant (Olaniran, 1981). The first is the study of fundamentals of plant-climate relationships using the radiation and moisture balance for various crops in various climatic environments. The second method of determining whether climate-agriculture relationships are significant is by studying the agricultural data and climatic data for a number of places within a given area, for as long a period as consistent records of both agriculture and climate allow, and deducing agro-climatological relationships from the analyses from the data. The third method is that of studying plant-climate relationships under controlled environments.

The second method that is based on the analysis of agricultural and climatic data is employed in this study. As earlier stated, rainfall is the only climatic parameter that is not constant, so the climatic data used are rainfall data. Although, many other factors influence crop yield, rainfall is the major one.

Relationships between Climate and Crop Yield

As earlier mentioned, yearly rainfall does not really have effect on crop yield as seasonal rainfall, therefore in this section, seasonal rainfall values are computed and compared with crop yield using different statistical values. The above statement is fairly proved when the various computed seasonal rainfall data are correlated against crop yield to know how seasonal rainfall affects the yield of a particular crop. The growing months in Saki zone i.e. April to September are used as the growing season rainfall values. These growing season rainfall values are correlated against crop yield. The table below shows the seasonal rainfall values and crop yield data

Table 1 Seasonal Rainfall Values and Crop Yield Data

YEAR	Cassava	Yam	Maize	SEA. RF
2000	10.73	12.45	1.42	934.9
2001	11.87	13.85	1.51	1350.2
2002	10.07	18.89	1.66	1065.6
2003	8.9	15.07	1.53	872.1
2004	8.86	9.51	1.3	1125
2005	11.77	13.81	1.53	1382.1
2006	10.13	16.43	1.44	894.2
2007	9.27	16.88	1.28	804.9
2008	7.03	13.84	1.37	1316.4
2009	8.09	15.22	1.57	1161
2010	10.41	16.12	1.76	1147.2
Total	**107.13**	**162.07**	**16.37**	**12053.6**

Source: Ologeh 2012

Correlation as a statistical tool is used on the above data to explain the relationship between climate and the crop yield. The summation of the growing season rainfall value is correlated with the summation of each crop yield. The correlation result is presented in the table 2 below

Table 2 Correlation between Rainfall and Crop Yield

Seasonal Rainfall	Cassava yield	Yam yield	Maize yield
April-Sept	0.950	0.834	0.750

Source: Ologeh 2012

All three crops under study –cassava, yam and maize have a positive and strong correlation with growing season rainfalls.

To support the above correlation results and interpretations, linear regression analysis is adopted to further explain how the different crops depend on rainfall to produce a good yield. All the various computed seasonal rainfall data are used as independent variables and each crop as the dependent variable and linear regression analysis is run using enter option at 95% level of significance. The result for each crop is displayed below:

1. *Cassava*
   Cassava yield was regressed against growing season rainfall and this gave 95% level of relationship between the two parameters and the relationship is positive and significant. The strength of the relationship is 90%. This denotes that the amount of yield explained by rainfall or dependency of yield on rainfall is strong.
   Inferences can be made from the above results that variation in rainfall will strongly influence good cassava yield. Cassava is usually planted before the raining

season, so that rainfall will meet it in the ground and give it a good growth start. But in case rainfall tarries, cassava growth will be retarded. This is as a result of its strong and significant relationship with rainfall.

2. *Maize*

   Maize was regressed against seasonal rainfall values and this gave 75% correlation and 56% regression between the two parameters. There exist a 75% level of positive and significant relationship between rainfall and maize, also there is 56% determining power between the two parameters.

   The above analysis shows a positive and slightly strong relationship between maize and rainfall variability. The amount of maize yield explained by rainfall is above 50%, therefore, maize cannot survive without rainfall. This is confirmed by the fact that maize is cultivated during the long raining season, because high concentration of moisture is needed at the early stage of maize growth. Maize cultivated in the absence of rainfall or irrigation often withers off or grows without producing grain; this implies a negative impact on final maize yield.

3. *Yam*

   The growing season rainfall has 83% correlation and 70% regression with yam yield. The 83% level of correlation shows a positive and significant relationship between yam yield and rainfall, while 70% regression shows a strong determining power of the relationship. Rainfall can explain to a large extent the yield of yam.

   Yam has a strong, significant and positive relationship with rainfall. There is a positive correlation between moisture supply, vine growth and tuber formation. Rainfall is needed at propagation as the seed may wither or be eaten up by burrowing animals.

Table 3 Correlation and Regression Values between Rainfall and Crop Yield

At 0.05 Sig Level	Correlation Value	Regression Value
Cassava	.950	.902
Maize	.750	.562
Yam	.834	.696

Source: Ologeh 2012

From the above results and interpretations, cassava has the strongest relationship with rainfall and should be given priority in land allocation during wet years but its land allocation must be reduced in dry years. Next in the trend is Yam, but maize has the weakest relationship of all the crops under study with growing season rainfall. By this analysis, maize do not need all the growing season's months, but three heavy rainfall months for good yield. Thus, the land initially allocated to maize during early rainfall months can be reallocated to other crops like yam and cassava after harvest.

Price-Yield Relationships

In order to make a proper decision, apart from knowing the weather favorable crops, the profitability of allocating land to that crop should also be analyzed. The prices per kilogram of crops are correlated with crop yield to determine if there is any positive and significant relationship between them and to know which crops are economically profitable and which are not. The profitable crops can substitute the unprofitable ones, the reason is not farfetched; the main goal of farming is the profits made at the market not the bulkiness of yield at harvest. As a result, crops with greater profit margin are encouraged to be cultivated for economic benefit of the farmer.

Correlation between Crop Prices and Crop Yield

The table below shows the values of price per kilogram. The values were correlated and the result shows that cassava has a -0.94% negative but significant relationship with price. On the contrary, yam and maize has positive and significant relationship between their prices and yields. The correlation values are 89% and 94% respectively.

From this analysis, it can be deduced that cassava has a negative but significant relationship with price. This denotes that the crop has an inverse relationship with price/kilogram; when cassava yield is high, its price will be low and vice versa. It was observed during one of the visits to the study area that cassava yield in the area is high and sometimes in excess. This explains the inverse relationship between the crop yield and its price. Although cassava has the highest yield per hectare, is not as profitable as the other two crops but its high yield rate covers up for the low price (the more they produce, the more the gain) and the farmer still makes his good profit from cassava cultivation.

The Choice of Crop Substitution as an Adaptation Strategy

Of all the methods of crop cultivation mentioned earlier, crop substitution is preferred due to the following reasons

1. Farm lands are endangered as urbanization is creeping into the farms.
2. The available lands for farming should be maximized for yield and profit
3. As such, of all the crop cultivation options, only crop substitution is a land management system that can deliver high yield or profit/hectare

CONCLUSION

In conclusion, farmers should be aware of their environments, and know what the seasons are saying in order to minimize the effect of climate variability. Adaptation strategies should not only be adopted towards the direct impact of climate on yield alone, but also on the indirect impacts. In the words of Gommes (1998), he said that climate variability do not affect crop yield directly alone but also indirectly through pests and diseases. Pests and diseases are known to change with variation in climate, and they reduce the quality of yield. Crop substitution solves this problem by shifting the location of crops, thereby destabilizing the pests. Gommes also said seasonal weather forecasts up to one year in advance are urgently needed to allow farmers to significantly reduce risks associated with climate variability.

The allocation of lands between crops is a matter of maximizing the farmer's wealth and investments in crop production and equivalent to investing in financial assets (Paul Richards, 1983).

REFERENCES

1. Adejuwon J.O, (1962): *Crop- Climate Relationship: The Example of Cocoa in Western Nigeria.* Nigerian Geological Survey.
2. Amao, J. O, (2008), *Analysis of Off-Farm Work among Farming Households in Oyo State.* International Journal of Agricultural Economics & Rural Development, 16-1 (2)
3. Anup Shah, (2012). *Climate Change and Global Warming Introduction. Global Issues*. http://www.globalissues.org/article/233/climate-change-and-global-warming-introduction. Assessed on March 5th, 2012
4. CGE (Consultative Group of Experts) Training Materials for Vulnerability and adaptation Assessment. *Chapter 7- Agriculture.* United Nations Framework, 2012
5. Eroarome Martin Aregheore, (2009), *Country Pasture/Forage Resource Profiles- NIGERIA*. FAO
6. Gommes Rene, (1998): *Sustainable Development Dimensions.* Food and Agricultural Organization of the United Nations. (FAO)
7. Iglesias Ana, (2004). *Climatic change effects on Mediterranean Rain-fed agriculture.* CHIHEAM
8. Iglesias Ana, Luis Garrote, Sonia Quiroga, Marta Moneo, (2009). *Impacts of Climate Change in Agriculture in Europe. PESETA-Agriculture study*. Joint Research Centre Scientific and Technical Report
9. Oguntoyinbo J.S and Hayward O.F, (1975): *The Climatology of West Africa. Barness and Noble Books.*
10. Olaniran O.J., (1981): *Research in Agro-climatology in Nigeria. J. Agric. Research (Pakistan)*
11. Oyo State Agricultural Research Programme. (2000) *RUSEP Need Assessment Study*.
12. Oyo State Website. www.oyostate.gov.ng
13. Paul Richards, (1983): *Ecological Change and the Politics of African Land Use.* African Studies Review.
14. Sanderson, E.H, (1954): *Methods of Crop Forecasting*. Cambridge, Massachusetts

Desmutagenic and antimutagenic potential of *Khaya grandifoliola* (C.DC.), Meliaceae

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ABSTRACT

Five phenolics were isolated for the first time from *Khaya grandifoliola* leaves. These compounds were identified using spectroscopic analysis (UV, ^{1}H-NMR, ^{13}C-NMR and ESI) as Quercetin 3-*O*-rhamnoglucoside (rutin), Quercetin 3-*O*-rhamnoside, Quercetin 3-*O*-glucoside, Quercetin aglycon and 6- methoxycoumarin, 7-*O* arabinofuranoside. Desmutagenic and antimutagenic activities of specimen extracts of immaculate *khaya grandifoliola* leaves and flowers were ascertained by measuring the inhibition of *Salmonella typhimurium* TA 100 His^{+} revertants induced by ethyl methane sulphonate EMS and ribose lysine RL. A frustration of the induced reversion was observed. The alcoholic extracts of both leaves and flowers (total and successive) of *khaya grandifoliola*, rutin and quercetin rhamnoside isolated from the leaves, exhibited desmutagenic and antimutagenic activity against EMS and RL induced reversion.

Kaywords: *Khaya* grandifoliola, desmutagenic and antimutagenic activity

INTRODUCTION

Family Meliaceae Juss. Trees, or shrubs or rarely herbs, may be laticiferous (rarely, with milky juice exuding from the bark). Plants of this family distributed in tropical, subtropical, and occasionally warm temperate regions. Genus *Khaya* is a genus of seven species of trees in the mahogany family Meliaceae, native to tropical Africa and Madagascar. Synonym of *Khaya grandifoliola* : *African Mahogany*. Limonoids are heavily oxygenated modified triterpenes dominant in the plants of family Meliaceae, limonoids have anticancer activity and antifeedant activity against insects. Compounds other than limonoids are catechin from bark seed (Bickii *et al*., 2000) and steroid hormone (Adesogan and Taylor, 1967) isolated from *K. grandifoliola* bark, rutin and quercetin flavonoids were isolated from *K. senegalensis* (Mesbah *et al*., 1984). Antimalarial activity (Agbedahunsi *and Elujoba*. 1998), schistosomicidal (Yousif, *et al*., 2007), hypoglycemic and hypocholesterolaemic (Bumah *et al*., 2005) are biological activities reported for *Khaya grandifoliola* stem bark. Directly assaying potential carcinogens by testing for their ability to form tumors in animals is difficult and expensive. However, in addition to causing tumors in animal cells most carcinogens are mutagens. [(Ames, *et al*., 1973), (McCann, *et al.*, 1975a) and (McCann, *et al.*, 1975b). Some chemicals (called pro-mutagens) are not mutagenic unless metabolized to more active derivatives.

EXPERIMENTAL

Plant material:

The fresh leaves of *Khaya grandifoliola* (C.DC.) were collected from Giza Zoo, Dokki, Cairo. Egypt. And identified by Dr. Mohamed El-Gebaly, Ph.D in plant taxonomy, Plant Taxonomy Department, National Research Centre.**Preparation of successive extracts:**

600 g of the air-dried powdered leaves were successively extracted with solvents of increasing polarities: petroleum ether, chloroform, ethyl acetate and 95% ethanol in a Soxhlet apparatus. After complete extraction, these extracts were evaporated to dryness under vacuum at 40°C.

Preparation of crude extract:

The crude extract was prepared by percolating 500 g dry powder with 90% ethanol till exhaustion the filtered percolate was concentrated under vacuum at 40^{o}C.

Investigation of flavonoids content:

The successive ethanol extract was subjected to two dimensions paper chromatography examination for the detection of flavonoids using Whatmann No. 1 sheets and developing with solvent systems (s_1) n- butanol - acetic acid - water (3: 1: 1) and (s_2) acetic acid - water (15%). The chromatograms were examined under UV light before and after exposure to ammonia vapour and spraying with $AlCl_3$ solution.

Isolation of flavonoids:

60 g of successive ethanol extract was fractionated on polyamide column using (water/methanol) as eluent. The fractions were purified on sub-columns of Sephadex (LH-20) using butanol saturated with water as eluent for comp. **I** and compounds **II**, **III** and **IV** were isolated from ethyl acetate extract using preparative paper chromatography. spots detected in each fraction, their R_f values in systems a & b and their colours being recorded.

Apparatus:

- ^{1}H-NMR Spectrophotometer Jeol EX 500 NMR spectrometer.
-^{13}C-NMR spectrophotometer Jeol EX, 125 spectrometer.
-Ultraviolet visible recording spectrophotometer, UV-VIS. Double Beam, UVD-3500, Lambomed, Inc.
-Mass spectrometer, Electrospray ionization mass spectrometry.

Characterization of the isolated compounds:

The purified compounds were subjected to UV spectral analysis and ^1H-, ^{13}C-NMR determinations. The spectroscopic UV data of these compounds were compared with the published data (Mabry *et al.*, 1970 and Markham, 1982).

Table (1): Chromatographic properties of isolated flavonoids:

Compound No.	R_f (s_1)	R_f (s_2)	UV	UV/amm.	$AlCl_3$
I	0.58	0.74	Purple	Yellow	Yellow
II	0.77	0.57	Purple	Yellow	Yellow
III	0.58	0.44	Purple	Yellow	Yellow
IV	0.96	0.02	Yellow	Yellow	Yellow

Table (2): UV spectral data of isolated flavonoids $\lambda_{\max}^{methanol}$:

Comp. No.	Methanol	NaOMe	$AlCl_3$	$AlCl_3$/HCl	NaOAc	NaOAc/ H_3BO_3
I	257, 266(sh), 359	273, 327, 410	275, 304 (sh), 435	271, 300 (sh), 357, 402	273, 320, 413	263, 294 (sh), 380
II	256, 339, 351	271, 326, 395	275, 305, 331, 432	269, 299(s), 355, 395	271, 316, 339, 377	261, 308, 368
III	255, 269(s), 294, 371	274, 330, 409	272, 321(S), 449	264, 300, 339, 361, 422	254, 274, 329, 385	259, 295, 386
IV	255, 270 (sh), 302 (sh), 371	247.8, 277 (sh), 333, 418	229 (sh), 271, 449	229 (sh), 265, 303, 357, 426	257, 276, 325, 385	260, 387, 461

Table (3): ^{1}H-NMR of isolated flavonoids in DMSO, δ ^{1}H (ppm) (J in Hz):

Carbon No.	Comp. I	Comp. II	Comp. IV
6	6.15 (d, J= 1.5, 1H)	6.13 (d, J= 1.5, 1H)	6.21 (d, J= 1.5, 1H)
8	6.35 (d, J= 1.5, 1H)	6.32 (d, J= 1.5, 1H)	6.47 (d, J= 1.1, 1H)
2`, 6`	7.51 (m, 2H)	7.25 (m, 2H)	7.64 (d,d., J=2.2, 8.4, 1H-6`); 7.74 (d, J= 2.2, 1H, 2`)
5`	6.81 (d, J= 8.4, 1H)	6.82 (d, J= 8.4, 1H)	6.95 (d, J= 8.4, 1H)
1``	5.29 (d, J= 6.8, 1H)	----	----
2``		----	----
3``		----	----
4``	3.2 – 3.8	----	----
5``		----	----
6``		----	----
1```	4.34 (s, 1H)	5.21 (s, 1H)``````	----
2```			----
3```		3.9-4.7	----
4```			----
5```			----
6```	0.96 (d, J= 6.0, 3H)	0.78 (d, J= 6.1, 3H)	----

Compound III:

Acidic hydrolysis of compound III by 6% aqueous HCl (5 mL) using minimal methanol to produce complete solution. The solution was heated on steam bath for 45 min. and then cooled and extracted by shaking with ether to give the aglycon in the ethereal layer after drying on sodium sulfate and the sugar moiety in the aqueous layer.

Table (4): ^{13}C-NMR of isolated flavonoids in DMSO, δ ^{13}C (ppm):

Carbon No.	Comp. I	Comp. II	Comp. IV
2	157.11	157.66	146.60
3	133.81	134.63	135.59
4	177.87	177.72	175.67
5	161.73	161.77	160.56
6	99.3	99.50	98.12
7	164.68	167.68	163,98
8	94.11	94.47	93.25
9	156.94	157.66	156.01
10	104.44	105.58	102.78
1`	122.10	121.60	121.81
2`, 6`	115.75, 121.67	115.9, 121.15	114.87, 119.83
3`	145.28	145.79	144.94
4`	148.96	148.80	147.58
5`	116.77	116.09	115.47
1``	101.70	----	----
2``	73.0	----	----
3``	76.9	----	----
4``	68.8	----	----
5``	77.3	----	----
6``	60.8	----	----

1```	101.26	102.29	----
2```	70.8	70.73	----
3```	71.0	70.57	----
4```	72.3	71.14	----
5```	70.5	70.85	----
6```	18.25	18.02	----

Compound V:

Isolation of Compound V:

Compound **V**: was isolated from 30% (methanol/water) fraction of polyamide column of successive ethanol extract, purified on silica gel column using gradient elution from pet. ether to chloroform then column Sephadex LH 20 with methanol eluent to give yellow needle crystals.

Characterization of compound V:

Compound **V:** appeared as blue florescent spot on TLC (Silica gel 60 GF_{254} precoated plates) turned yellow by exposure to ammonia vapor, R_f: 0.39 (Benzene: ethyl acetate, 7:3). identified by UV spectral analysis, ^{1}H-, ^{13}C-NMR and Electron spray ionization mass spectroscopy.

UV $\lambda_{\max}^{methanol}$: 261, 295, 339, 363 nm, (in methanol).

ESIMS: (m/z, rel. int.) $C_{15}H_{16}O_8$. M^{+1}, 325

^{1}H-NMR: (500 MHz, MeOD), δ ppm 6.2 (1H, d, $J_{3,4}$ = 9.15, H-3), 7.8 (1H, d, $J_{4,3}$ = 9.15, H-4), 6.7 (1H, s, H-8), 7.1 (1H, s, H-5), 5.2 (H-1`).

^{13}C-NMR: (75 MHz, MeOD), 55.5 (OCH_3), 102 (C-8), 108 (C-5), 111.2 (C-3), 114.8 (C-9), 144.9 (C-4), 145.8 (C-6), 149.3 (C-7), 150 (C-10), 162.8 (C-2), 109 (C-1`), 71.0 (C-2`), 71.2 (C-3`), 72.1 (C-4`), 62.8 (C-5`).

2.8. Inhibition of mutagen-induced revertants in *Salmonella typhimurium*:

Desmutagenic and antimutagenic activities of leaves and flowers of *Khaya grandifoliola* extracts were detected by using bacterial strain of *Salmonella typhimurium* TA100 (His). The concentration of each mutagen used is: (25 μL in 100 μL DMSO)
EMS (Ethylmethylsulphonate).
RL (Ribose lysine): (0.5 M in water)
Using ascorbic acid as authentic desmutagenic and antimutagenic compound.

Desmutagenic activity:

Various amounts of the **alcohol extracts** (total and successive) of *Khaya grandifoliola* (leaves and flowers), **compound I**(rutin), **compound II** (quercetin-3-*O*-α-L-rhamnopyranoside) and the mutagen were added to sterile distilled water (1mL final volume) containing 100 μ mol. phosphate buffer (pH 7.4). The mixture was incubated at 37° for 30 min. 100 mL of a 24 hrs. bacterial culture of TA100 His-strain (10^8 cells) and 2 mL of molten top agar (45°) were added and the mixture was poured onto minimal glucose-agar plates: After addition of the cells the mixture was incubated once more for 1/2 hr. at 37°. The number of His^+ induced revertants were scored after incubation for 48 hrs. at 37°.

Antimutagenic activity:

Various concentrations of alcohol extract (total and successive), compound I and compound II. were added to sterile distilled water (1 mL final volume) containing 100 µL of 24 hrs. culture of TA100 His^- test strain. and 100 g mol. phosphate buffer pH 7.4. After incubation at 37° for 1/2 hr., cells were collected by centrifugation, washed twice with phosphate buffer to remove antimutagen (tested compounds) and finally suspended in 1 mL of the buffer**.** After addition of the mutagen and 2 mL of soft agar, the mixture was poured onto minimal glucose agar plates. After incubation for 48 hrs. at 37° revertant colonies (His^+) were counted.

Desmutagenic and antimntagenic activities were calculated as the percentage of decrease of induced revertants according to (**Hayatsu, *et al.* 1988**) and (**Mortelmans and Zeiger 2000**) after subtraction of corresponding spontaneous reversion) according to the equation: % inhibition = 100 – (N / N_0 X 100), N is the revertant / plate induced by the mutagen in the presence of increasing amounts of the tested material. N_0 is the reversion induced in the control.

RESULTS AND DISCUSSION

Identification of isolated compounds

Compound 1 was expected to be quercetin-3-*O*-glycoside on the basis of its chromatographic properties (R_f values, colour under UV/NH_3 and $AlCl_3$) (Mabry, 1970). The bathochromic and hypsochromic shifts observed in the UV-spectra were in good agreement with quercetin-3-*O*-glycoside (Mabry, 1970).

UV spectra shows a bathochromic shift in band I (51 nm), on addition of NaOMe, accompanied with an increase in intensity which was an evidence for free 4`-OH. The bathochromic shift in band II (16 nm), on addition of NaOAc, referred to a free 7-OH. A bathochromic shift of 43 nm in band I in the presence of $AlCl_3$/HCl confirming the presence of 5-OH. In addition, a bathochromic shift of 21 nm in band I in the presence of NaOAc/H_3BO_3 and a hypsochromic shift of more than 21 nm of band I in $AlCl_3$/HCl spectrum relative to band I in the spectrum of $AlCl_3$ confirmed the presence of *ortho*-dihydroxyl groups in B ring (Markham, 1982).

The **^{1}H, ^{13}C-NMR** spectrum of compound **1** revealed the presence of glucose, rhamnose and quercetin. The ^{1}H-NMR spectrum showed an overlapping signal at δ 7.51 for H-2`, 6` and a doublet at δ 6.81 (J= 8.4 Hz) for H-5` due to *ortho*-coupling with H-6` and two doublets of two aromatic protons at δ 6.35 and 6.15 (J= 1.5 Hz), each proton assigned for H-8 and H-6, respectively.

A *β*-D-rutinoside moiety at C-3 was deduced from downfield signal of C-3 to 133.81 ppm and the two anomeric carbons appeared at 101.70 and 101.26 ppm., together with two anomeric proton signals at δ 5.29 (d, J= 6.8 Hz) and δ 4.34 (singlet) and a doublet of three protons at δ 0.96 (J= 2.0 Hz) for Me-6```. A 1```→6`` inter-glycosidic linkage was followed from the characteristic up-field location of H-1``` as a singlet at δ 4.34.

Therefore compound **1** was identified as **Rutin** [quercetin-3-*O*-*α*-L-rhamnopyranosyl-(1```→6``)-*O*-*β*-D-glucopyranoside]. This is the **first report for its isolation from the plant.**

Compound II

The UV spectrum of compound **II** shows a bathochromic shift (44 nm) in band I with increase in intensity relative to that of MeOH upon addition of NaOMe was indicative for free 4`-OH. As well as, a characteristic bathochromic shift in band II (15 nm) on addition of NaOAc attributed to a free 7-OH group. On the other hand, a bathochromic shift of 44 nm in band I in the presence of $AlCl_3$/HCl confirming the presence of 5-OH. In addition, a bathochromic shift of 17 nm in band I in the presence of NaOAc/H_3BO_3 and a hypsochromic shift about 37 nm of band I in $AlCl_3$/HCl spectrum relative to band I in the spectrum of $AlCl_3$ confirmed the presence of *ortho*-dihydroxyl groups in B ring **(Markham, 1982)**.

^{1}H, ^{13}C-NMR spectrum of compound **II** revealed the presence of quercetin and rhamnose. The ^{1}H-NMR spectrum showed an overlapping signal at δ 7.25 for H-2`, 6` and a doublet at δ 6.81 (*J*= 8.4 Hz) for H-5` due to *ortho*-coupling with H-6`. Two doublets at δ 6.13 and 6.32 ppm assigned H-6 and H-8 respectively. The downfield signal of C-3 in ^{13}C-NMR to 134.63 ppm confirmed the flavonol structure. The anomeric carbon of rhamnose appeared at 102.29 ppm with anomeric proton appeared as a doublet of small *J* value at δ 5.21 ppm, while the protons of methyl group gave doublet with *J*= 6 Hz at δ 1.19 ppm appeared in ^{13}C-NMR at 18.02 ppm. So compound **II** was identified as quercetin- 3-*O*-α-L-rhamnopyranoside.

Compound III.

UV spectra shows a bathochromic shift in band I (40 nm), on addition of NaOMe, with no decrease in intensity which was an evidence for free 4`-OH. As well as, a characteristic bathochromic shift in band II (20 nm) on addition of NaOAc referred to a free 7-OH group confirmed by new peak appeared at 330 upon addition of NaOMe. A bathochromic shift of 31 nm in band I in the presence of $AlCl_3$/HCl confirming the presence of 5-OH. In addition, a bathochromic shift of 15 nm in band I in the presence of NaOAc/H_3BO_3 and a hypsochromic shift of more than 27 nm of band I in $AlCl_3$/HCl spectrum relative to band I in the spectrum of $AlCl_3$ confirmed the presence of *ortho*-dihydroxyl groups in B ring (Markham, 1982). The compound was expected to be quercetin-3-*O*-glycoside on the basis of its chromatographic properties. The sugar moiety was determined after complete acid hydrolysis to give glucose in the aqueous phase and quercetin in the organic phase (Co-paper chromatography, Aniline phthalate reagent for sugars and $AlCl_3$ for the aglycone). So compound III is quercetin-3-*O*-α-L-glucopyranoside.

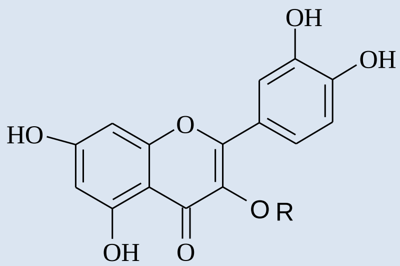
Compound IV.

Compound **IV** was expected to be quercetin on the basis of its chromatographic properties. The bathochromic and hypsochromic shifts observed in the **UV**-spectra were in good agreement with quercetin aglycon (Mabry, 1970).

UV spectra shows a bathochromic shift in band I (47 nm), on addition of NaOMe, accompanied with an increase in intensity which was an evidence for free 4`-OH. The bathochromic shift in band II (11 nm), on addition of NaOAc, referred to a free 7-OH. A bathochromic shift of 55 nm in band I in the presence of $AlCl_3$/HCl confirming the presence of 5-OH. In addition, a bathochromic shift of 16 nm in band I in the presence of NaOAc/H_3BO_3 and a hypsochromic shift of 23 nm in band I in $AlCl_3$/HCl spectrum relative to band I in the spectrum of $AlCl_3$ confirmed the presence of *ortho*-dihydroxyl groups in B ring (Markham, 1982).

The **^{1}H, ^{13}C-NMR** spectrum of compound **IV** revealed the presence of flavonol structure with downfield signal of C-3 in ^{13}C-NMR to 135.59 ppm. The ^{1}H-NMR spectrum showed a signal at δ 7.64 for H-6` d,d, with (J= 8.4 Hz) due to ortho coupling with 5` which appeared as a doublet at δ 6.95 ppm and (J= 2.2 Hz) due to meta coupling with 2` which appeared as a doublet at δ 8.4 ppm and two doublets of two aromatic protons at δ 6.47 and 6.21 (J= 1.5 Hz), each proton assigned for H-8 and H-6, respectively. So compound IV was identified as quercetin.

Compound I: R = rutinoside
Compound II: R = rhamnoside
Compound III: R = glucoside
Compound IV: R = H



Compound V:

The UV absorption bands at 288 nm and 339 nm could be attributed to the benzene and pyrone rings, respectively. ^{1}H-NMR spectrum shows signals corresponding to methoxy substituents in an aromatic system at δ 3.7 ppm confirmed in ^{13}C-NMR at 55.5 ppm. Signals corresponding to H-3 and H-4 appeared at 6.2 and 7.8 ppm respectively with $J_{3,4}$ = 9.15 Hz, confirming ortho coupling. Other two singlets appeared at 6.7 and 7.1 ppm corresponding to H-5 and H-8 respectively and confirming (with the ^{13}C-NMR spectrum) the structure of 6, 7 disubstituted coumarin. The signal appeared at 5.2 ppm in ^{1}H-NMR indicates the presence of sugar moiety which is confirmed by ^{13}C-NMR and identified as arabinose using acid hydrolysis and co-chromatography with authentic sugar.

From these data compound V can be identified as 6- methoxy, coumarin-7-*O*-arabinofuranoside (scopoletin 7-*O*-arabinofuranoside).

6- methoxy, coumarin-7-*O*-arabinofuranoside

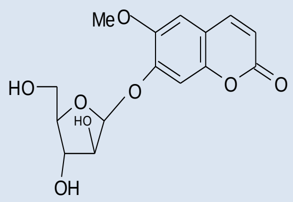


Table 5. Desmutagenic and antimutagenic potential of alcohol extracts, compoundI and compound II isolated from *Khaya grandifoliola* using EMS and RL induced revertants:

Sample	Conc. µg/plate	Desmutagenic % inhibition		Antimutagenic % inhibition	
		EMS	RL	EMS	RL
Leaves					
T.E.	100	100	0	75	0
	250	100	0	80	0
	500	100	0	86	0
	1000	100	57	90	0
E	100	88	0	85	0
	250	100	0	86	0
	500	100	60	97	20
	1000	100	80	100	30
Flower					
T.E.	100	100	100	95	0
	250	100	100	97	0
	500	100	100	98	67
	1000	100	100	100	87
E.	100	43	0	97	0
	250	100	0	100	0
	500	100	100	100	0
	1000	100	100	100	80
Rutin	25	88.5	0	54	0
	50	97	0	58	0
	100	100	0	77	34
Q.R.	25	90	0	79	0
	50	97	43	91	0
	100	100	55	95	0
Ascorbic acid	25	96	57	67	0
	50	97	86	99	0
	100	100	87	100	0

Desmutagenic and antimutagenic potential:

Results of desmutagenic activity produced using EMS are better than RL. Also flower extracts (total and successive) are more active than leaves extracts in case of RL. While rutin and quercetin rhamnoside showed somewhat similar results in case of EMS and RL,

Desmutagenic and antimutagenic activities of specimen extracts of immaculate *khaya grandifoliola* leaves and flowers were ascertained by measuring the inhibition of TA 100 His^+ revertants induced by ethyl methane sulphonate EMS and ribose lysine RL. The results produced in table 5 showed that flower extract is more active than leaf extract as desmutagenic and antimutagenic especially in case of EMS. Tests on EMS induced reversion adverted on good activity of all the extract specimens. On the contrary desmutagenic and antimutagenic activities of RL were verifiable. This phenomena can be interpreted by the different action mechanism of these mutagens, or presumably due to the selective activity of the antimutagen compound.

Discussion:

Hung and co-workers (2009) classified inhibitors of mutagenesis into three categories on the basis of their mode of action. As bioantimutagenic agents, the chemopreventive agents modulate the cellular mutagenic processes by acting on DNA replication and repair processes. These agents exert their effect when DNA is damaged by the mutagen. In co-incubation method, the bioantimutagenic effect of phytochemicals is determined. The phytochemicals might be involved in the direct inactivation of mutagens or suppressed the activity of metabolic enzymes. Such type of inhibition is known as desmutagenesis and pre-incubation treatment is destined to evaluate the desmutagenic effect. There is another category of antimutagens that exert its effect by acting as blocking agents.These agents act differentially from bioantimua-tegnic and desmutagenic agents as they modify the function of bacterial cells in order reduce the DNA mutations induced by mutagens (Hung *et al*., 2009). It has been seen that desmutagenicity or bioantimutagenicity are the probable mode of action of tested compounds and extracts. In order to evaluate desmutagenicity in the current study, test sample was incubated with mutagen at 37˚C for 30 min prior to addition of bacterial culture.

REFERENCES

Adesogan, E. K. and Taylor, D.A. H. (1967). Isolation of a steroid hormone from *Khaya grandifoliola. Chem. Ind*. (London), 32: 1365.

Agbedahunsi, J.M. and Elujoba, A.A. (1998). Grandifolin form *Khaya grandifoliola* stem bark. *J. Nat. Prod. Med*., 2: 34-36 .

Ames, B., Lee, F. and W. Durston. (1973). An improved bacterial test system for the detection and chssihcation of mutagens and carcinogens. *Proc. Natl. Acad. Sci*. USA 70: 781-786.

Bickii, J.; Njifutie, N. Ayafor Foyere, J.; Basco, L.K. and Ringwald. P. (2000). *In vitro* antimalarial activity of limonoids from *Khaya grandifoliola* C.D.C. (Meliaceae) *J. Ethnopharmacol*., 69: 27-33.

Bumah, V.V.; Essien, E.U.; Agbedahunsi, J.M. and Ekah, O.U. (2005). Effects of *Khaya grandifoliola* (Meliaceae) on some biochemical parameters in rats*. J. Ethnopharmacol*., 102: 446-449.

Hayatsu, H.; Arimoto, S., Negishi, T. (1988). *Mut. Res*. 202: 429-4467.

Hung Y. H.; Wang Y. J. and Chou C.C. (2009). Antimutagenic activity of Aspergillus awamori-fermented black soyabean response to stimulated digestive juice treatments and its antimutagenic mechanisms. LWT-*Food Sci. Technol*., 42: 56-62.

Mabry, T.; Markham, K.R. and Thomas, M.B. (1970). The Systematic Identification of Flavonoids. Springer Verlag, Berlin.

Markham, K.R. (1982). Techniques of Flavonoid Identification. Academic Press, London.

McCann, J., Choi, E. Yamasaki, E. and Ames, B. (1975b). Detection of carcinogens as mutagens in the Salmonella/microsome test: Assay of 300 chemicals. *Proc. Nati. Acad*. *Sci*. USA 72: 5135-5139.

McCann, J., Spingarn, N. Kobori, J. and Ames, B. (1975a). Detection of carcinogens as mutagens: Bacterial tester strains with R Factor plasmids. *Proc. Natl. Acad. Sci*. USA 72: 979-983.

Mesbah, M. K.; Abd El-Hafiz, M.A. and El-Shanawany, M.A. (1984). Pharmacognostic study of Khaya senegalensis A. Juss growing in Egypt. 1: Botanical and chemical study of the leaf. *Bull. Pharm. Sci.,* Assuit Univ., 7: 207-223.

Mortelmans K, and Zeiger, E. (2000). The Ames Salmonella/microsome mutagenicity assay. *Mut. Res*. 455: 29-60.

Yousif, F; Hifnawy, M.S.; Soliman, G.; Boulos, L.; Labib, T.; Mahmoud, S; Ramzy, F.; Yousif, M; Hassan, I.; Mahmoud, K.; El-Hallouty, S.M.; El-Gendy, M.; Gohar, L.; El-Manawaty, M.; Fayyad, W. and El-Menshawi, B. S. (2007). Large-scale in vitro screening of Egyptian native and cultivated plants for schistosomicidal activity. *Pharmaceutical-Biology*. 45: 501-510.

Effects of Climate Change Critical Factors on the Seedling Growth and Development of Maize (*Zea mays L.*)

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ABSTRACT

Crop production is highly dependent on weather and change in climate has a major effect on crop yield, and thus on food supply. The effect of critical factors for climate change on growth and development of *Zea mays* was investigated. The parameters used were water, temperature, light intensity and soil (pH and nutrients). Growth factors such as height, leaf area, fresh and dry weights as well as dry and fresh weight ratio were determined. An average weight of 3kg of sandy, clay, loamy and laterite soils in black planting bags of 21 by 25cm were used. Single (SN) and double (DN) netted cages were constructed to reduce the amount of light absorbed by plants. The control was without net (WN) while another set without net_1 (WN_1) was subjected to drought (watered only once). Three replicates for each soil treatment were used, and the experiment lasted for 8 Weeks. The results revealed that seeds sown in clay and laterite soils for WN_1 germinated and died after three weeks because of the drought condition. Loamy soil for SN showed the highest mean height of 125cm ± 0.95. Also, loamy soil (WN) had the highest values of 214.49^2cm ± 0.35 and 92.90 ± 3.21 for leaf area and dry weight, respectively. Soil pH values for sandy and loamy soils were within the acceptable pH range of 6.5 – 8.5. Plants sown in loamy soil for SN, DN and WN flowered within the period of the experiment. The highest value of 1.80g weight for inflorescence was recorded for WN with loamy soil. For loamy soil, there was significant difference between all soil treatments (nutrient, temperature and light intensity) at $P<0.05$. Since salts (ions) absorption is through solution in the soil, water may be considered as the most critical factor for the growth and development of plants.

Keywords: Growth, light intensity, nutrients, soil pH, temperature, water and *Zea mays.*

INTRODUCTION

Crop production is highly dependent on weather and, therefore, change in global climate could have major effects on crop yields, and thus food supply. Temperature exerts a major effect on crop growth rate; plant development and growth can be retarded when the temperature is either too low or too high (Monteith, 2006). Important direct effects of climate on crops will be through changes in temperature, precipitation, length of growing season and timing of extreme or critical threshold events, relative to crop development (Saarikko and Carter, 1996). Climate change also will modify rainfall, evaporation, run-off and soil moisture storage. Temperature range that supports plant growth is generally from 4.5 – 36^{0}C, Optimum temperature for growth varies with the species and storage of development; and usually fluctuates between night and day. Several growth processes are sensitive to temperature. Among these are respiration, flowering, fruit ripening and dormancy (Noggle and Fritz, 1976).

Plants respond to light of wavelength from 300 to 800nm. Plants grown in the absence of light are said to be etiolated. Etiolated plants lack chlorophyll; they are tall and spindle-shaped with long internodes. They also have small leaves that have failed to expand (Hopkins, 2004). Light accelerated many phases of growth while inhibiting certain aspects of internodes elongation. Light can have an effect on the morphology of plants. Leaves of the same plant may differ depending on whether they are sun leaves or shade leaves. Sun leaves are often thicker with extra layers of palisade parenchyma and shorter petioles (Kerr *et al.,* 2005). Response of plant to light varies depending on the intensity, duration and wavelength of light it received. Light intensity refers to the concentration of light waves striking a leaf surface. Light plays a critical role in plant growth and development. The quantity, quality and direction of light are perceived by photosensory systems which collectively regulate plant development presumably to maintain photosynthetic efficiency (Hangarter, 1997).

Photo-oxidation damage, that is, light dependant generation of reactive oxygen species (ROS) in chloroplast, is a key process involved in cell damage and cell death in plants exposed to environment stress factors (Okunlola *et al*., 2012). The response of plants to stress conditions differs among development with cultivars, within species, and among stages of plant development with cultivar (Okunlola *et al.,* 2012). The response reflects differences in area of adaptation and in the biological mechanisms that have evolved for coping with adverse environmental conditions. Light indirectly affects the transpiration and photosynthesis by showing its influence on salt absorption.

Seeds require water, air (oxygen) and proper temperature range such that biochemical processes can operate. A seed is considered germinated when it has produced a plant that is potentially capable of continuous growth. Water is one of the raw materials required for photosynthesis and production of new compounds. A net loss of water will cause growth to stop and continued deficiency results to death (Noggle and Fritz, 1976). A growing plant absorbs water from the soil and gives it off in transpiration. Transpiration loss of water in exchange for carbon (IV) oxide is necessary for plant growth. However, water stress caused a reduction in height, leaf area, root biomass, whole plant biomass, leaf area ratio and relative growth rate of stress plants (Umebese *et al*., 2012).

Plant growth and development are influenced by physical, chemical and biological components in plants environment. Any factor that is less or more than optimum, i.e. deficient or in excess, will limit plant growth (Hopkins, 2004). Phosphorus uptake is influenced by temperature and a deficiency may be induced by cool nutrient solution temperature. The pH of soil can also affect the availability of nutrient to plants. One of the reasons behind giving importance to soil pH is that the occurrences of some of the diseases are dependent on the pH of the soil. Gardening with improper level of soil pH can result in poor yield of crops. The decrease in pH of soil solution accelerates the absorption of anions while the increase in pH favours the absorption of cations. The pH values across the physiological range may inhibit salt absorption (Verma and Verma, 2007).

Maize (*Zea mays*) belongs to the family *Poaceae* (grass family). It is widely grown because it is adapted to different ecological conditions and it is more extensively distributed over the earth than other cereal crops (Remison, 2005). It is mostly grown in regions with a temperature range of 21 – 30^{o}C. It is not suitable to humid sub-tropics climate. It does well in sandy, loamy soils rich in nutrients, especially nitrogen. The time of flowering is influenced by photoperiod and temperature. It is considered a short-day plant, when flowering is hastened and vegetative growth retarded by long night. Long days increase the leaf number, plant size and length of the growing period. *Zea mays* is grown in Nigeria, several zones from coastal swamps of the South to the dry savanna lands of the North (Remison, 2004).

Maize is a major grain crop grown worldwide. It is regarded as one of the world's major food crops feeding humanity since ages. It also serves a major ingredient for feeding animals in poultry, swine and cattle ranches. In addition to its use as human and animal food, is also a potential crop for ethanol. As industrial raw materials, corn starch, corn oil, corn syrup and corn sugar are the chief industrial products obtained from maize. Other uses include the use of stalks and leaves for making paper, paper board and wall board (Remison, 2005). The expanded use of maize in industry gives this crop a prominent place in agricultural economy. World production in 2009 was about 808 million mega grams. Brazil is a major producer with 53 million mega grams produced in 2010 (United States Department of Agriculture, 2010). Maize is the most important crop grown in South Africa, it accounts for about 70% of total human caloric intake (Byerlee and Eicher, 1997). Most maize production is fed by rain. In South Africa, irrigated land is less than 1% of the cultivated area (Chenje and Johnson, 1994). A strong dependence upon agriculture, high population growth rate and unstable economic condition compounds the sensitivity to extreme climate.

Nature provides a large portion of the environmental influence on maize growth and yields, however, the maize producer can manipulate the environment with managerial operations including hybrid selection, soil hullage, soil fertilization, irrigation, crop rotation and pest control to achieve his aims. The three most ecological important environmental factor affecting plant growth are temperature, water and light. Therefore, there is need to investigate the effect of these critical factors for climate change on the growth and development of plants generally and *Zea mays* in particular.

MATERIALS AND METHODS

The *Zea mays* seeds used for this study were purchased from Obiaruku Local Market, Obiaruku, Ukwani Local Government Area of Delta State, Nigeria. Before used, the seeds were soaked in water for ten minutes (10 minutes) to test for viability. Forty-eight black planting bags measuring 21 x 25cm were purchased from Lagos Street around King Square in Benin-City, Edo State. Cages (2) were constructed with height of 5ft and breath of 2ft. the first cage was constructed with a single mosquito net and a chicken net (Single net, SN) and the second cage was constructed with a double mosquito nets and chicken net (DN), they were constructed to reduce the amount of light and temperature available to the plants. The duration of the experiment was from the 4th of December, 2010 to 4th of February, 2011. Sandy, clay, loamy and laterite soils were used. The reason was to determine the effect of the different soil levels (in terms of nutrient status) on the growth of plant (*Zea mays*).

The experiment was set up at the Department of Botany, Delta State University, Abraka, Nigeria. The experiment was laid out in a split-split plot design with three replicates per soil. Between row spacing was 0.25cm. Three seeds were sown to a depth of 2cm per bag containing 3kg of the different soils. Four rows were also planted outside 3 replicates of each soil. The single double, without net (WN) experiment were watered once a day, while the without net$_1$ (WN_1) was watered only once (subjected to drought) throughout the experiment. The WN_1 was introduced to mimic a very dry environment. Rainfall was not recorded in Abraka, Delta State, South-South. Nigeria throughout the duration of the experiment. The experiment was terminated on the 14th January, 2011 (when the first rain for the year was experienced).

Elemental Soil analysis

One gram of soil sample from each of the treatment groups was placed in a teflon beaker followed by the addition of 9ml $HN0_3$ (60% v/v), 4ml of HF (40% v/v), 2ml of perchloric and (70% v/v) and 1ml of HCL (37% v/v). the digestion mixture was heated to 120^{o}C in regulated digestion block in the fume chamber. The completely mineralized sample was dissolved using 5ml of 1 $MNN0_3$ solution, and filtered with Whatman (No. 1) filter paper and diluted to 25ml mark with 1 $MHN0_3$. The solution was subsequently analysed for N, P and K using flame emission spectrophotometric method.

Physical analysis:

The pH values were measured using pH meter. The values for light intensity were measured using light meter. A simple thermometer was used to measure the temperature.

Plant Analysis:

Leaf area analysis was by Remison (1997). That is length x the widest width x 0.75. weighing balance and digital weighing balance were used for fresh and dry weight respectively. The plant was measured with the help of tape. While the ratio of fresh to dry weight was done by dividing the mean dry weight by the mean fresh weight.

Statistical analysis

The data were subjected to 2 – way ANOVA with replications using mean ± standard error, Two-way analysis of variance and comparison test (Bonferroni)

Results and Discussion

Effects of climate change critical factors on the seedling growth and development of maize (*Zea mays)* were investigated. At 36.35^{0}C ± 0.25 and light intensity of 499.75 x 100 Lux ± 28.20 (WN) the results in Table 1 show there was reduction in phosphorus and potassium levels of loamy soil with *Zea mays*. This shows that there was absorption of P and K. The absorption of one ion is influenced by the presence of other ions in the medium e.g. the absorption of potassium is found to be affected by the presence of calcium, magnesium and other cations in the external medium (Verma and Verma, 2007). At the same temperature and light intensity, clay soil with *Zea mays* showed increases in phosphorus and potassium levels after exposure. Sandy soil with *Zea mays* recorded reduction in phosphorus, while laterite soil with the plants showed uptake of K. Only clay soil recorded reduction in values for nitrogen ion at 36.35 ± 0.25 and 499.75 x 100 Lux ± 28.20 of temperature and light intensity, respectively.

At temperature of 33.50 ± 0.74 and light intensity of 149-95 x lux ± 95.44 (DN) there were increases in P of sandy, clay, loamy and laterite soils after exposure to plants, while there was uptake of N and K ions in the four soils with *Zea mays*. At 38.75^{0}C ± 0.21 and 499.23x 100 lux ± 35.80 (WN_1), the results showed reduction in the value of P for sandy, clay and loamy soil (Table 1). The pH values across the physiological range may inhibit salt absorption (Verma and Verma, 2007). Nitrogen uptake was recorded for clay and laterite soils, while clay soil recorded reduction in N value. Absorption of salt causes increases in temperature, but confined to very narrow range. At very high temperature, salt absorption is inhibited most probably due to denaturation of enzyme (proteins) involved (Verma and Verma, 2007). There are also claims that nitrogen controls the efficient utilization of phosphorus and potassium.

At temperature of 36.35^{0}C and light intensity of 499.75 x 100 lux ± 28.20, pH value of 7.02 and with the absorption of P and K, the highest dry weight value of 92.72 ± 3.20 was recorded for WN (loamy soil). Active cell division, elongation and developmental processes promote absorption of salt (Verma and Verma, 2007). Laterite and clay soil for WN_1 (subjected to drought) had no growth. When plants are exposed to increasing stress, they tend to have a reduced total dry matter and leaf number (Crossely *et al.,* 2002). Water is one of the raw materials required for photosynthesis and the production of new compounds, a net loss of water will cause growth to stop and continued deficiency will result to death (Noggle and Fritz, 2003). During environmental stress such as drought, reactive oxygen species (ROS) which include oxygen, ions, free radicals and peroxides increase dramatically, resulting in oxidative damage to protein and lipid (Appel and Hert, 2004). The different treatments for loamy soil show significant difference between all other soil treatments (nutrient, temperature and light intensity) at $P<0.05$.

Loamy soil with SN (35.40^{0}C ± 0.42 and 214.91 x 100 lux 175.07) recorded the highest values for leaf area and height of plants (214.99 ± 0.35 and 125.00 ± 9.03cm, respectively), while dry and fresh wt were recorded for loamy soil with WN. The lowest values for leaf area, fresh weight, dry weight and plant height were recorded for WN_1 (clay and laterite) soils. This shows that water or precipitation, and nutrient are very critical for the growth and development of plants. It also shows that pH values of loamy soil before and after were within the optimum pH. Soils with improper level of pH can result in poor yield of crop of plants.

It was also revealed that temperature between 33.50 and 36.35^{o}C, in loamy soil with SN and DN flowered within the period of the experiment (8 weeks). Without net (WN) had the highest fresh weight of 1.80g at the end of the exposure. This supports the report of Noggle and Fritz, 1976 that several growth processes like flowering, respiration, fruit ripening and dormancy are sensitive to temperature. Also, Remison, 2005 reported that photoperiod and temperature influence flowering.

Generally, the absence of water inhibits the absorption of nutrients by plants. For most part of the year when there is no precipitation or water the nutrients adhere to and accumulate in the soil till when water is available. This may account for the high protein in annual grasses that grow in the fertile soil of the Sahel most part of the year. When nutrients are lacking the yield of crops may become affected. Climate change modifies soil moisture by creating environmental stress such as drought and flooding. When this happens salt (ions) absorption by plants will be affected. Since salts (ions) absorption is through soil solution, water may be considered as the most critical factor for the growth and development of plants.

	P				N				K			
	Sandy	Clay	Loamy	Laterite	Sandy	Clay	Loamy	Laterite	Sandy	Clay	Loamy	Laterite
Before Exposure (Control)	20.25 ± 0.96	18.43 ± 0.38	18.89± 0.47	18.74± 0.40	0.15± 0.03	0.37± 0.07	0.22± 0.06	0.20± 0.04	0.75± 0.23	0.94± 0.26	1.22± 0.06	1.00±0.00
(SN)	19.22± 0.88	19.42± 0.67	18.68± 0.35	19.42± 0.68	0.15± 0.03	0.24± 0.03	0.16± 0.04	0.10± 0.03	1.11± 0.00	1.23± 0.06	1.20± 0.06	0.81±0.23
(DN)	20.55± 0.28	20.74± 0.54	20.37± 0.28	19.79± 0.28	0.28± 0.09	0.23± 0.01	0.10± 9.81	0.14± 0.04	0.70± 0.15	0.86± 0.24	1.15± 0.03	1.00±0.05
WN	19.72± 0.26	20.25± 0.96	18.55± 3.77	18.31± 0.51	0.30± 0.30	0.32± 0.06	0.41± 0.21	0.25± 0.03	1.17± 0.06	1.21± 0.06	1.06± 0.03	0.77±0.25
WN_1	18.95± 0.18	18.31± 0.58	18.46± 2.14	18.86± 0.25	0.21± 0.06	0.26± 0.04	0.27± 0.09	0.17± 0.03	1.16± 0.66	0.78± 0.33	1.32± 0.01	1.11±0.01

Table 1: Macronutrients (NPK) of soil

Table II: Average light and temperature at 8 weeks

	Temp ^oC	Light (lux)
SN	35.49 ± 0.42	214.94 x 100 ± 175.07
DN	33.50 ± 0.74	149.95 x 100 ± 95.44
WN	36.35 ± 0.28	499.75 x 100 ± 28.20
WN_1	38.75 ± 0.21	499.23 x 100 ± 351.8

Table III: Mean fresh $wt_{(g)}$ of plants at week 8

	Sandy	Clay	Loamy	Laterite
SN	14.20±1.95	1.55±0.12	374.86±4.02	5.90±2.67
DN	6.90±3.40	2.50±0.30	129.29±13.56	5.40±2.47
WN	8.00±2.08	4.40±0.85	396.60±5.77	4.86±1.69
WN1	1.30±0.1	0.00±0.00	91.60±2.37	0.00±0.00

Table IV: Mean dry $wt_{(g)}$ of the plant at week 8

	Sandy	Clay	Loamy	Laterite
SN	3.40±0.35	0.40±0.06	63.00±7.84	2.20±0.19
DN	3.20±0.67	0.80±0.50	31.40±6.53	1.60±0.82
WN	3.30±0.61	2.50±0.47	92.70±3.20	3.00±0.36
WN_1	0.30±0.12	0.00±0.00	22.40±1.52	0.00±0.00

Table V: Mean height (cm) of maize seedings at week 8

	Sandy	Clay	Loamy	Laterite
SN	49.00±32.19	28.67±2.91	125.00±9.03	40.40±9.84
DN	56.33±9.01	34.70±10.06	116.43±26.76	45.40±12.65
WN	40.10±5.77	29.47±2.39	106.10±6.98	55.70±15.70
WN_1	23.40±3.30	0.00±0.00	78.17±7.57	0.00±0.00

Table VI: Ratio of fresh wt to dry wt$_{(g)}$

	Sandy	Clay	Loamy	Laterite
SN	4.18±0.05	3.88±0.06	5.92±7.84	2.68±0.19
DN	2.16±0.67	3.13±0.50	4.17±6.53	3.38±0.82
WN	2.42±0.61	1.76±0.47	4.28±3.21	1.62±0.75
WN1	4.33±0.12	0.00±0.00	4.09±1.52	0.00±0.00

Table VII: Mean pH values of the soil

	Sandy	Clay	Loamy	Laterite
Before exposure	6.21±0.41	5.54±3.84	7.30±3.00	5.70±3.65
SN	6.53±3.86	4.69±3.18	6.84±3.07	3.10±0.52
DN	6.98±3.33	3.92±3.17	6.83±3.31	4.33±3.05
WN	6.72±3.30	4.53±3.35	7.02±3.00	4.14±2.98
WN_1	6.81±3.35	5.20±3.00	8.06±3.48	5.88±3.32

Table VIII: Mean leaf area at week 8

	Sandy	Clay	Loamy	Laterite
SN	43.17±0.03	12.42±0.02	214.49±0.35	22.06±0.25
DN	52.19±0.18	18.43±0.36	183.31±6.81	26.11±7.15
WN	34.99±4.02	14.32±0.91	171.87±3.42	22.93±1.28
WN_1	4.89 ±	0.00±0.00	106.80±0.06	0.00±0.00

REFERENCES

Adejare, F.B and Umebese, C.E. (2008). Water stress induces cultivar dependent changes in samatal complex, yield and osmotic adjustment in *Glycine max* L. *International Journal of Agricultural Research. 3*: 287-295.

Apel, K. and Hart, H. (2004). Reactive oxygen Species: Annual review of Plant Biology. *55*:373-399

Byerlee, D. and Eicher, C.K. (1997). Africa's emerging maize revolution. Lynne Rienner Publishers, 301p

Chenge, M. and Johnson, D. (1994). State of the environment in Southern Africa. Southern. *African Research and Documentation Centre*. Vol. 322p

Crossley, M.N., Dennison, W.C., Williams, R.R. and Wearing, A.H. (2002). The interaction of water flow and nutrients on aquatic plant growth. *Hydrobiology. 489*: 6370

Food and Agricultural Organization of the United nations (FAO), (2001). Towards 2015/2030 summary report.

Hangeter, (1997). Gravity, light and plant farms.*Plant, Cell and Environment. 20*: 796 – 800

Hopkins, W.G. and Hunner, N.P.L (2004). Introduction to plant physiology. 4th edition. John Wiley and Sons Incorporation. London. Pp 25-29

IPCC (2008). Second assessment report of climate change. In: Houghton, J.I. Maris Fillo, l.G., Callender, B.A.., Kattenburg, N., Maskell,K. (ends). The science of Climate Change. Cambridge University Press. U.K.

Monteith, J.L. (2006). Climate variation and growth of crops. Q.J.R. *Meteorol. Soc. 107*:749 – 774

Noggle, G.R. and Fritz, G.J. (1976). Introductory plants physiology. Prentice Hall, Inc. New Jersey.

Okunlola G.O. and Adelusi, A.A., (2012). Effects of nutrient and light stress on the morphological parameter of tomato (*licopersicum esculentus mill*). *Ife Journal of science*.Remison, S.U. (2005). Arable and vegetative crops of the tropics. Gift prints Associates, Benin-City, Nigeria. Pp 4-18.

Remison, S.U. (2004). Agriculture as the way. Ambik Press. Benin-City, Nigeria. 73p

Saarikko, R.A. and Carter, T.R. (1996). Estimating regional spring wheat development and suitability in Finland under climate warming. *Clim. Res. 7*:243-252.

United States Department of Agriculture (2010). Foreign Agricultural Service. Production, supply and distribution online. Custom query. Available and accessed 17 May, 2010.

Umebese, C.E., Okunade, K.I. and Orotope, o.M. (2012). Impact of water deficient stress on growth and alkaloid content of organs of *spigelia anthemia* (L). *IF Journal of Science. 14*:357-362.

Verma, S.K. and Verma, M. (2007). A textbook of plant physiology, biochemistry and Biotechnology. Sixth edition, s. Chand and Company Ltd. New Delhi. Pp 118-123.

Evaluation of the Impact of Climate Change and Mitigating Factors for Enhanced Food Security in Nigeria

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ABSTRACT

Climate change is indeed the biggest environmental issues of our time. It is the drastic alteration in the natural components of the atmospheric environment with the resultant adverse responses as shift in weather variations involving overall and unprecedented changes in weather patterns, which may include unusual challenges in rainfall or precipitation and temperature. Although it is global in its cause, its consequences are far more reaching in developing countries like Nigeria. This paper highlights the determining factors of its effect to man and the environment to include average temperature and precipitation caused primarily by the way air circulates over the earth's surface. Factors determining global air circulation; how ocean current and chemical makeup of the atmosphere affect climates as well as factors affecting changes in the earth's average temperature would be discussed. The impact of climate change in agriculture; hence on food security is multi-various and include shift in food-growing areas, life stock insecurity, variation or change in crop yield, increased irrigation demands, increased pests, crop diseases and weeds in warmer areas, disruption of aquatic life, which indeed is evident in Global Hunger index of the country. Possible mitigating factors for sustainable food security are reduction in climate change by human activities, removal or sequestering of enough CO_2 to slow global warming, reduction in green house gas emission, preparation for possible long term effect of climate change, knowledge through education and creation of awareness.

Key words: climate change, weather pattern, impact, agriculture, food security, global hunger index, mitigating factors, Nigeria

INTRODUCTION

Climate change is one of the most serious environmental threats facing mankind worldwide. It is actually a global issue, which has become a major concern to governments and the public at large because of its general effects on all facets of human life, including, particularly, the agricultural sector of the economy It affects agriculture in several ways, including its direct impact on food production.

Climate change, which is attributable to the natural climate cycle and human activities, has adversely affected agricultural productivity in Africa [1]. Available evidence shows that climate change is global, likewise its impacts; but the most adverse effects is felt mainly by developing countries, especially those in Africa, due to their low level of coping capabilities [2,3]. Nigeria is one of these developing countries and rainfall is by far the most important element of climate change [4] and water resources potential in the country [5]. The northeast region of Nigeria is increasingly becoming an arid environment at a very fast rate per year occasioned by fast reduction in the amount of surface water, flora and fauna resources on land [6]. Consistent reduction in rainfall leads to a reduction in the natural regeneration rate of land resources [7]. This makes people to exploit more previously undisturbed lands leading to depletion of the forest cover and increase on sand dunes/Aeolian deposits in the northern axis of Nigeria. As the planet warms, rainfall patterns shift, and extreme events such as droughts, floods, and forest fires become more frequent [8,9], which results in poor and unpredictable yields, thereby making farmers more vulnerable, particularly in Africa [10]. Farmers (who constitute the bulk of the poor in Africa), face prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases [8,9]. Prediction has it that crop yield in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change [11], particularly because African agriculture is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather. As the people of Africa strive to overcome poverty and advance economic growth, this phenomenon threatens to deepen vulnerabilities, erode hard-won gains and seriously undermine prospects for development [8]. There is therefore the need for concerted efforts toward tackling this menace. Wisner *et al* ., [12] however, reports that the vulnerability of agriculture is not determined by the nature and magnitude of environmental stress like climate change per se, but by the combination of the societal capacity to cope with and/or recover from environmental change. While the coping capacity and degree of exposure is related to environmental changes, they are both also related to changes in societal aspects such as land use and cultural practices.

The threat that climate changes pose to agricultural production does not only cover the area of crop husbandry but also includes livestock and in fact the total agricultural sector. African farmers also depend on livestock for income, food and animal products. Climate can affect the livestock both directly and indirectly [13,14,15]. Direct effects of climate variables such as air, temperature, humidity, wind speed and other climate factors influence animal performance such as growth, milk production, wool production and reproduction. Climate can also affect the quantity and quality of feed stuffs such as pasture, forage, and grain and also the severity and distribution of livestock diseases and parasite [16]. Hence the totality of agricultural sector is considered by examining agricultural productivity.

Actually, Nigeria has the ambition of diversifying her economy from crude petroleum to agricultural dependency because the country faces a looming food security crisis with a growing population that is increasingly dependent on imported foods. The once dominant subsistence-oriented farm economy is at risk of gradual marginalization. Insecure land tenure, scarcity of funds and credit, labour scarcity despite overall high unemployment and stagnant technology have crippled its further development. Until today, a wide range of policies, programmes and projects have had limited impact in ameliorating these problems. Climate change however, compounds the challenges confronting agriculture. The sector is dependent on the natural resource base and thus faces risks such as desertification, rising temperatures, changing rainfall patterns and sea level rise, leading to degrading agriculture and exacerbating conflict. Climate change thus affects food and water resources that are critical for livelihood in Africa where much of the population especially the poor, rely on local supply system that are sensitive to climate variation. Disruptions of existing food and water systems will have devastating implications for development and livelihood. These are expected to add to the challenges climate change already poses for poverty [17, 18], the sustainability of the environment to provide all life support systems and the materials for fulfilling all developmental aspirations of man and animal is dependent on the suitability of the climate which is undergoing constant changes. The effect of these changes is posing threat to food security in Nigeria. This paper therefore evaluates the climate change effects on agriculture in Nigeria hence to food security because climate change presents a heightened risk, new combinations of risks and potentially grave consequences, in the country due to its direct dependence on rain-fed agriculture. Possible mitigating factors were consequently elucidated as well.

Determining Factors of Climate Change

Average temperature and precipitation are the two main factors according to Miller, [19] that determines a region's climate and its effect on man and its environment. The temperature and precipitation patterns resulting to different climates are primarily caused by the way air circulates over the earth's surface. This global air circulation pattern are however, determined by uneven heating of the earth's surface since air is heated much more at the equator where the rays of the sun strikes directly throughout the year unlike what happens at the poles where it strikes at an angle. It is also determined by long term variation in the amount of solar energy due to both occasional changes in solar output and planetary shifts in which the earth's axis wobbles; hence , seasonal changes in temperature and precipitation results. Rotation of the earth on its axis which disrupt the general flow of air mass through and fro equator and the poles, as well as the air and water properties as evaporation of water by heat from the sun thereby transferring heat from the ocean to the atmosphere; the resulting convection of which air, heat and moisture circulates in the troposphere, all leads to different climate patterns of vegetation in various regions of the earth [20].

Chemical makeup of climate do also affect climate. Indeed, small amounts of certain gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), (Fig 1) and water vapour (H_2O) among others, play a key role in determining the earth's temperature hence, its climate. These gases which are the green house gases, act like a glass plane which permits mostly visible light and some infrared and ultraviolet radiation to pass through the troposphere [19]. Much of this solar energy is absorbed by the earth's surface, consequently transforming it to longer wavelength radiation which then rises into the troposphere. Though some of this heat escapes into space, some are yet absorbed by the green house gaseous molecules, emitted at a longer wavelength into the troposphere which warms the air. The amount of heat in the troposphere therefore depends primarily on the concentration of greenhouse gases and the length of time they stay in the atmosphere. However, the two green house gases with the largest concentration in the atmosphere are water vapour, controlled by the hydrologic cycle and CO_2 controlled by the carbon cycle [4]. Although CO_2 has the highest contribution to greenhouse gases, its potency is far lower. For instance, a gram of CH_4 is about 23 times higher than the effects of the same volume of CO_2 and a gram of sulphuric hexafluoride (SF6) released into the atmosphere is about 22,000 times that of CO_2 with respect to tropospheric zone depletion. The life time of CO_2 in the atmosphere varies, but obviously less than ten years, while that of CH_4, N_2O, CFCs and SF6 are 12.2, 120, 50-1700 and 3200 years respectively [21, 22]. While a molecule of CO_2 could cause damage to stratospheric ozone just for a few years, other greenhouse gases could cause ozone layer damage for between decades to thousands of years. Although the potency of CO_2 released into the atmosphere which increase input is through human activities may be significantly lower than many other greenhouse gases, the much greater volume of its emissions still makes it the most important influence in humans' enhancement of the natural greenhouse effect due in part to its formation of secondary air pollutant [20].

Natural and human influenced factors that may amplify or dampen changes in the earth's average surface temperature are multi-various. These factors as reported by Miller [19] include change in solar output which affects the projections of climate models, changes in earth's reflectivity during glacial periods which increases when polar ice caps expands and decreases on exposure of less reflective land and ocean surfaces when they melt; change in average sea level, ocean currents, cloud cover and the ability of the ocean to help moderate the earth's average surface temperature through CO_2 and heat storage as well as change in air pollution, photosynthesis, methane emission and storage of carbon in the soil.

IMPACT OF CLIMATE CHANGE ON MAN AND THE ENVIRONMENT IN NIGERIA

Obviously, climate change has enormous potential impact on food security and health. The Intergovernmental Panel on Climate Change (IPCC) [24] report predicted that by 2020 between 75 and 250 million people in Africa will be exposed to increased water stress caused by climate change, hence agricultural production and access to food in many African countries may be further threatened.

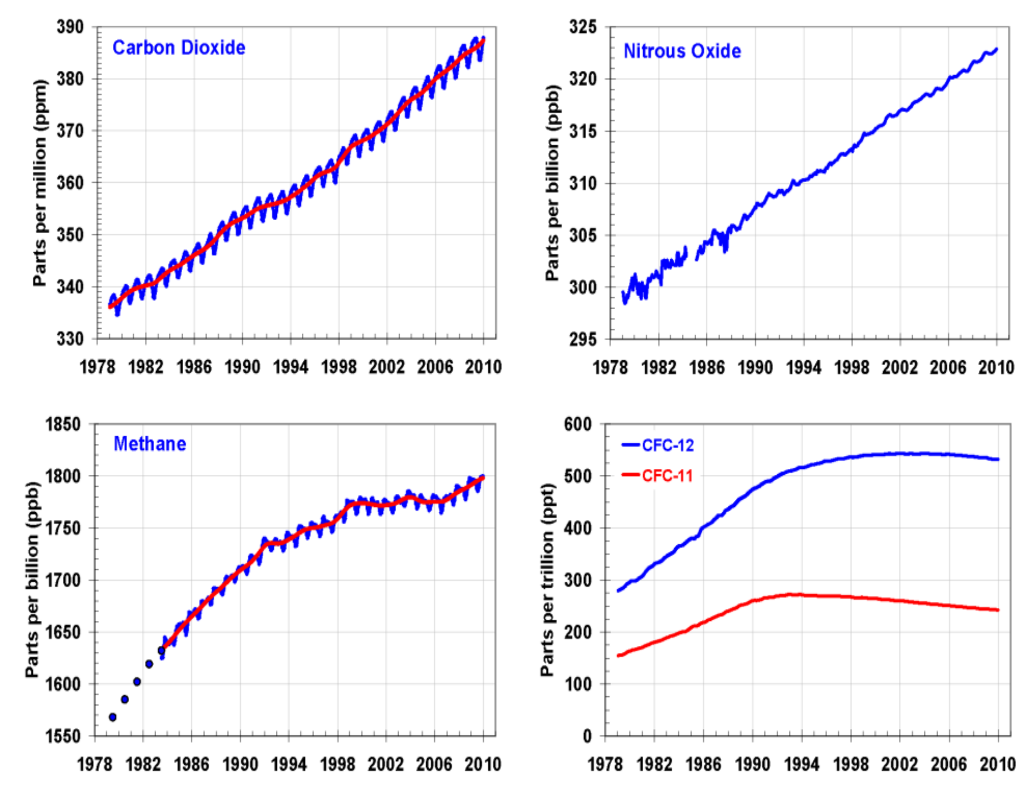

Fig 1: Major greenhouse trend [23]

of which Nigeria is among. This will adversely affect food security, aggravate malnutrition and increase diseases on the continent. Within Africa, Nigeria is particularly vulnerable to climate change. This is because agriculture in Nigeria is predominantly in the hands of rural smallholder farmers, who have been generally described as poor and hungry and most agricultural practices in Nigeria rely on rainfall and over 70% of the country's population relies directly or indirectly on rain-fed agriculture [25, 26]. Further, there are traditional farming practices that the typical Nigerian farmer is accustomed to, which he/she may find difficult to modify or change, even though these may pose serious challenges to climate change adaptation. Hence, any change in climate in the country would have a great impact on both the agriculture and economy of the nation. Moreover, since the discovery of oil in Nigeria, the attention of the government has been diverted away from agriculture to petroleum resource development. Nigerians therefore are highly vulnerable to diseases related to the warm and moist climate and occurrence of extreme climatic events. Epidemics of malaria and meningitis are common in Nigeria. As these diseases thrive better in warmer climates, any increase in temperature in the country will likely aggravate the epidemics. These specific effects of climate on agriculture and health are related to variability in the local climate rather than in the global climate patterns. This reinforces this importance of assessing the impacts of climate change for each local area or ecological zone in the country.

In Nigeria, climate change has already begun to, alter the dynamics of drought, rainfall and heat waves, and trigger secondary stresses such as the spread of pests, increased competition for resources, and attendant biodiversity losses. Nigeria's food security challenges will grow with its population. At current food production growth rates, Nigeria remains unable to feed its population. Predicting the impact of climate change on complex biophysical and socio-economic systems that constitute agricultural sectors is difficult. Warmer climates and changes in precipitation has destabilize agricultural production especially in the of case 2012 flooding. Many Northern, Eastern and South-South States of Nigeria, witnessed intensive down-pour with excess yield volume resulting in the flooding. Most parts of the listed states even remained submerged by floods. For instance, as in most affected states, Kogi State has nine (9) of its 21 local governments completely submerged with as many as 623,690 residents sacked from their homes and evacuated [27]. According to the State's Environmental Management Agency (SEMA), property estimated at over N2 billion had been lost to the flood while a total of about 344 communities were completely submerged [27]. In Adamawa, Taraba, Benue and Niger States, only protruding roofs inside flooded areas provided signs of existing communities. More than 13,000 people were displaced in 30 communities in Taraba State. Persistent rainfalls coupled with the over-flowing of Rivers Benue and Niger contributed to the flooding in Niger and Kogi States [28]. Imo and Edo States were badly affected. At least 20 communities with more than 10,000 people were rendered homeless. The same situation was also evident in River state. Flooding has submerged and devastated over 100 communities with over 12,000 people displaced in the state and casualties was recorded for at least 148 people were dead, according to the Red Cross [28, 29]. In Delta State, 20 of its 25 local government areas were affected with nearly 1000 communities, with over 25,000 people displaced [30]. The flood emergencies have equally affected the economic life of the concerned states and the nation at large. An important area in this regard is the transportation system. Roads have been washed away while airport tarmacs have been submerged thereby making landing difficult for aircrafts. Bridges were also washed away. The very busy Abuja-Lokoja road, which links North and South Nigeria, was completely submerged by water for days with motorists and passengers becoming stranded. Also the East-West road was sacked to motorists and commuters.

A much more critical area however is the concern for agricultural production and food security. Large expanse of farmlands have been devastated by flooding while livestock have been washed away. In Kogi State, the floods affected at least 5,775 farmers [30]. Actually, the nine local governments ravaged by flood are the "food baskets", the major rice producers of the state. About 200,000 hectares of rice farms and other crops in 41 wards of the state were washed away. In many other states where flood has caused havoc, farmers were net losers as a result of crop failures. Aside from the consequent effect of loss of revenue to the affected farmers, the contributions to Nigeria's GDP will be affected. In the second Quarter (Q2) of 2012, which was before the heavy downpour reached its peak and before the devastating effects of the floods, the National Bureau of Statistics (NBS) revealed that agriculture contributed 41% to the GDP with a monetary value of N2.931 billion [31]. With the agricultural sector adversely affected by the floods, it would be difficult to record the same positive feat in the remaining two quarters of the year, with the implication that less income would accrue to the country.

Evidence from literature and past studies has revealed that the recent global warming has influenced agricultural productivity leading to declining food production [32, 33, 34]. In order to meet the increasing food and non-food needs due to population increase, man now rapidly deplete fertile soils, fossil groundwater, biodiversity and numerous other non-renewable resources to meet his needs [35]. This resource depletion was linked with other human pressures on the environment. Possibly the most serious of human impacts as stated earlier as enhancing factor of climate change is the injection of greenhouse gases into the atmosphere. The reality of the impact of climate change on agricultural development has started showing signs [36, 37]. A substantial body of research has documented these wide-ranging effects on many facets of human societies [38, 39]. Rough estimates suggest that over the next 50 years or so, climate change may likely have a serious threat to meeting global food needs than other constraints on agricultural systems [24, 40]. Specifically, population, income, and economic growth could all affect the severity of climate change impacts in terms of food security, hunger, and nutritional adequacy thus worsening hunger and malnutrition problems particularly in developing countries like Nigeria which is evident in global hunger index (GHI) [41] for the country (Table 1).

Table 1: Global Hunger Index per country and year

Rank	Country	1990	1996	2001	2012
1	Burundi	31.6	35.9	38.0	37.1
2	Eritrea	—	37.8	37.8	34.4
3	Haiti	33.9	32.2	25.8	30.8
4	Ethiopia	42.2	38.6	34.5	28.7
5	Chad	39.3	35.6	30.4	28.3
6	East Timor	—	—	26.1	27.3
7	Central African Republic	27.4	28.4	27.4	27.3
8	Comoros	22.2	26.9	29.7	25.8
9	Sierra Leone	32.7	30.1	30.1	24.7
10	Yemen	29.0	27.6	27.9	24.3
11	Angola	41.9	39.9	33.0	24.1
12	Bangladesh	37.9	36.1	27.8	24.0
13	Zambia	24.8	25.0	27.2	23.3
14	Mozambique	35.5	30.7	28.8	23.3
15	India	30.3	22.6	24.2	22.9
16	Madagascar	24.1	23.8	24.9	22.5
17	Niger	36.4	35.9	30.5	22.3
18	Djibouti	30.8	25.7	25.3	21.7
19	Sudan	28.7	24.5	25.9	21.5
20	Nepal	26.9	24.4	23.0	20.3

21	Rwanda	28.2	32.7	25.6	19.7
22	Pakistan	25.5	21.8	21.7	19.7
23	Laos	28.6	25.2	23.6	19.7
24	Cambodia	31.8	31.5	26.0	19.6
25	Tanzania	23.2	28.0	25.9	19.3
26	Kenya	20.7	20.8	20.4	19.3
27	Togo	26.4	22.0	23.3	19.0
28	North Korea	15.7	20.1	20.1	19.0
29	Liberia	22.7	25.2	25.0	18.9
30	Guinea-Bissau	20.7	20.8	21.4	18.4
31	Ivory Coast	16.5	17.8	16.6	18.2
32	Cameroon	21.6	22.2	19.0	17.4
33	Zimbabwe	18.6	22.3	21.3	17.3
34	Burkina Faso	23.5	22.4	21.8	17.2
35	Malawi	29.9	27.5	22.5	16.7
36	Guinea	22.4	20.0	21.6	16.6
37	Mali	27.8	26.3	23.0	16.2
38	Uganda	18.7	20.3	17.3	16.1
39	Tadschikistan	—	24.1	24.6	15.8
40	Nigeria	24.1	20.9	18.2	15.7
41	Gambia	16.2	20.1	16.3	15.6
42	Benin	21.3	20.1	16.8	14.6
43	Sri Lanka	20.8	18.4	15.2	14.4
44	Senegal	18.3	19.6	19.2	13.7
45	Botswana	13.4	15.4	15.7	13.7
46	Namibia	20.3	19.1	16.3	13.2
47	Guatemala	15.2	15.8	15.1	12.7
48	Bolivia	16.9	14.3	12.3	12.3
49	Philippines	19.9	17.6	14.2	12.2
50	Indonesia	18.5	15.4	14.2	12.0
51	Lesotho	12.6	13.6	13.9	11.9
52	Mongolia	16.5	17.5	14.8	11.7
53	Republic of the Congo	23.6	24.1	15.7	11.4
54	Vietnam	25.6	21.4	15.5	11.2
55	Mauritania	22.6	16.7	16.6	11.1
56	Swaziland	9.3	12.6	12.9	10.9
57	Dominican Republic	14.2	11.8	10.9	10.0

Legend: Countries with extremely alarming (GHI ≥ 30), alarming (GHI between 20.0 and 29.9) or serious (GHI between 10.0 and 19.9) hunger situation The Global Hunger Index is composed of the proportion of the undernourished as a percentage of the population, the prevalence of underweight children under the age of five and the mortality rate of children under the age of five (calculated average, in percentages) [41].

Generally, IPCC's Fourth Assessment Report summary for Africa however, describes the trend of global warming at a rate faster than the global average, and increasing aridity in many countries. climate change exerts multiple stresses on the biophysical as well as the social and institutional environments that underpin agricultural production [24]. That is, socio-economic factors, international competition, technological development as well as policy choices will determine the pattern and impact that agro-climatic changes will have on agriculture [42]. Khanal [43] classified the patterns of impact of climate change on agriculture into biophysical and socio-economic impact. The biophysical impacts include; physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise and changes to ocean salinity and sea temperature rise causing fish to inhabit in different ranges. The socio-economic impacts result in decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, changes in geographical distribution of trade regime, increased number of people at risk of hunger and food insecurity, migration and civil unrest [44]. According to Khanal [43], the patterns of the effects of climatic change are however dependent on latitude, altitude, type of crop grown and livestock reared. Some of the induced changes are expected to be abrupt, while others involve gradual shifts in temperature, vegetation cover and species distributions. However, when looking critically on plant production, the pattern of climate change has both positive and negative impacts. Rises in temperature for example helps to grow crops in high altitude areas and towards the poles. In these areas, increases in temperature extend the length of the potential growing season, allowing earlier planting, early harvesting and opening the possibility of completing two crop cycles in the same season [43]. The warmer conditions support the process of natural decomposition of organic matter and contribute to the nutrient uptake mechanisms. The process of nitrogen fixation, associated with greater root development is also predicted to increase in warmer conditions and with higher CO_2, if soil moisture is not limiting [45]. The increased CO_2 levels lead to a positive growth response for a number of staples under controlled conditions also known as the carbon fertilizations effect [46]. But when temperatures exceed the optimal level for biological processes, crops often respond negatively with a steep drop in net growth and yield. Khanal [43] stated that heat stress might affect the whole physiological development, maturation and finally reduces the yield of cultivated crop.

The developing world already contends with chronic poverty and food crisis. The estimate for Africa is that 25-42% of species habitat could be lost, affecting both food and non-food crops [43]. Habitat change is already underway in some areas, leading to species range shifts and changes in plant biodiversity which include indigenous foods and plant-based medicines. FAO [45] reported that up to 11% of arable land could be highly affected by climate change in the developing world. There will be a reduction of cereal production in 65 countries and retardation of about 16% of agricultural GDP. A decrease of up to 30% in world food production due to effects of climate change on agriculture is generally predicted [24].

A Nigerian study applied the Erosion Productivity Impact Calculator (EPIC) crop model to give projections of crop yield during the 21st century. The study modeled worst case climate change scenarios for maize, sorghum, rice, millet and cassava [47]. The indications from the projections are that, in general, there will be increases in crop yield across all low land ecological zones as the climate changes during the early parts of the 21st century. However, towards the end of the century, the rate of increase will tend to slow down. This could result in lower yields in the last quarter than in the third quarter of the century. The decreases in yield could be explained in terms of the very high temperatures which lie beyond the range of tolerance for the current crop varieties and cultivars. Other potential impacts linked to agriculture include erosion that could be exacerbated by expected increased intensity of rainfall and the crop growth period that is expected to be reduced in some areas [48]. Changes are also expected in the onset of the rainy season and the variability of dry spells. This projections are all evident now in the context of the 2012 scenario mentioned above.

MITIGATING FACTORS OF CLIMATE CHANGE FOR ENHANCED FOOD SECURITY

Recently, international tensions and concerns are heightening over what the impact of climate will have on the environment and agricultural produce [35, 39, 40, 49]. Also, how agricultural and food-distribution systems will be further stressed up by the shifting of temperatures and precipitating belts, especially if changes are rapid and not planned for [49]. Indeed, agriculture is important for food security in two ways: it produces the food people eat; and (perhaps even more important) it provides the primary source of livelihood for 36 percent of the world's total workforce [50]. If agricultural production in the low-income developing countries of Asia and Africa is adversely affected by climate change, the livelihoods of large numbers of the rural poor will be put at risk and their vulnerability to food insecurity increased. The crucial issue in this study is whether agricultural output supply can keep pace with population increase under this climate variability. This will depend; both on the scope for raising agricultural productivity (including reducing waste during distribution), availability of inputs used in the agricultural sector (land, labour, machinery, water resources, fertilizers, etc.) and having sufficient information on climatic variables for possible effective adaptation and mitigation strategies. According to data released by IPCC [24], clearing of forested area for agriculture accounted for 17.4 percent of total greenhouse gas emissions in 2000, with emissions from intensive crop and livestock production contributing another 13.5 percent By contrast, studies carried out by the World Resources Institute (WRI) indicate that energy sector emissions attributable to agricultural and food processing use of fossil fuel account for only 2.4 percent of greenhouse gas emissions [51]. The share of total transportation emissions attributable to food system activities is not identified, but as total emissions for all forms of transport for all purposes came to just 13.1 percent, the part attributable to transport of food commodities and products is likely to be low.

Mitigation of climate change involves actions to reduce greenhouse gas emissions and sequester or store carbon in the short term, and development choices that will lead to low emissions in the longterm. In the long term, mitigating climate change as highlighted by FAO, [50] will be critical to avoid future breakdowns in food and livelihood systems and sharp increases in the number of food-insecure people worldwide. Previous reports have shown that land conversion from forest to pasture- or cropland, and intensive crop and livestock production practices have been important sources of greenhouse gas emissions. However, food systems also have enormous potential to mitigate climate change, particularly at the production end of the food chain. Moreover, many of the most effective mitigation measures also represent highly effective adaptation strategies, especially for commercial agriculture [50]. Furthermore, there are factors that enhances reduction in threat of climate change in the food and agriculture sector which could have multiple payoffs for food security, including contributing to the stability of global food markets and providing new employment opportunities in the commercial agriculture sector, as well as enhancing the sustainability of vulnerable livelihood systems. Such factors include:

a) *reducing emissions of CO_2*, such as through reduction in the rate of land conversion and deforestation increase in aforestation, better control of wildfires, adoption of alternatives to the burning of crop residues after harvest, reduction of emissions from commercial fishing operations, and more efficient energy use by forest dwellers, commercial agriculture and agro-industries, non-till cultivation practices,
b)*reducing emissions of methane and nitrous oxide,* such as through improved nutrition for ruminant livestock, more efficient management of livestock waste and of irrigation water on rice paddies, more efficient applications of nitrogen fertilizer on cultivated fields, and reclamation of treated municipal wastewater for aquifer recharge and irrigation;
c) *sequestering carbon*, such as through improved management of soil organic matter, with conservation agriculture involving permanent organic soil cover, minimum mechanical soil disturbance and crop rotation (which also reduces fossil fuel usage); improved management of pastures and grazing practices on natural grasslands by optimizing stock numbers and rotational grazing; introduction of integrated agroforestry systems that combine crops, grazing lands and trees in
ecologically sustainable ways, use of degraded, marginal lands for productive planted forests or other cellulose biomass for alternative fuels; and carbon sink tree plantings, collection of CO_2 from smokestacks and natural gas wells and pumping it deep underground into unminable coal seams and abandoned oil fields or injection into deep ocean.

Furthermore, other mitigating factor do exist which involves the concept of the “carbon footprint” (which is the total amount of carbon emitted to arrive at a final product/Carbon Trust [50]. This is undertaken through carbon investigation of supply chains. In other words, all businesses can minimize the carbon emitted at every stage of a product's life cycle, from source to shelf, consumption and disposal. Nevertheless, as already described, the carbon footprint of food processing and transport is negligible compared with the emissions generated by production processes in the food system. And even though there are opportunities for reducing the carbon footprint of food at all stages of the food chain, the focus of mitigation efforts in the food system should be on introducing agricultural production practices that reduce emissions or increase carbon sequestration.

International Solid Waste Association [52] declaration on climate change also stated that waste management including recycling are proven and effective strategies to reduce greenhouse gas emission, mitigate the cause of climate change and advance towards sustainable development. Other waste management strategies which can enhance reduction in greenhouse gases is rhizoremediation a plant-microbe based energy efficient system (Fig 2and 3), to remediate sites with low to moderate levels of contamination and it can be used in conjunction with other more traditional remedial methods as a finishing step to the remedial process [53, 54, 55, 56,57] . Plants involved in this process produce exudates that have been shown to stimulate growth of degrading microorganisms or stimulate co-metabolism. The type, amount, and effectiveness of exudates and enzymes produced by a plant's roots will vary between species and even within subspecies or varieties of one species [55, 58, 59, 60]

Creating awareness of the impact of climate change is yet another mitigating strategy. Incorporation of Climate change education into the curriculum of some subjects as civic education or social studies from post primary level in Nigeria will provide effective and efficient awareness of the dangers of climate change; it should be premised on integrated approach, which social studies is known for; The teachers who will handle the issues of environment and climate change should be provided with professional development programmes to enhance their competence and disposition. Indeed, recognizing the role which school children can play as critical stakeholders in the society, there should be establishment of the Climate Change Club among schools in different states in Nigeria. Such Environment Protection Club when set up in schools, the learners should be encouraged to belong to the club. Aside this, use of media and organization of talks in both rural and urban settlements to educate them on our environment and implications of certain daily activities especially to farmers that are most vulnerable to climate change impact, will enhance awareness. With that, farmers will have regular information on current issues related to climate change and agriculture. This can also be achieved through the strengthening of the nation's extension services perhaps by devolving the bulk of the services down to the local councils, which is closer to the farmers, and encouraging farmers to form farmer groups for enhanced capacity through group efforts. This may help them take advantage of the internet.

CONCLUSION/RECOMMENDATION

Global climate change projection places Nigeria at a very precarious position in the table of countries at danger from the negative effects of climate change and thus raises the concern over food security when considered against the backdrop of the fact that the geographical belt mostly at risk apparently accounts for the bulk of the food crops consumed by Nigerians. However, climate change challenges definitely has to be addressed. The National Adaptation Strategy and Plan of Action [61], adopted by the Ministry of Environment should be approved by the Federal Executive Council. Such approaches include a) adoption of improved agricultural systems for both crops and livestock so as to diversify livestock and improve range management; increase access to drought resistant crops and livestock feeds; adopt better soil management practices; and provide early warning / meteorological forecasts and related information; b) Implementation of strategies for improved resource management in order to promote irrigation systems that use small amounts of water; increase rainwater and groundwater harvesting for use in agriculture; increase planting of native vegetation cover and promote re-greening efforts; and intensify crop and livestock production in place of slash-and-burn practices. Renewable energy sources such as wind energy, solar energy, hydroelectric power energy e.t.c. should be adopted and encouraged as alternatives to fossil fuel.

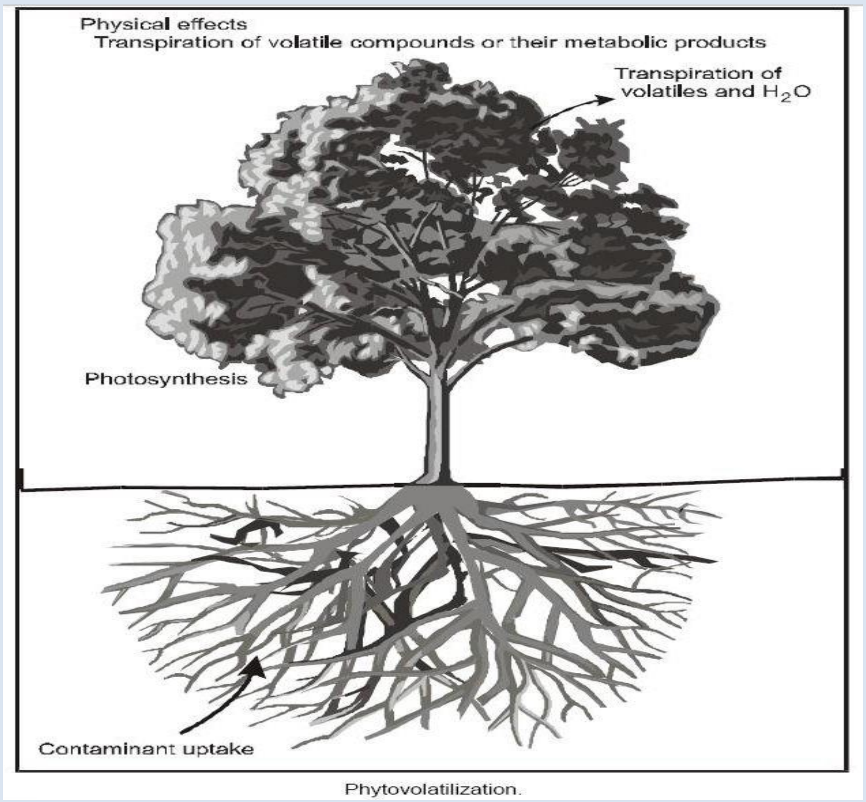

Fig 2: An overview of Rhizoremediation [55].

Trans-boundary water resources management, particularly across West African sub-region should be initiated. Mass transport system including rail transport should be developed to reduce proliferation of cars and motorcycles on our roads. Furthermore, there should be an explicit national agricultural research policy framework to provide a conducive environment for continuity and effectiveness in agricultural programmes/projects. An effort should also be made by government to decentralize research funding and activities to reduce concentration at the federal level. For instance, the ownership structure of research institutes could be decentralized to the lower tiers of government where the farmers at the local levels can actively benefit. The Nigerian government should establish better-equipped weather stations accurate weather forecast and predictions will be possible and this will help to prevent weather-related disasters through early warning and effective response/adaptation system. In addition, efforts need to be made towards tackling the dilapidated infrastructure in the country. With the increasing rate of erratic rainfall patterns, drought and desertification, drought resistant and short duration high yielding crops should be developed through research efforts and made available to farmers. Investment on improved agricultural technology by government and other stakeholders are very necessary for agriculture to be able to cope with climate change. There is need for effective capacity building to strengthen the most vulnerable group in agricultural production with requisite knowledge and information necessary for climate change mitigation and adaptation. Desertification and other unhealthy environmental practices must definitely be curtailed if Nigeria must meet the 2015 target of the Millennium Development Goal (MDGs) of fighting hunger and poverty.

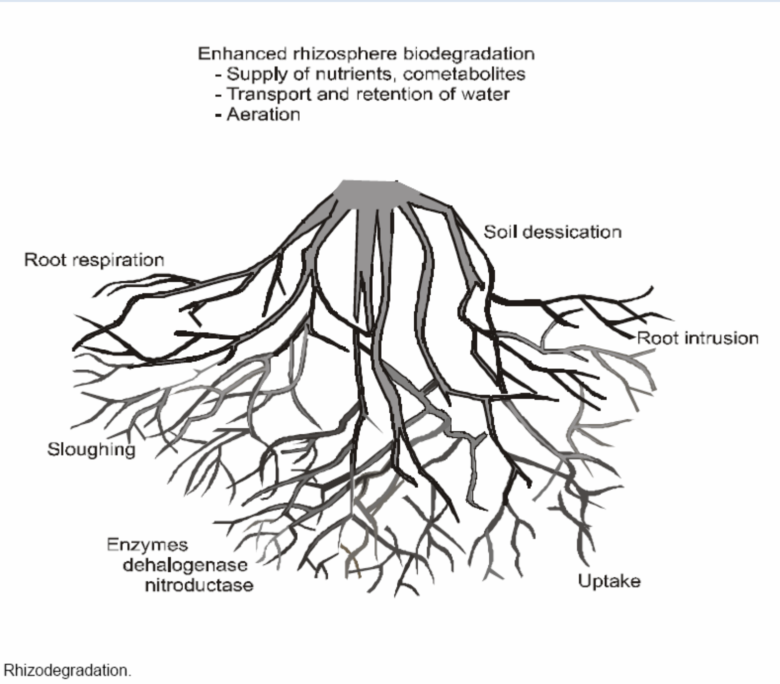

Fig 3: Rhizodegradation within the rhizosphere [55].

REFERENCES

[1] Ziervogel G., A. Nyong, B. Osman, C. Conde, S. Cortes, and T. Dowing (2006). Climate variability and change: implications for household food security. Assessments of Impacts and Adaptations to Climate Change (AIACC) Working Paper No. 20, January 2006. The AIACC Project Office, International START Secretariat, Washington DC, USA.

[2] Nwafor, J. C (2007) Global climate change: The driver of multiple causes of flood intensity in Sub-Saharan Africa. *Paper presented at the International Conference on Climate Change and Economic Sustainabilityheld at Nnamdi Azikiwe University, Enugu,* Nigeria, 12-14 June 2007.

[3] Jagtap, S (2007) Managing vulnerability to extreme weather and climate events: Implications for agriculture and food security in Africa. *Proceedings of the InternationalConference on Climate Change andEconomic Sustainability held* at Nnamdi Azikiwe University, Enugu, Nigeria. 12-14 June 2007.

[4] Odjugo, P. A. O (2010). General Overview of Climate Change Impacts in Nigeria. *Journal of Human Ecology,* 29(1): 47-55.

[5] Adejuwon SA (2004). Impacts of climate variability and climate change on crop yield in Nigeria. Paper presented at the stakeholders' workshop on assessment of impacts and adaptation to climate change (AIACC), Conference centre, Obafemi Awolowo University, Ile-Ife, pp 271-279.

[6] Obioha E (2008). Climate change, population drift and violent conflict over land resources in north eastern Nigeria. *Journal of Human Ecology,* 23(4): 311-324.

[7] Fasona, M. J and Omojola, S. A (2005). Climate Change Human Security and Communal Clashes in Nigeria*. An International Workshop* Holmen Fjord Hotel, Asker, near Oslo, 21–23 June 2005.
[8] Zoellick S and Robert BA (2009). Climate Smart Future. The Nation Newspapers. Vintage Press Limited, Lagos, Nigeria, pp 18.
[9] Bello O. B, Ganiyu O. T, Wahab M. K. A, Afolabi M. S, Oluleye F, Ig S. A, Mahmud J, Azeez M. A and Abdulmaliq S. Y.(2012). Evidence of Climate Change Impacts on Agriculture and Food Security in Nigeria. *International Journal of Agriculture and Forestry 2012, 2(2):* 49-55

[10] United Nations Framework Convention on Climate Change (UNFCCC). 2007. Climatic Change Impact, Vulnerabilities and Adaptation in Developing Countries UNFCCC Secretariat, Martin-Luther-King-Straat 8 53175 Bonn, Germany. http;//www.unfccc.int

[11] Jones, P.G. and Thornton, P.K. (2002). Croppers to livestock keepers: Livelihood transition to 2010 in Africa due to climate change. Global Environmental Change, World Health Organization, Geneva, Switzerland.

[12] Wisner, B., P. Blaikie, T. Cannon and I. Davis. (2004). At risk: natural hazards; people's vulnerability and disasters. 2nd Edition. London: Routledge.

[13] Adams, R., Brian H. Stephanie, L and Leary, N. (1998). Effects of global climate change on agriculture: an interpretative review *Climate Research. 11*: 19–30, 1998

[14] Adams R, McCarl B, Segerson K, Rosenzweig C, Bryant KJ, Dixon BL, Conner R, Everson RE, Ojima D (1999). The economic effect of climate change on United States agriculture. In: R Mendelsohn, J Neuman (Eds.): *The Impact of Climate Change on the United States Economy*. Cambridge, UK: Cambridge University, pp.18-54.

[15] Manning M, Nobrew C 2001. Technical Summary Impact, Adaption and Vulnerability: A Report of Working Group II of the Intergovernmental Panel on Climate Change. In: J McCarthy, OF Canziani, NA Leavy, JD Dekken, C White (Eds.): *Climate Change 2001: Impact, Adaption and Vulnerability*. Cambridge: Cambridge University Press, pp. 44-65.

[16] Niggol, S., and Mendelsohn, R., (2008). Measuring impacts and adaptations to climate change: a structural Ricardian model of African livestock management *Agricultural Economics* :38 151–

165.

[17] De Wit M and Stankeiwicz J (2006). Changes in surface water supply across Africa with predicted climate change. *Science,* 311: 1917-1931.

[18] Obioha E (2009). Climate variability, environmental change and food security nexus in Nigeria. *Journal of Human Ecology,* 26(2):107-121.

[19] Miller, G. T (2004). Climate Change, Ozone Depletion and Air Pollution In: *Sustaining the Earth- An Integrated* Approach Sixth Edition, Thompson Learning Inc, United Kingdom pp236-268

[20] Enger and Smith

[21] Smith G (1994). Environmental pollution and global warming. *IRCD,* 2: 11-20

[22] Msumba A Global 2006. climate change and sustainable human development. *Journal of Arid Environment,*5(1): 18-24.

[23] Wikipedia, (2013a) "Climate Change". Wikipedia, The Fee Encyclopaedia Retrieved June, 2013.

[24] IPCC (2007) Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7-22.

[25] IFAD (2007) Rural Poverty in Nigeria: Agriculture in the Federal Republic of Nigeria. International Fund for Agricultural Development. Retrieved August 7, 2010 from http://www.ruralpovertyportal.org/web/guest.

[26] IFAD (2009). Enabling poor rural people to overcome poverty. International Fund for Agricultural Development. IFAD website: www.ifad.org/operations/projects/regions/pa/factsheets/ng.pdf

[27] Nwogu, S, (2012). "623,690 residents displaced by Kogi flooding" The Punch, Lagos, Punch Newspapers Ltd. October 9.

[28] Jaji, Z, (2012). "Water, Water everywhere", Abuja, Leadership Newspaper, September 30.

[29] Business Day, 2012 "Flood: Over 100 Villages submerged in Rivers", Business Day, Lagos, Business Day Media Ltd, October 9.

[30] Onu, N, O. Ogbemudia and O, Ofabor, 2012, "Floods take toll on more Nigerians", Business Day, Lagos, Business Day Media Ltd, October 9.

[31] Ejiro, O.(2012) Business opportunities in our import, export data. www.businessonloine.org (retrieved August, 2013).

[32] Kurukulasuriya, P. and Mendelsohn, R. (2006). A Ricardian Analysis of the Impact of Climate Change on African Crop Land.*CEEPA Discussion Paper No. 8.* Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa: University of Pretoria.

[33] IISD (International Institute for Sustainable Development) (2007). Community based adaptation to climate change Bulletin. A Summary of the Second International Workshop on Community-Based Adaptation to Climate Change. IISD Reporting Services.

[34] Lobell DB, Burke MB, Tebaldi C, Mastrandrea MD, Falcon WP and Naylor RL (2008). "Prioritizing climate change adaptation needs for food security in 2030". *Science 319*(5863): 607–610.

[35] Apata T.G, Ogunyinka A, Sanusi RA and Ogunwande S (2010). Effects of global climate change on Nigerian Agriculture: An empirical analysis. Paper presented at the 84th annual conference of Agricultural Economics Society held Edinburgh, Scotland, pp 345-351.

[36] Adams RM, Glyer JD, McCarl BA, Dudek DJ (1988). The implications of global change for western agriculture. *West J Agric Econ* 13:348–356

[37] Fischer G., Shah M. and van Velthuizen H. (2002) "Climate Change and Agricultural Vulnerability". International Institute for Applied Systems Analysis. Report prepared under UN Institutional Contract Agreement 1113 for World Summit on Sustainable Development. Laxenburg, Austria.

[38] Wolfe DW, MD Schwartz, AN Lakso, Y Otsuki, RM Pool, NJ Shaulis. 2005. Climate change and shifts in spring phenology of three horticultural woody perennials in northeastern USA. Internat J Biometeorol 49:303-309. Meteorological Organization, Geneva.

[39] Apata T.G., Samuel, K.D., and Adeola, A.O, (2009). Analysis of Climate Change Perception and Adaptation among Arable Food Crop Farmers in South Western Nigeria. *Contributed Paper prepared for presentation at the International Association of Agricultural Economists' 2009 Conference, Beijing, China, August 16-22,2009.*

[40] Building Nigeria's Response to Climate Change (BNRCC), (2008). 2008 Annual Workshop of Nigerian Environmental Study Team (NEST): The Recent Global and Local Action of Climate Change, held at Hotel Millennium, Abuja, Nigeria; 8-9th October, 2008.

[41] Wikipedia, (2013b), "Global Hunger Index". Wikipedia, *The Free Encyclopaedia, http//en.wikipedia.org/wiki/Global Hunger Index Accessed October 6*

[42] Brussel, S.E.C. 2009. Adapting to climate changes: the challenge for European agriculture and rural areas. Commission of the European communities. Commission working staff working document accompanying the white paper No. 147.

[44] Enete, A.A and Amusa, T. A. (2010). Challenges Of Agricultural Adaptation To Climate Change In Nigeria: A Synthesis From The Literature. *Field Actions Science Reports* Vol. 4 | 2010, http://Factsreports.Revues.Org/678.

[45] FAO. (2007). Food and Drug Administration *Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities.* Report of the FAO Interdepartmental Working Group on Climate Change. Rome.

[46] Mark, W.R., E. Mandy, Y. Gary, B. Lan, H. Saleemul and V.S. Rowena. 2008. Climate change and agriculture: Threats and opportunities. Federal Ministry for Economic Cooperation and Development, Germany.

Germ Plasm Collection, Morphological Characterisation and Proximate Composition of Air Potato (Dioscorea bulbifera L.) from Southern Nigeria

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ABSTRACT

Dioscorea bulbifera is an underutilized, neglected crop with high potential for provision of food security if exploited. It is widely distributed throughout the Southern and Eastern States of Nigeria, both in the wild and in small farm holdings. Collections of this crop were made from three different locations namely; Akwa Ibom, Cross River and Imo States of Nigeria with a view to identify available germ plasm and study the morphology, yield and nutritional composition of this crop. This study sought to provide information on the existence of adapted food crop which if exploited could make food available for the starving population in the face of climate change. From the collections made, four distinct types were identified based on the shape, texture, colour and taste of the bulbils, significant differences were observed ($P \geq 0.05$) for number of leaves per plant, stem length, number and weight of bulbils per plant, days to heading as well as days to sprouting of bulbils. Proximate composition analysis revealed that the edible variety contains the following nutrients; crude protein- 4.1%, crude fibre – 25.05%, carbohydrates – 61.6%, fat – 6.2%, ash -3.1%, nitrogen free extracts -55.6% and moisture - 6.0%. Based on the high nutrient composition, the vigorous and invasive growth habit and spread in large areas of the region as revealed by the study, we recommend the air potato as an indigenous crop which is capable of helping millions of people meet their daily food requirement.

Key words: Food Security, Climate change, underutilized crop, carbohydrate source, air potato. Neglected crop.

INTRODUCTION

The current unpredictable and harsh climate condition has given rise to food shortage occasioned by drought and desertification on the one hand, flooding and pest infestation on the other hand as well as loss of germ plasm and genetic resources. It is now difficult for many populations in developing countries to meet their daily food requirements. And many more are deficient in one or more micronutrients (FAO, 2004). Many rural communities in the world depend on wild and some domesticated plant species from the richness and diversity of materials in their local environments, to meet their food needs particularly in times of food shortage such as now. The solution to the current food situation in developing world seems to lie in the diversity in wild indigenous species. They give variety in the diet, provide the much needed micronutrients as well as folk medicines and contribute greatly to household food security. They are adapted to the environment and resilient to the climate change. Plant genetic resources also form the bedrock of modern plant breeding systems and should therefore be studied and investigated for their improvement.

Many of these edible plant resources abound in Nigeria and were at one time or the other recognized and utilized by our ancestors, but the younger generations are hardly aware of their existence. A typical rich food resources which has been neglected, underutilized relegated to the wild and marked for extinction is the aerial yam, also known as air potato.

The air potato, *Dioscorea bulbifera* is an indigenous crop which according to Coursey (1967) and Shultz, (1983), originated from Asia and Africa from where it was introduced to new tropical and subtropical areas including the Americas. In Nigeria, it is found in the tropical rain forest regions of the South, South East and West, including the Delta states. The air potato is vigorously growing dioecious plant species with glabrous twinning vines which is reported to rich heights of about 70m in one season. It produces underground tubers as well as above ground bulbils which arise from the axils along the stem (Cobley, 1962).

The leaves are simple, alternate, non-pubescent and rounded or ovate with sharply acute apex. The leaves have distinct chordate shape, and attached to long petioles Langeland (2001). The leaves are divided longitudinally into lobes by prominent arching veins about 7-9cm long radiating from a single point around the base of the leaf. According to Cobley (1962), Langeland, (2001) and Morton, (1976) *Dioscorea bulbifera* has a stem that is cross sectionally roundish. Morton (1976) also reported that flowers do not usually occur and if they do are very small, pale green and fragrant forming a pinnacle of inflorescence. The flowers arise from the leaf axils. *Dioscorea bulbifera* can be propagated both sexually through seeds and asexually by vegetative growth of both the underground tubers and the aerial bulbils.

Germination of the bulbils is said to occur in approximately 21 days at 30^0C (Ellis *et al*, 1985). Productivity of a large number of bulbils assures continuity of the species since production of flowers is a rare event (Schultz, 1993).

Dioscorea bulbifera is of great economic importance. It is edible although it has some wild inedible varieties. It is also a medicinal plant applied as analgesic, diuretic, aphrodisiac and for treatment of conjunctivitis, hernia, goiter, dysentery and even food poisoning (Cobley, 1962).

Given the economic importance of this yam species both for food and medicine, with it attendant vigorous and aggressive growth characteristic, which can enable it to withstand the harsh condition of climate change, thus providing food security in times of need. There is need to evaluate it genetically with a view to conserve its germ plasm especially with the fact of neglect and relegation by the new generation of Nigerians to prevent its extinction. There is also need to create awareness of its existence for food security because presently there is dearth of literature with regards to the Nigerian varieties of this crop. Hence the objective of the present study was to collect available germ plasm for on-farm conservation and morphological characterization as a first step towards crop improvement program. The tested hypothesis was that there is genetic variability in the local population which could be exploited for further breeding programs for the species. The variations observed would be documented and analysed statistically for significance. The proximate composition of the species was also determined to highlight its usefulness as a food security crop species.

MATERIALS AND METHODS

Germ plasm collection

Field trips were made to various communities in Cross River, Akwa Ibom, and Imo states of Nigeria. These areas are located on South/Eastern parts of the country where subsistence farming is practiced and they occupy the geographical location which can be described as tropical rain forest.

Three trips were made first in January, 2011, then August, 2011 and January 2012; collections were made of both edible, cultivated varieties as well as wild types as identified by the rural farmers. Many of the plants were found already growing in abandoned bushes in the wild, while others were found in the farmers plots. The farmers were also interviewed about the cultural practices and uses of this crop. Notes were made according to their reply.

Morphological Studies

The collected bulbils were labeled and brought for establishment in our experimental plots behind the Biological Science block in University of Calabar.

Although data were collected *in situ* at the various locations, the data reported here are those from composited accessions established in our plots in a randomized complete block design (RCBD). Although thirty plants from each location were planted, data was collected randomly from 10 plants chosen from each group/state. The plants were observed for morphological differences in vine length, stem diameter, leaf area, shape and colour as well as petiole length. Shape, colour, number and weight of bulbils per plant, internode length. Days to germination and bulbils initiation and flowering. Cultural practices such as heap planting, staking and weeding were observed, at appropriate times. The plants were staked individually for ease of vine length and leaf number measurements.

Statistical analysis was carried out using the SPSS statistical package for analysis of variance (AOV). The main effects were considered to be the varieties as well as the locations and replications and significant means were separated using LSD.

Proximate composition studies were carried out in the Biochemistry Department of the University of Calabar following the AOAC Method (2003).

RESULTS

General observation: Although various numbers of accessions were collected from each of the areas visited. It became very difficult assigning bulbils with particular shapes or sizes to particular states except in one or two cases. The various morphological types were found in each of the three locations but in varying frequencies (Table 1). The bulbils were therefore grouped according to morphological attributes rather than locations of origin. The various accessions of *D. bulbifera* planted were similar in their morphology being herbaceous climber with long twining stems. The stems twined in anti-clockwise direction. However there was a high heterogeneity among the bulbils with regards to shapes, weight, peel texture and colour, and based on these attributes, four types were identified (Table 2 refers).

Bulbils Shapes, Colour and Weight

Some of the bulbils (accessions) were dumb bell / liver shaped with undulating topography, dark brown in colour and quite large in size weighing upto 1kg each. They were grouped as Type 1. Others, Type 2, Brown coloured, kidney shaped but were more globular than broad with a ridge in the middle which tends to divide them horizontally into two halves (Mirror images). They were quite heavy weighing approx. 0.6kg/bulbil. Type 3 were variously shaped, weighing upto 0.4kg or less. They are light brown/ grey, while others (Type 4) were irregular in shape, small in with very dark brown and rough pitted peels. Bulbil size and weights per plant varied from large ones to small and very small ones

With regards to bulbils colour, four colour types were also identified as follows: very dark brown, dark brown, brown, and very light grey/ ash. The skin texture was either smooth-pimpled or pitted and rough or just rough without pits or pimples. Every plant possessed only one type of bulbil with regards to colour (See Figure 1-2). Table 2 summarizes these observations.

No of leaves per plant

As recorded in Table 2, the accessions could be identified into three groups with regards to number of leaves per plant. The greatest number of leaves were counted for Type 4, with mean leaf number of 269.5 ± 35.62. This was followed by Type 1 with 189.2 ± 38.46 leaves. Types 2 and 3 had mean leaf numbers 178.2 ± 21.75 and 159.12 ± 13.47 respectively. These values were significantly different ($P \leq 0.05$), as shown in Table 3.

The leaves have long petioles with length ranging from 5.20 to 11.50 ± 0.56cm. The leaves have broadly rounded basal lobes. In the darkly coloured varieties, these basal lobes had purple colour tint. Some accessions had more darkly coloured green leaves than others. Leaf colours tallied with bulbil colours

Vine length, vine diameter and internodes length

Stems or vines are hairless, non-branching and roundish in cross section. Stem diameter measurements ranged from 0.18±0.09cm to 2.5±0.01cm; while the internode length ranged from 8.70±0.26 to 11.90± 0.26, to 20.2 ± 0.66cm in some morphotypes. Vine lengths ranged from 12.72 to 18.6m (Table 2) These differences are significant at ($P \geq 0.05$)

Days to sprouting and heading

Days to sprouting of the bulbils were also significantly different among the accessions, ranging from 67.9±2.46 to 83.4±0.64. Significant differences were also observed in the number of days it took each of the accessions to initiate bulbils (days to heading). This ranged from 81.2±10.1 to 138 days for the various accessions.

No. and weight of bulbils per plant

The mean number of bulbils produced per plant ranged from 5.12± 3.23 to 38.5±0.28. There was significant difference in the mean number of bulbils produced per plant between the types. Weight of individual bulbils differed significantly both within and between the types.

Leaf area (cm^2), shape and colour

There was great variability between the four groups in their mean leaf area, leaf shape and colour. Type 3 accessions possessed very large ovately round light green coloured leaves with sharp pointed leaf apex, and mean area of 315.6± 1.8cm^2 while Type 1 accessions had rather dark green coloured elongated heart shaped leaves with mean area of 107.7±22.26cm^2. The Types 2 and 4 had leaves with areas of 128.4±0.11 and 79.5± 6.12 respectively. Type 2 leaves though elongated inshapre, were lightly coloured, while Type 4 leaves, ovately shaped were very dark in colour (Fig. 3&4). The bulbil colour seemed to tally with the leaf colours, plants with darker leaves produced bulbils with very dark peel colour. Again four leaf types could be identified easily based on colour, shape and size as follows:

- Large, dark green coloured elongated heart shaped leaves – Type 1
- Small light green coloured elongated heart shaped leaves – Type 2
- Very large light green ovately round leaves – Type 3
- Small dark green coloured ovately round leaves – Type 4

Flowers: Some accessions flowered during the course of their growth. The flowers were long green inflorescence which consisted of tiny pale green florets. (See Fig. 5& 6) The flowers were born alongside the bulbils i.e. a single plant could bear both bulbils and flowers on the same leaf axis.

Edibility and Cultural practices:

Types 1,2,3 are edible to some communities in the area of study. The air potato was planted in conjunction with other crop species such as yam, cocoyam and cassava. This was the practice in all communities studied, but many were growing in the wild.

Proximate Composition

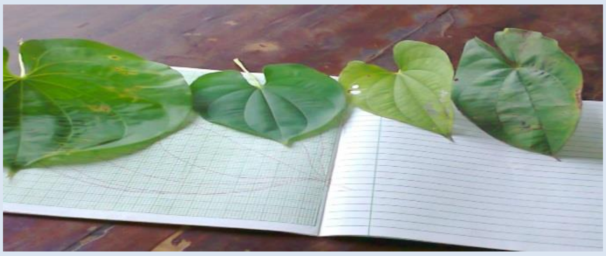
TABLE I: Collection sites of *D.bulbifera* accessions from Southern Nigeria

Collection site	State	Habitat description	Latitude/ Longitude	Altitude (elevation) (m)	Bulbils types
Umunebia	Imo	Farm land	N05^{0}29:727, E007^{0}20:408	155.9±43.9	Dark brown, dark brown brown
Ntu Umoogba	Imo	Abandoned farm land	N04^{0}59:85, E008^{0}19:981	29.9±15.0	Brown grey
Okpala	Imo	Abandoned farmland	NO4^{0}20:680, E00819':960	120±15.2	Brown grey
Umuechem	Imo	Thicket abandoned old residence	N04^{0}59:88, E008^{0}28	35.2±20.1	Dark brown, Brown, grey
Akamkpa	Cross River	Abandoned farmland	N05^{0}36:45, 008^{0}50:41	102	Brown, v. dark brown grey
Akamkpa	Cross River	Farmland	N04^{0}33:45, E008^{0}23:34	97	Brown grey
Akamkpa	Cross River	Farmland	N05^{0}06:32, E008^{0}11:48	77	Brown grey
Ikom	Cross River	Forest	N05^{0}46:60, E008^{0}31:60	121	Dark brown, grey
Boki	Cross River	Abandoned farm	N06^{0}23:59, E00^{0}45:04	109	v. dark brown
Odukpani	Cross River	Forest	N04^{0}46:00, E007^{0}57:00	49	D. brown, brown, grey
Calabar South	Cross River	Farmland	N04^{0}61:56, E007^{0}72:04	92	Dark brown
Ikot Abasi	AKS	Farmland	N03^{0}52:00, E008^{0}43:28	60	V. dark brown, brown
Ukanafun	AKS	Farmland	N04^{0}68:58, E007^{0}42:22	102	Dark brown, brown
Ukanafun	AKS	Abandoned Farmland	N005:72:51 E008:61	112	Grey, dark brown

The results of the proximate composition analysis are shown in Fig. 7. The analysis shows that the brown Type 2 bulbils has high carbohydrate content 61.6%, crude fibre 25%, 6.2% fat, 3.1% ash, 55.6% Nitrogen free extract and 6.0% moisture content and low crude protein 4.1%.

Table 2:Means ± SE of morphological and yield attributes of 40 Accessions of *D. bulbifera* planted in University of Calabar

Types	Bulbil colour/ texture	Edibility	Leaf area (cm2)	Leaf No/ Plt	Internode (cm) length	Vine length (m)	Bulbils No./ plt	Bulbils wt/Plt (kg)	Petiole length (cm)	Stem diameter cm	Days to sprouting	Days to bulbil initiation
1	Smooth, dark Brown pimpled	Edible	107.7± 22.26	189.15±38.46	11.90±2.26	12.72±	28.3±	1.98±0.5	8.20±0.32	1.10±056	67.9±2.46	81.2±10.10
2	Rough, brown	Edible	128.4± 4.011	178.20±21.75	14.90±0.52	18.60±	5.12±3.2	1.85±0.01	5.68±0.24	218±0.01	71.6±0.54	109.2±1.02
3	Light grey, brown, pimpled	Edible	315±180cm	159.12± 13.47	20.2±0.66	15.37±8.24	24.5±	1.89±0.32	11.50±0.56	2.00±0.01	83.4±0.64	118.3±2.01
4	Very dark brown, pitted and rough	Not edible	79.5±6.12	269.5±35.62	8.70±0.26	15.32±	38.5±0.28	1.6±0.20	5.20±0.72	0.78±0.09	90.1±2.63	138.2±1.01
LSD	LSD		11.21	15.55	3.8	2.25	10.2	0.8	3.26	0.31	6.25	8.17



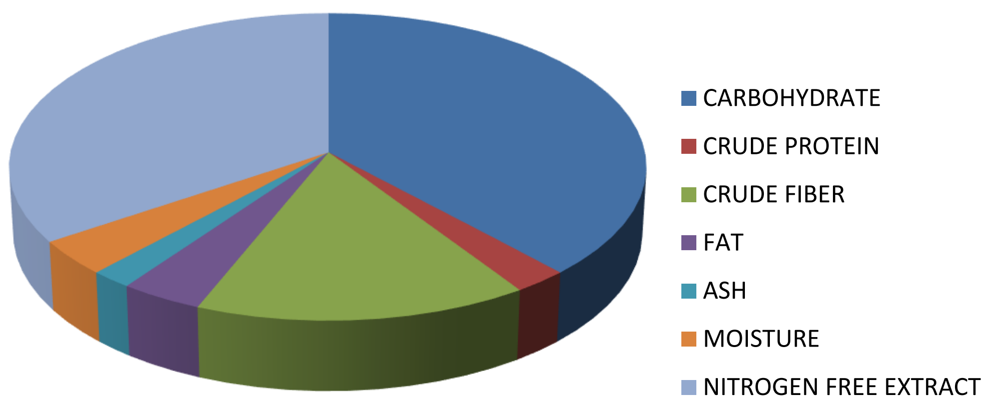


Fig. 8 **Proximate Nutrient Composition Of *D.bulbifera* (Type 2) From Southern Nigeria**

DISCUSSION

The morphology of organisms is a function of both the genotype and the environment. This is true not only of animals but also of plants. In this study, the morphological attributes of aerial yam indigenous to Southern Nigeria was studied with a view to characterizing them for eventual use in selection and breeding studies. The significant variation in attributes such as leaf size and number, bulbil size, weight as well as shapes and peel colour discovered in this study implies that there is room for selection and genetic improvement of the species. The accessions could not be grouped based on their states of collection because each state collection had accessions with characteristics similar to those from another. This report presents the initial four types based on morphological features identified, irrespective of origin. This observation seems to tally with the findings of Tewodrous (2013) in his studies with aerial yam in Ethiopia. A detailed genetic variability analysis will be worked out for this species.

Plant height reported by Langeland (2001) greatly exceeds that observed in this study. The reasons could be due to soil fertility differences or location of the plants. No fertilizers were applied in this study and also each plant was allowed to grow on its own not associated with other crops such as yam, therefore with no competition for light source hence the moderate vine length observed. Days to germination of the bulbils observed in this study was also different from that reported by Ellis *et al*. This again could be due to differences in environmental conditions.

The air potato is widely distributed through out the southern and eastern states of Nigeria both in the wild and in small farm holdings as revealed by this study. Studies also revealed that although the populace, (mainly the older generation) recognize it as food, it is not widely patronized as such perhaps because of its widespread availability due to it invasive growth nature. This attribute, which should be exploited is rather making the plant cheap and looked down upon, in favour of the Irish potato. The species is here recommended for value addition research which may encourage wider patronage.

Focus group discussion with the local farmers revealed that the crop is planted on the same mounds with yams, cocoyam and sometimes cassava. The crop, being a creeper with weak stem is staked alongside the greater yam and there is much competition for sunlight with the yam. The fact that the aerial yam is invasive and aerial climber makes it easy to grow in association with other yam species using the same stakes. This is advantageous to the farmer who does not have to bother about staking the crop separately. The other observed advantage is in the days to yield and maturity of the bulbils. These also correspond to the growth cycle of the greater yam- *D. alata* which is acceptable cash crops and staple food of the natives where the *D. bulbifera* are also found. Therefore the harvest of the *D. alata* has little or no disadvantage to the *D. bulbifera* when grown together. Both could be harvested together. Although the crop produces underground tubers, they are grown for their bulbils production and not for the underground tubers.

Regarding edibility of the varieties, there were some conflicting reports, Ikot Abasi people claimed they were not eating the large dark brown variety which however was the main edible variety for the Annang people of Ukanafun , Ikom and Boki in Cross River State.

This accession was also edible in Imo state. Some communities in Imo do not eat the grey /brown type. These were preferred in most parts of Cross River The very dark brown small types were clearly non-edible to all communities visited, perhaps because of its extreme bitter taste. This bitter, non-edible accessions can still be conserved for genes for improvement of the edible type.

Also from interviews, the farmers claim that the crop has some medicinal uses. It is used as cure for sore throat, diabetes, leprosy and tumours. Also for treatment of swelling and snake bites as well as fertility problems.

Proximate composition analysis revealed that the bulbils are a good source of carbohydrate comparable to other carbohydrate based foods. In addition, they are a good source of fibre.. Research on the phytochemical composition is underway.

It is ironical but interesting to note that while in the West African sub-region, the air potato is food and recommended for use as a panacea for hunger and resilience in this era of climate change, the species is being marked as invasive weed that ought to be eradicated in Florida, Southern United States, (Centre *et al* (2013), Langeland (2001) and Morton (1976).

REFERENCES

AOAC (2003). *Official methods of Analysis of Association of Official Analytical Chemists*, Arlington, Virginia.
Center Ted, D., Min Rayamajhi, F. Allen Dray, Paul M. Madeira, Gloria Witkus, Eric Rohrig, Elizabeth Mattison, Ellen Lake, Melissa Smith, Jialing Zhang, Mathew Purcell, Alex Konstantinor & Don Schmitz (2013). Host range validation, molecular identification and release and establishment of a Chinese biotype of the Asian Leaf beetle *Lilioceris cheni (Coleoptera: Chrysomelidae: Criocerniae)* for control of *Discorea bulbifera L*. in the southern United States. *Biocontrol Science and Technology* 23 (7) 735-755.

Cobley, L.S. (1962).*An introduction to the Botany of Tropical Crops*. London. Longman.

Coursey, D.G. (1967). *Yams: an account of the nature, origins, cultivation and utilization of the useful members of Discoreaceae:* Longman. London pp 43-51.

Ellis, R.H., Hong, T.D. and Roberts (1985). *A handbook of seed, Technology for Gene Banks. Vol.II Compendium of specific germination information and Test Recommendation. International Boards for Plant Genetic Resources*, Rome.

Langeland, K.A. (2001). *Natural Area Weeds: Air Potato* (*Dioscorea bulbifera*). UF/IFAS Document SSAGR. University of Florida, Gainville.

Morton, J.F. (1976). Pestiferous spread of many ornamental and fruit species in South Florida. *Proceedings of the Florida State Horticulture Society 89*.

Ogbuagu, M.N. (2008), Nutritive and anti-nutritive compounds of the wild (inedible) species of *D. bulbifera* (potato yam) and *Dioscorea dumentorum* (Bitter yam). *Pacific Journal of Science and Technology* 9(1):203-207.

Schultz, G.E. (1993). *Element Stewardship Abstract for Dioscorea bulbifera*. The Nature Conservancy, Davis Press, Washington DC pp. 10.

Tewodrous M., and Hussien M.(2012) Genetic variability and association among yield and yield related traits in aerial yam/ Dioscorea bulifera (L)/ Accession at South Western Ethiopia. *Journal of Natural Science Research* 2(9).

Tewodrous, M. B. (2013). *Genetic diversity of aerial yam/ Dioscorea bulbifera* (L:) accession in Ethiopia based an agronomic traits: *Agriculture, forestry and fisheries* 2(2), 67-72.

Seasonal Effects of Stem Borers Damage to Maize Under Different Management Practices in Guinea Savanna Zone of Cross River State, Nigeria

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ABSTRACT
Stem borers are major economic pests of maize worldwide. Field experiments were conducted in the early and late planting seasons of 2009 and 2010 at the Teaching and Research Farm of Ujia Secondary Commercial College, Ibiaragidi, Bekwarra, in the Guinea agro-ecological zone of Cross River State, Nigeria to assess the effects of stem borer damage and population dynamics on early and late season planted maize. Treatments consisted of seasons (early and late), 2 levels each of Carbofuran (1.0 and 1.5 kg a.i/ha), *Azadiracta indica* and *Gmelina arborea* seed powders (20 and 30 kg/ha) and a control. The treatments were laid out in a randomized complete block design (RCBD) with 3 replications. Data collected included percentage dead heart, lodged stem, bored stem, tunnel length, borer larval population and grain yield. Borer damage variables and population dynamics were significantly ($P<0.05$) lower in early planted maize than late. The lowest incidence of dead heart in the late season among the biopesticides was recorded in *A. indica* (30 kg/ha) treated plots 4.81% and 5.13% in 2009 and 2010, respectively. The same was observed for tunnel length 6.27 cm and 9.00 cm, lodged stem 4.40% and 8.89% in 2009 and 2010, respectively. Maize yield was generally higher in the early season planting than the late season. The highest yield of 2.23 and 2.95 tonnes/ha was obtained from Carbofuran (1.5kg a.i/ha) followed by *A. indica* (30kg/ha) (2.20 and 2.90 tonnes/ha) treated plots in the early planting seasons of 2009 and 2010, respectively. The results of our findings indicated that the stem borer population and yield varied with the seasons which are components of climate.

Key words: Stem borers, Guinea savanna, Early and Late seasons, *Zea mays*

INTRODUCTION

Maize, *Zea mays* L. (Poaceae) is perhaps one of the most important cereal crops cultivated for food, feed and as industrial raw materials (Benz, 1994; Ukeh, *et al.*, 2010). However, sustainable maize production especially in the developing world is threatened by various insect pests and diseases, such as stem borers, maize streak (Polaszeck, 1998; Ukeh, *et al.*, 2007).The major species of stem borers associated with maize production in Nigeria are the maize stalk borer (*Busseola fusca* Fuller (Noctuidae), the pink stalk borer

(*Sesamia calamistis* Hampson (Noctuidae), the millet stem borer (*Acigona ignefusalis* Hampson (Pyralidae) and the African sugar cane borer (*Eldana saccharina* Walker (Pyralidae) (Polaszek, 1998; Balogun and Tanimola, 2001). Stem borers infestation begins with arrival of migrant population moths from wild host, or stems left on the field after the previous season's crop, or the stems used for fencing in homestead (Polaszek, 1998; Sosan and Daramola, 2001). *Busseola. fusca* and *S. calamistis* are the earliest arrivals, followed later from eight weeks after planting (WAP) by *E. saccharina* (Polaszeck, 1998). Okweche, *et al.*(2010) reported that early planted maize suffer less attack by borers than late planting in the Middle Belt of Nigeria. Similar observations were reported by Bosque-Perez and Dabrowski (1989), Oigiangbe *et al.* (1997). Heavy stem borer infestation has precluded second cropping of maize even in areas with potentials for two rain-fed crops (Ogunwolu, 1987).

Kakule *et al.* (1997) reported that in Africa damage to maize vary with locations, with sub-Saharan Africa recording the highest population of stem borers which is directly correlated with damage and grain yield. Crop losses and grain yield reduction may result from damage caused to growing points leading to loss of stands (dead heart), damage to leaf (window pane),stem tunneling, hole (as portal of entry to secondary rot organisms), stem lodging, stem breakage, tassel and direct damage to ear shank and ear (Sosan and Daramola, 2001). All over the world, stem borers have been the most damaging group of insect pest in maize cultivation (CIMMYT, 2000). In Nigeria, stem borers cause 10 to 100% loss in maize grain yield (Sosan and Daramola, 2001). The yield loss varies depending on season, ecological zone and region (Bosque-Perez, 1992). The objectives of the study was to determine yield loss due to stem borers in the agro-ecological zones and to determine the intensity of stem borers attack on early and late maize cultivation.

MATERIALS AND METHODS

Land preparation and planting

The experiment was conducted at the Teaching and Research Farm of Ujia Secondary Commercial College, Bekwarra, in the Guinea agro-ecological zone of Cross River State, situated in latitude $5^{0}15"$E and longitude $8^{0}22$E, Nigeria.

The experimental site was cleared, ploughed and harrowed to give a uniform and smooth planting surface. The experiment occupied 0.05ha demarcated into three blocks containing seven plots. Each plot measured 4m x 2m wide. Adjacent plots were separated by 0.5m path while 1.0m path was used to separate the blocks.

Planting Materials

The maize variety (OBA Super 1 Op-yellow) used for the experiment was obtained from the Cross River Agricultural Development Programme, Ogoja, Cross River State, Nigeria. Matured ripe fruits from *Azadirachta indica* and *Gmelina arborea* seeds were collected washed and sun dried for 8 days then ground into powder, using a mechanical grinder.

The powder of both products was weighed into 0.19g and 0.28g using Mettler P163 weighing balance.

Treatments

The treatments included: Seasons (early and late), *A. indica* seed powder (NSP), *G. arborea* seed powder (GSP) at the rates of 20kg and 30kg/ha while Carbofuran was applied at the rates of 1.0 and 1.5kg a.i /ha (13.33 kg/ha and 20 kg/ha) an untreated plot which serves as control. The treatments were laid out in a randomized complete block design (RCBD) and replicated three times. Planting was done on 2nd of April for early and 12th of September for late 2009 while in 2010; planting was done on 3rd of April for early and 4th of September for late season respectively. Three seeds were sown manually at a spacing of 75cm x 25cm and a planting depth of 3cm. Two weeks after sowing, the seedlings were thinned to one plant per stand to maintain a population of about 53,333 plants/ha. Two hand- weeding was carried out at four and six weeks after planting (WAP) using weeding hoes and cutlasses. Compound fertilizer N.P.K (20:10:10) was applied in a ring at the rate of 90kg N/ha, 45kg P_2O_5/ha and 45kg K_2O/ha.

Data collection and analysis

Dead heart was recorded at six weeks after sowing (WAP) as percentage of total number of plants in the plot. At harvest, lodged stems were counted and expressed as percentage of total number of plants per plot. A random sample of 5 stems from experimental unit was examined for the number of bored stems, total number of internodes bored. Bored stems were split to record borer larvae and borer tunnel length. The different borer larvae were recorded after sorting to species (Polaszek, 1998). Grain weight was measured in kilogramme and converted to tones per hectare. Data were subjected to analyses of variance (ANOVA) and the means were separated using T-test.

RESULTS

Tables 1 and 2 show the effect of season on dead heart incidence (%), tunnel length (cm),

percent lodged and percent bored stems for 2009 and 2010 cropping seasons. The untreated plots had significantly ($P \leq 0.05$) higher infestation and damage (dead heart, tunnel length, lodged stem and bored stem) in late season planting than early. In 2009 cropping season (Table 1), the treated plots showed significantly ($P \leq 0.05$) higher incidence of dead heart (%) in late season than early season. Tunnel length in 2009 was significantly ($P \leq 0.05$) longer in late season than early season in the untreated crops. Percent lodged stem was significantly ($P \leq 0.05$) higher in late season planting in untreated than treated plots. Similar result was observed in percent bored stem. Again, in 2010 (Table 2) dead heart incidence and tunnel length were significantly ($P \leq 0.05$) higher in late season than early season planting except that crops treated with *A. indica* at 30 kg/ha showed no significant difference ($P \geq 0.05$) between early and late season in tunnel length. Similar result was observed in percent bored stem, except in plots treated with *G. arborea* at 20 kg/ha which showed no significant (P≤ 0.05) difference between early and late planting. Control plot and The crops treated with Carbofuran at 1.0 kg a.i/ha and the control had significantly (P ≤ 0.05) higher percent lodged stems in late season than other treatments. The predominant stem borer species (*B. fusca* and *S. calamistis*) recorded in the locations were significantly (P≤ 0.05) higher in late season planting than in early season planting in all the treatments (Tables 3 - 4).

In 2009, *B. fusca*, mean population was significantly (P ≤ 0.05) higher in late planting than in early planting seasons in the control, compared with other borer species (Table 3). No significant (P ≥ 0.05) difference was observed in the treated crops in early and late season with the exception of crops treated with Carbofuran, where *B. fusca* and *S. calamistis* were significantly higher in late than early season. In 2010, *B. fusca, S. calamistis* and *C. partellus* were significantly higher for untreated crops in late than early season while there was no significant (P ≥0.05) difference between early and late planting seasons in the treated crops (Table 4).

In 2009 early and late plantings, significantly (P≤ 0.05) higher grain yield was observed in crops treated with Carbofuran and *A. indica than on G. arborea* and the control. Similar result was observed in the early planting of 2010. In the late planting of same year (2010) *A. indica* at all levels and Carbofuran at 1.5 kg a.i/ha had significantly (P ≤ 0.05) higher grain yield compared with *G. arborea* and the control. However, maize yield on crops treated with Carbofuran at 1.0 kg a.i/ha was not significantly (P ≥ 0.05) different from *A. indica* in the late planting season of same year.

Table 1: Effects of season on some stem borer damage parameters in 2009

	Dead heart (%)			Tunnel length (cm)			Lodged stem (%)			Bored stem (%)		
Treatments	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*
Control	9.36	19.61	0.0264	32.23	49.83	0.0449	16.28	38.11	0.0032	41.33	60.00	0.0106
C1.0	2.81	4.44	0.0574	3.80	6.40	0.0273	4.07	5.05	0.3259	11.00	17.00	0.1169
C1.5	2.45	4.07	0.0185	2.93	5.23	0.0518	2.96	3.70	0.3232	12.00	14.00	0.3392
N20	7.40	8.51	0.1706	5.74	8.80	0.1428	6.66	6.66	0.4993	12.33	19.33	0.1400
N30	3.02	5.55	0.0624	4.47	6.27	0.1327	3.33	4.44	0.3152	11.33	17.67	0.0294
G20	10.67	10.73	0.2549	16.33	19.80	0.1903	11.47	14.66	0.1520	26.67	32.67	0.0934
G30	8.62	8.88	0.3829	10.37	13.53	0.0218	12.21	11.84	0.4675	12.00	24.00	0.0175

C1.0 and C1.5= Carbofuran at 1.0 kg a.i/ha and 1.5 kg a.i/ha respectively; N20 and N30= *A. indica* at 20 kg/ha and 30 kg/ha respectively; G20 and G30 = *G. arborea* at 20 kg/ha and 30 kg/ha respectively. P= Probability values at 5% level.

Table 2 : Effects of season on some stem borer damage parameters in 2010

	Dead heart (%)			Tunnel length (cm)			Lodged stem (%)			Bored stem (%)		
Treatments	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*
Control	12.21	36.65	0.0005	15.20	36.40	0.0090	22.22	41.85	0.0020	29.26	56.40	0.0070
C1.0	2.22	13.33	0.0010	3.13	12.93	0.0090	7.41	12.96	0.0430	12.28	24.87	0.0020
C1.5	0.74	8.15	0.0010	3.13	8.67	0.0030	6.67	8.89	0.2240	12.68	24.28	0.0020

N20	2.22	12.96	0.0007	6.07	14.37	0.0070	7.04	10.74	0.0600	14.74	31.12	0.0240
N30	2.59	10.00	0.0003	5.47	9.00	0.0550	6.30	8.89	0.0780	12.44	26.22	0.0240
G20	8.52	16.30	0.0004	10.07	18.53	0.0140	16.67	18.12	0.3200	22.09	29.51	0.0600
G30	7.78	11.81	0.0190	5.27	11.80	0.0030	14.45	18.52	0.2130	12.24	26.03	0.0080

C1.0 and C1.5= Carbofuran at 1.0 kg a.i/ha and 1.5 kg a.i/ha respectively; N20 and N30= *A. indica* at 20 kg/ha and 30 kg/ha respectively; G20 and G30 = *G. arborea* at 20 kg/ha and 30 kg/ha respectively. P= Probability values at 5% level.

Table 3: Effects of season on stem borer population in 2009

	B. fusca			*S. calamistis*			*E. saccharina*			*C. partellus*			*C. ignefusalis*		
Treat	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*
Control	27.67	44.67	0.0456	9.00	11.00	0.4163	4.33	6.33	0.2554	8.33	9.33	0.3601	2.00	2.00	0.5000
C1.0	7.33	6.00	0.4002	0.67	3.67	0.0267	0.00	0.00	-	1.00	0.00	0.2113	1.00	1.33	0.4256
C1.5	7.67	13.00	0.0356	0.33	0.00	0.2113	0.00	0.00	-	0.00	0.00	-	0.00	1.33	0.2113
N20	16.33	12.00	0.2738	3.67	5.00	0.2652	2.00	0.00	0.2113	3.00	2.3 3	0.3459	0.00	0.00	-
N30	11.00	9.67	0.2282	3.00	1.33	0.1870	2.33	0.00	0.1678	2.00	2.33	0.4256	0.00	0.33	0.2113
G20	20.67	23.33	0.3546	4.67	5.00	0.4698	2.67	2.00	0.3863	4.00	4.33	0.4075	0.00	2.33	0.0959
G30	20.00	14.67	0.2201	4.00	2.67	0.1965	2.67	2.33	0.2593	3.33	4.67	0.2018	0.00	1.00	0.2113

C1.0 and C1.5= carbofuran at 1.0 kg a.i/ha and 1.5 kg a.i/ha respectively; N20 and N30= *A. indica* at 20 kg/ha and 30 kg/ha respectively; G20 and G30 = *G. arborea* at 20 kg/ha and 30 kg/ha respectively. P= Probability values at 5% level.

Table 4: Effects of season on stem borer population in 2010

	B. fusca			*S. calamistis*			*E. saccharina*			*C. partellus*			*C. ignefusalis*		
Treat	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*	Early	Late	*P*
Control	14.67	42.67	0.0096	4.67	10.33	0.0341	3.00	5.33	0.1388	4.33	6.67	0.0039	0.67	2.00	0.1914
C1.0	4.33	6.00	0.2367	1.33	4.00	0.0697	0.00	0.67	0.2113	1.00	1.00	0.5000	1.00	1.33	0.3998
C1.5	3.67	5.00	0.1914	1.00	0.00	0.1127	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-
N20	7.67	8.00	0.4208	3.00	5.00	0.1540	2.00	1.00	0.3425	2.00	2.33	0.4038	0.33	1.33	0.1361
N30	4.67	5.00	0.3257	2.00	1.33	0.3333	1.00	0.00	0.1127	1.00	1.00	0.5000	0.00	0.33	0.2113
G20	11.00	10.33	0.3493	4.00	4.67	0.3257	1.00	2.67	0.1689	2.33	3.00	0.1955	0.67	02.33	0.1560
G30	8.00	9.33	0.2459	3.33	2.67	0.3232	2.67	1.67	0.0506	3.33	2.33	0.1361	0.33	1.00	0.2958

C1.0 and C1.5= carbofuran at 1.0 kg a.i/ha and 1.5 kg a.i/ha respectively; N20 and N30= *A. indica* at 20 kg/ha and 30 kg/ha respectively; G20 and G30 = *G. arborea* at 20 kg/ha and 30 kg/ha respectively. P= T-test values values at 5% level.

Table 5: Effect of insecticides on maize yield (tonnes).

	2009		2010	
Treatment	Early	Late	Early	Late
Control	1.06 ±0.06b	0.89 ±0.05b	1.60 ±0.26b	1.73 ±0.06c
C1.0	2.06 ±0.06a	2.00 ±0.10a	2.84 ±0.10a	2.00±0.10b
C1.5	2.23 ±0.06a	2.00 ±0.17a	2.95 ±0.06a	2.34 ±0.10a
N20	2.00±0.10a	1.84 ±0.10a	2.73 ±0.06a	2.17 ±0.10ab
N30	2.20 ±0.06a	1.88 ±0.10a	2.90 ±0.06a	2.17 ±0.10ab
G20	1.22 ±0.22b	1.11±0.06b	1.50 ±0.10b	1.11±0.11d
G30	1.20 ±0.10b	1.00 ±0.11b	1.39 ±0.20b	1.06 ±0.06 d

Key – C1.0=Carbofuran at 1.0 kg a.i /ha, C1.5= Carbofuran at 1.5 kg a.i /ha, N20= *A. indica* at 20 kg/ha, N30=*A. indica* at 30 kg/ha,G20= *G. arborea* at 20 kg/ha, G30= *G. arborea* at 30 kg/ha

DISCUSSION

The results from this study showed that stem borer species recorded in 2009 and 2010 planting seasons included *Busseola fusca, Sesamia calamistis, Elana saccharina, Acigona ignefusalis,* and *Chilo partellus. Busseola fusca* was the most predominant borer species recorded in the Guinea agro-ecological zone for both seasons and years. This study showed that seasons, insecticide type and rates had significant ($P \leq 0.05$) effects on damage and population dynamics of stem borers in the two years. This has confirmed reports by Ajayi and Labe, 1990; Polaszek, 1998, that stem borer infestation and severity of damage vary with season, ecological zones and region depending on weather conditions. The early planting recorded significantly ($P<0.05$) lower borer population compared to late planting. This is in agreement with the reports by Bosque-Perez and Dabrowski (1989), Polaszek (1998) and Okweche, *et. al.* (2010) that early planting suffers less attack by borers but build up is higher in late season planting (September-/ October). Stem borer population and damage were significantly reduced by application of both Carbofuran and the bio-insecticides. The insecticidal properties of *A indica* products have been reported by many authors (Schmutterer, 1990; NRC, 1992; Emosairue and Ukeh, 1996)). Azadirachtin, the most active component of *A. indica* seed- oil has been reported to alter insect behavior due to its antifeedant, repellent and phagodeterrent properties (Schmutterer, 1990; NRC, 1992; Emosairue and Ukeh, 1996). Oparaeke (2005) reported the effectiveness of *Gmelina* fruit extract on the control of *Clavigralla tomentosicollis* and on *Maruca* pod borer on cowpea.

Generally, Carbofuran applied to the soil at the rate of 1.5 kg a.i/ha significantly reduced stem borer infestation and damage in agreement with the findings of Bosque-Perez (1992), Seshu and Sum (1992) and Polaszek (1998). Higher yield which was recorded in the Carbofuran and *A. indica* seed powder treated crops could be attributed to the lower larval population recorded in the study. Again, yields obtained from early season plantings were significantly higher than in late season planting, this report agrees with the findings of Okweche *et al.* (2010) which reported higher yield of maize in early planting than in late planting. The effects of stem borers on grain yield and quality of maize have been assessed by a number of research workers including Usua (1966, 1968) and Schulthess *et al.,* (1991). This study revealed a significant difference between yield of treated untreated crops.

In conclusion, heavy infestation and damage by stem borers in borer endemic zones may be reduced by early planting, since there was no significant ($P \geq 0.05$) differences in many cases in results obtained by applying carbofuran(a synthetic insecticide) and the two bio-insecticides used the later are preferred since they are environmentally more friendly. Besides, they are readily available, cheap and do not require robust processing to obtain the products hence can be recommended for use by the poor resource farmers.

REFERENCES

Ajayi, O. & Labe, D. A. (1990). The effect of sowing date and planting methods on stem borer damage in Dauro millet. Annals of Applied Biology, 117: 487-494

Balogun, O. S & Tanimola, O. S. (2001). Preliminary studies on the occurrence of stem borer and incidence of stalk rot under varying plant population densities in maize. Journal of Agricultural Research and Development, 1: 67-73

Benz, B. F. (1994). Maize: origin, domestication and development. In: Carraso, D. (editor). The Oxford Encyclopedia of Mesoamerican Cultures: the Civilization of Mexico and Central America. Oxford University Press, New York. Pp 147-150.

Bosque-Perez, N. A. & Dabrowski, Z. T. (1989). Mass rearing of the maize stemborer *S. calamistis* and *E. saccharina* at IITA. In : Towards insect resistant maize for the third world

Proceedings of the International Symposium on Methodologies for Developing Resistance to Maize Insects. CIMMYT, Mexico city. Pp 22-26.

Bosque-Perez, N. A. (1992). Major insect pests of maize in Africa. Biology and Control. *IITA Research Guide*, *30: 5-13.*

CIMMYT (2000). Meeting World Maize Needs: Technological Opportunities and Priorities for the Public Sectors. Mexico D . F. CIMMYT. 60pp.

Emosairue, S. O. & Ukeh, D. A. (1996). Field trials of Neem products for the control of okra flea beetles (*Podagrica* sp.) in South-Eastern Nigeria. *Afr . J. Plant Prot., 37: 22-26.*

Galinat, W. C. (1992). *Maize. Gift from America's First Peoples. Chiles to Chocolate. Food the Americans Gave the World.* University of Arizona Press, Tucson.

Gonzalez, R. F. (2001). *Zapotec Science: Farming and Food in the Northern Sierra Oaxaca.* University of Texas Press, Austin, U.S.A.

Kakule, T. O., Latigo, M. W. & Okoth, V. A. O. (1997). Distribution and damage by *Chilo partellus* (Swinhoe), *Busseola fusca* (Fuller), *Eldana saccharina* (Waller) and *Sesamia calamistis* (Hampson) in two locations in Uganda. *African Crop Science Journa, 5 (4) : 385 – 393.*

NRI (1996). Insect Pest of Nigerian Crops. Identification, Biology and Control Natural Resource Institute. Chatham, UK. Pp. 36-48

Ogunwolu, E. O. (1987). Efficacy of Carbofuran against lepidopterous stem borer of maize. *Nigerian Journal of Agronomy, 2(2):27-32*

Oigiangbe, O. N., Ivbijaro, M.F., Ewete, F. K. & Mutsaers, H. J. W. (1997). Incidence and damage caused by maize stem borer on farmers fields in South western Nigeria. *African Crop Science Journal, 5(3):295-302.*

Okweche, S. I., Ukeh D. A. & Ogunwolu E. O. (2010). Field infestation of three maize (*Zea mays* L.) genotypes by lepidopterous stem borers in Makurdi, Nigeria. *Global Journal of Agricultural Science, 9(1):41-45.*

Oparaeke, A. M. (2005). Studies on insecticidal potentials of extracts of *Gmelina arborea* products for control of field pests of cowpea, *Vigna unguiculata* (L.) Walp: The pod borer, *Maruca vitrata* and the coreid bug, *Clavigralla tomentosicollis. Journal of Plant Protection Research*, *43 (1)1-7*

Polaszek, A. (1998). *African Cereal Stem Borers: Economic Importance, Taxonomy, Natural Enemies and Control.* Wallingford, UK: CABI. 530 pp.

Schmutterer, H. (1990). Properties and potential of natural pesticides from the Neem tree, *Azadirachta indica. Annual Review of Entomology*, 35: 271-97.

Schulthess, F., Bosque-Perez, N. A. & Gonuous, S. (1991). Sampling lepidopterous pest on maize in West Africa. *Bulletin of Entomological Research*, *81: 297-301*

Seshu Reddy, K. V. & Sum, K. O. S. (1992). Yield infestation relationship and determination of injury level of the stem borer *Chilo partellus* (Swinhoe) in three varieties of maize, *Zea mays* L. *Maydica*, *37:371-376*

Sosan, M. B. & Daramola, A. M. (2001). Studies on the relationship between methods of assessing lepidopterous stem borer infestation and grain yield losses in maize (*Zea mays* L.). *Nigerian Journal of Plant Protection*, *18:12-20*

Ukeh, D. A; Emosairue, S. O; Udo I. A; & Ofem, U. A (2007). Field Evaluation of Neem (*Azardirachta indica* A. Juss) products for the management of lepidopterous stem borer of maize (*Zea mays* L.) in Calabar, Nigeria. *Research Journal of Applied Science*, *2(6) 653-658*.

Ukeh, D. A., Birkett, M. A., Bruce, T. J. A., Allan, E. J., Pickett, J. A. & Mordue (Luntz), A. J. (2010).

Behavioural responses of the maize weevil, *Sitophilus zeamais,* to host (stored- grains) and non-host plant volatiles. *Pest Management Science*, *66 : 44 – 50.*

Usua, E. J. (1966). Stem borers of maize in western Nigerian with particular reference to *Busseola fusca* (Fuller) and *Sesamia species* (Lepidoptera: Noctuidae). M.Sc thesis, University of Ibadan. Nigeria. 169pp

Usua, E. J. (1968). Effects of varying population of *Busseola fusca* larvae on growth and yield of maize. *Journal of Economic Entomology*, *61 (2): 375-376*

Single Nucleotide Polymorphism (SNP) Markers Discovery within *MUSA SPP* (PLANTAIN LANDRACES, AAB GENOME) for use in Beta Carotene (PROVITAMIN A) Trait Mapping

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ABSTRACT

The need for biofortification of staple crops has become the concern of Modern Nutritional Genomics in producing staple crops with the ability of accumulating high micronutrients. Beta-carotene (Provitamin A) biosynthesis pathway is a stepwise process which is coded by two main genes; *phytoene synthase (PSY)* and *lycopene beta-cyclase (LYB)*. These two important genes *LYB 7 and PSY 1 1* were amplified, sequenced and analyzed within various diploid and triploid plantain landraces to identify SNPs present and to study their potentials for mapping the quantitative trait loci in those genes brought about by climatic variation within plantain landraces over time and also reveal their phylogenetic relationship. A total of 7 SNPs were found in the two genes from 68 genotypes used for PSY 11 and 35 plantain genotypes for *LYB 7* gene. A frequency of 1 SNP per 80bp was detected in *LYB 7* and I SNP per 32bp in *PSY 11* gene of 160 bp sequences each. The allelic diversity was 0.0286 in *LYB 7* and 0.0147 to 0.0294 in *PSY* 11. The phylogenetic relationship revealed that the genotypes for *LYB 7* gene follow two distinct lines of evolution whereas in *PSY 11* gene, the genotypes are similar with Zue and Sel advancing a bit. From the research, the high frequency of SNPs detected showed that it is sufficient in mapping the quantitative trait loci associated with high beta-carotene synthesis and could be incorporated in plantain breeding program.

Keywords: *LYB 7, PSY 11*, Indels, *Musa species*, ORF, Quantitative trait, SNPs, transition, transversion

INTRODUCTION

Musa species belong to the family *Musaceae* together with the genus *Ensete.* They are the most important food crops, which rank fourth in the world (after rice, wheat and maize). The major edible cooking bananas are triploid, that is with 2n=3x=33 chromosomes, and are mostly male and female sterile issued from the hybridization of two wild diploid ancestors namely *Musa acuminata* (AA genome) and *M. balbisiana* (BB genome). The triploids are grouped into three major types: AAA (Cavendish or dessert bananas), AAB (plantain), and ABB (cooking or dessert bananas). Nearly 30 million tons of bananas are produced yearly in Africa, mostly by smallholders and consumed locally. Bananas are rich in potassium, manganese, vitamins and fiber but low in fat and help to reduce risk of colorectal cancer [1, 2, 3]. Evaluation of genetic diversity and genetic structure in crops has important implications for plant breeding programs and the conservation of genetic resources. With changes in the environmental conditions, the challenges of pests and diseases, nutrient content as well as genetic vulnerability have posed a threat to Musa production [4]. So, there is a need to breed for improved Musa plants with these agronomic traits so as to alleviate poverty and food insecurity especially in the developing countries. Global genetic diversity studies have shown to be found in landraces, subspecies and wild –related ancestors of the current commercial cultivars. Different plantain landraces have large genetic broad base and many plantain genotypes have evolved to adapt to various environments [5, 6]. In view of this, IITA conserves more than 100 plantain landraces segregating for several agronomic traits in different environments.

Moreover, *Musa* breeding is difficult and slow and requires integration of molecular techniques to achieve a faster result. Marker-assisted selection (MAS) has become a routine procedure in many breeding programs of major crops. Linkage Disequilibrium (LD) between DNA markers and quantitative trait loci, QTLs provides the basic principle of MAS that marker alleles are not randomly associated with QTL alleles [7]. *Musa* has been successfully studied with different molecular markers such as RFLP [8, 9, 10], AFLP [11, 12, 13, 14]; SSR [15, 16, 17] and SNP [5, 18]. In association with ploidy level, all these molecular methods led to clearer representations of the *Musa* complex [19].

Single nucleotide polymorphisms (SNPs) refer to specific and defined positions at a chromosomal site which the DNA sequence of two genotypes differ by a single base. This might be the result of a transition (purine to purine or pyrimidine to pyrimidine change) or transversion event (purine to pyrimidine interchange) or a small deletions or insertions (indels). SNP markers are effective in detecting genetic diversity. They are the most abundant occurring at a frequency of about one SNP in 1000 nucleotides in genomic DNA and can be used to directly detect alleles responsible for a trait of interest [6, 20]. The data from DNA microsatellites or SSR and SNP are known to be consistent with each other and independent of the techniques used to produce them and is reproducible between laboratories but SNPs produce more reliable data than microsatellites [21]. Single-nucleotide polymorphisms (SNPs) are the markers of choice for those crops where massive sequence data are available, such as ESTs from diverse germplasm. In SNP technique, primers are designed, aiming to span single alleles at a locus independently thereby allowing the identification of a specific allele [22]. They are co-dominant markers. Due to their abundance and distribution through-out the genome, they are preferred for mapping, marker-assisted breeding and map-based cloning [23].

Nevertheless, Carotenoids have been reported to have anticancer and antioxidant properties [24]. They help to prevent eye problems, skin disorders, heart diseases, and enhance immunity. Of all the carotenoids synthesized in plants, β-carotene is the most active and the best plant source of vitamin A. In the body, β-carotene is converted into retinol (vitamin A) by central cleavage by an oxygenase, yielding two molecules of retinal as against α-carotene that releases only one molecule with vitamin A activity [25]. Beta-carotene biosynthesis is a stepwise pathway of which geranylgeranyl-diphosphate (GGDP) is the key intermediate. The pathway splits into two mutually exclusive branches, only one of which leads to β-carotene which is of interest. The genes lycopene *β-cylase* and *phytoene synthase*, have been reported to be the most important in beta-carotene biosynthesis [26].

Furthermore, the knowledge of the biosynthetic pathway of some genes has led to the production of biofortified crops with the ability of producing and accumulating the desired micronutrients in the edible portions of the plant's own biosynthetic (vitamins) or physiological (mineral) capacity [27]. Biofortified crops may be obtained through conventional breeding (interbreeding with wild relatives) or genetic engineering. An example of known vitamin A biofortified crop is the golden rice which was produced by insertion of two genes responsible for the synthesis of β-cartene [25].

Furthermore, Vitamin A deficiency (VAD) severely affects the immune system. According to WHO, an estimated 127 million children are affected by vitamin A deficiency, with 250,000 to 500,000 children becoming blind every year; half of whom die within a year [28]. *Musa spp* have been shown to have met the minimum nutritional requirement by FAO [29]. Improving the beta-carotene content of plantains will help to increase the micronutrients of plantain consumed by people especially in the developing countries like Africa where there are high cases of malnutrition, blindness and have the highest percentage of plantain consumption [29]. This research work aims at generating SNP markers at beta carotene biosynthetic pathway in diploid and triploid plantain. The SNP markers generated will be used for association mapping, and the SNP tightly linked to beta-carotenoid trait will be recommended and used to assist breeding in *Musa*.

MATERIALS AND METHODS

Plant Material and DNA Extraction

Sixty-eight different plantain germplasms used were obtained from the International Institute of Tropical Agriculture (IITA) plantain field germplasm. The DNA was extracted from the young emerging (cigar) leaves following the DNA miniprep Extraction protocol of Doyle and Doyle [5, 30].

Primer Design

PCR primers were designed using primer program and the sequence of partial and complete cDNA. *PSY 11 (Phytoene synthase), LYB 7 (Lycopene β-cyclase)* genes sequences used are available at NCBI [31] under accession number HM59159 and HM59169 respectively. Sequences of PSY *11* and *LYB 7* genes were PCR amplified for the sixty-eight selected plantain genotypes using the following forward (F) and reverse (R) primers:

PSY 11F (Phytoene synthase):	5´-GTGTGGTGTAGGAGGACAGATGAG-3´
PSY 11R:	5´-GCTCTCTTTGTGAAGTTGTTGTA-3´
LYB 7F (Lycopene β-cyclase):	5´-TGAGCTTCCCATGTATGACCC-3´
LYB 7R	5´-ACTGGGAGTGGACCACCCAT-3´

PCR and Sequencing

PCR reaction mixes were prepared for each sample by mixing 5 µl of Red Taq ready-mix (Sigma) which comprises of PCR buffer, dNTP, $MgCl_2$ and sterile water, o.5 µl each of Forward and Reverse primers and 4 µl of genomic DNA (15 ng/µl) making a total of 10 µl for one reaction. The cycling parameters for the PCR were set at an initial 94^oC for 3 minutes, followed by 37 cycles of 94^oC for one minute, annealing step for 45 minutes of 60^oC – 51^oC of 1^oC touchdown for *PSY 11* and *LYB 7* forward and reverse primers, 72^oC for 30 minutes and a polishing step of 72^oC for 5 minutes. Products were separated by 2% agarose gel electrophoresis run at 100 Volts to check for efficiency of amplification and to ensure that only a single band product of the expected size was present. PCR products were then transferred to ABI plates and sequenced three times with the forward primers used in the PCR amplification.

SNP Marker Discovery

The approach to the discovery of single nucleotide polymorphisms (SNPs) is through direct sequencing of PCR products of the *Musa* genotypes on ABI ROBOT sequencer. Polymorphisms between the sequences were identified by sequence alignment using ClustalW. The SNPs were detected by aligning different *Musa* accessions using the software CLUSTALW2 available at European Bioinformatics Institution, EBI [32]. The files downloaded were then aligned with the software GeneDoc [33] to show the conserved sites and mutation sites for SNP detection.

Furthermore, the sequence trace outputs from the sequencer were evaluated by eye to identify possible areas of heterozygous sequence. To increase the quality of sequences by minimizing false positives due to sequencing artifacts, potential SNPs were resequenced. Areas with ambiguous bases and baseline noise were removed usually at the beginning and at the end of the sequence. Since SNP analysis requires the highest sequence quality, the SNPs were detected from the Open Reading Frame (ORF), from the conserved sequence site in all the genotypes mostly about some distances from the beginning of the sequence spanning through the middle of the sequence. Sequences at the end of the gel at low resolution are cut off as it is prone to more oddly peaks and unidentifiable nucleotide bases.

Genetic Diversity and Data Analysis

To each SNP marker, two alleles are generally present because of its biallelic nature. Allelic frequencies for each marker were estimated by counting to determine the level of heterozygosity (h). This will help to measure the ability of a marker to adequately differentiate a genotype from another genotype effectively if it is present in only at that genotype. So low level of heterozygosity indicates the presence of a SNP at one or limited number of genotypes at a locus. Power of discrimination (PD) is the measure of the ability of the marker at different loci. It is used to measures the possibility of each marker to identify a locus was calculated using the formula [34].

$$PD = 1 - \sum_{i=1}^{g} f_i^2$$

Where f_i is the frequency of the ith genotype and the sum is over all genotypes.

The level of similarity among the different genotypes for a gene was estimated using online tool software, MrBayes [35]. Based on the genetic similarity matrix, the genotypes were clustered by the Maximum Likelihood (PhyML) with Bayesian analysis using the program Tool from Phylogenetic tree Service Tool of MrBayes-PhyML [35] to show the evolutionary relationship.

RESULTS

Single Nucleotide Polymorphism Detection

After editing and trimming the chromatogram PCR sequence products for the two genes (*LYB 7* and *PSY 11*), the good quality sequence were aligned for all the good genotypes. From the multiple sequence alignment of ClusterW2 [32], the conserved regions are the shaded portions forming blocks with few gaps indicating SNPs and Indels (Insertions and Deletions) (Fig 1 and 2). The SNP detection was obtained from the Open Reading Frame (ORF) regions of the sequences using ORF finder from NCBI website [31].

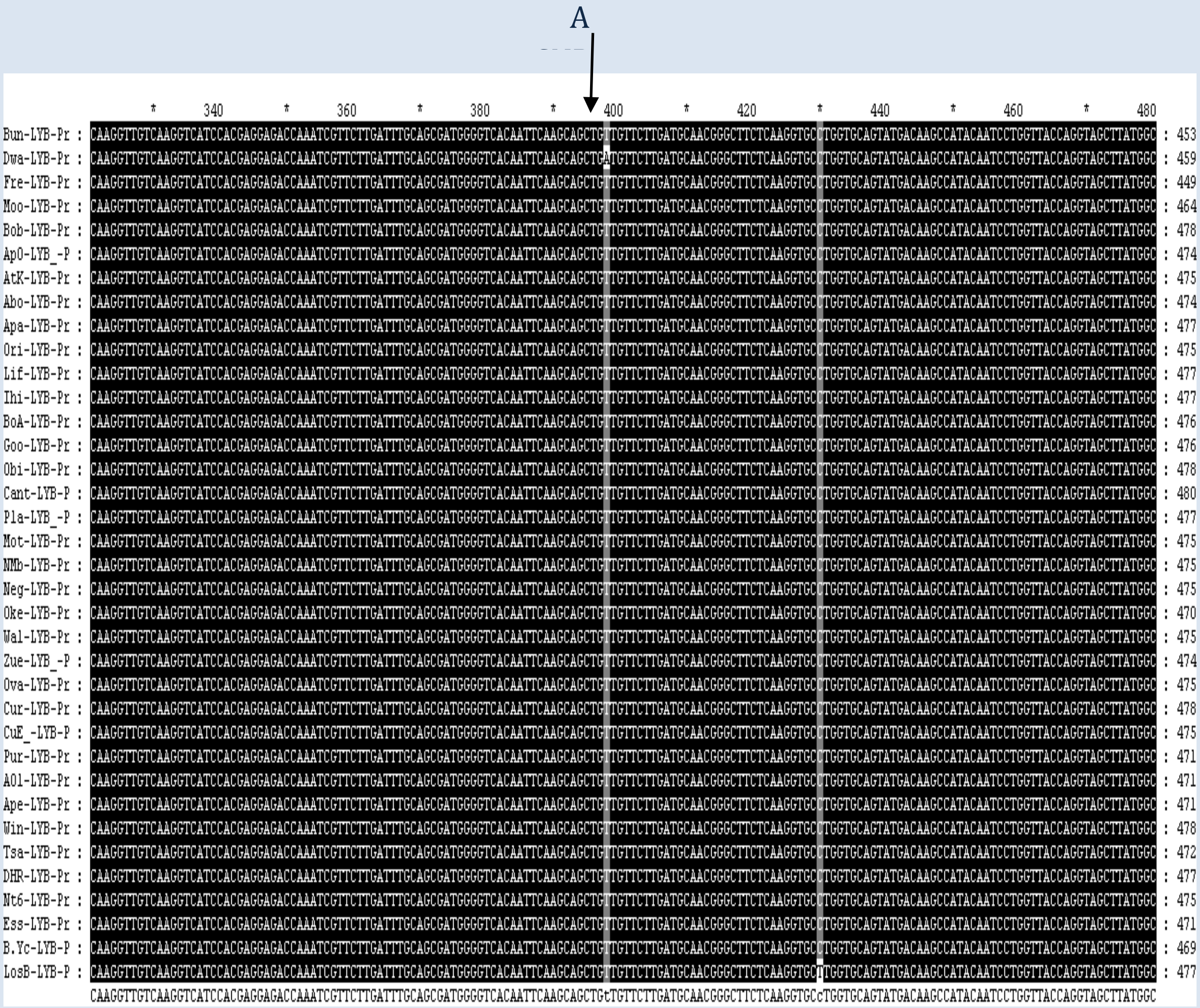

Fig. 1. Multiple sequence alignment obtained for *Lycopene beta-cyclase* (LYB 7) using GeneDoc Software [33].

The shaded portions are the Conserved sequences among the Musa genotypes while the gaps (unshaded) are the SNPs.

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Fig. 2. Multiple sequence alignment obtained for *Phytoene synthase* (PSY 11) using GeneDoc Software [33]

For *LYB 7* gene, within the 160bp quality sequences each from 35 different diploid and triploid plantain and wild *Musa* genotypes used for SNP analysis (Fig. 1), two SNPs were detected at mutant loci 398 and 430 as shown in the Table 1. No Indel was found for LYB gene. *Dwa* and *Losb* genotypes have one mutant (SNP) locus each. The SNP base pairs are in bold italics.

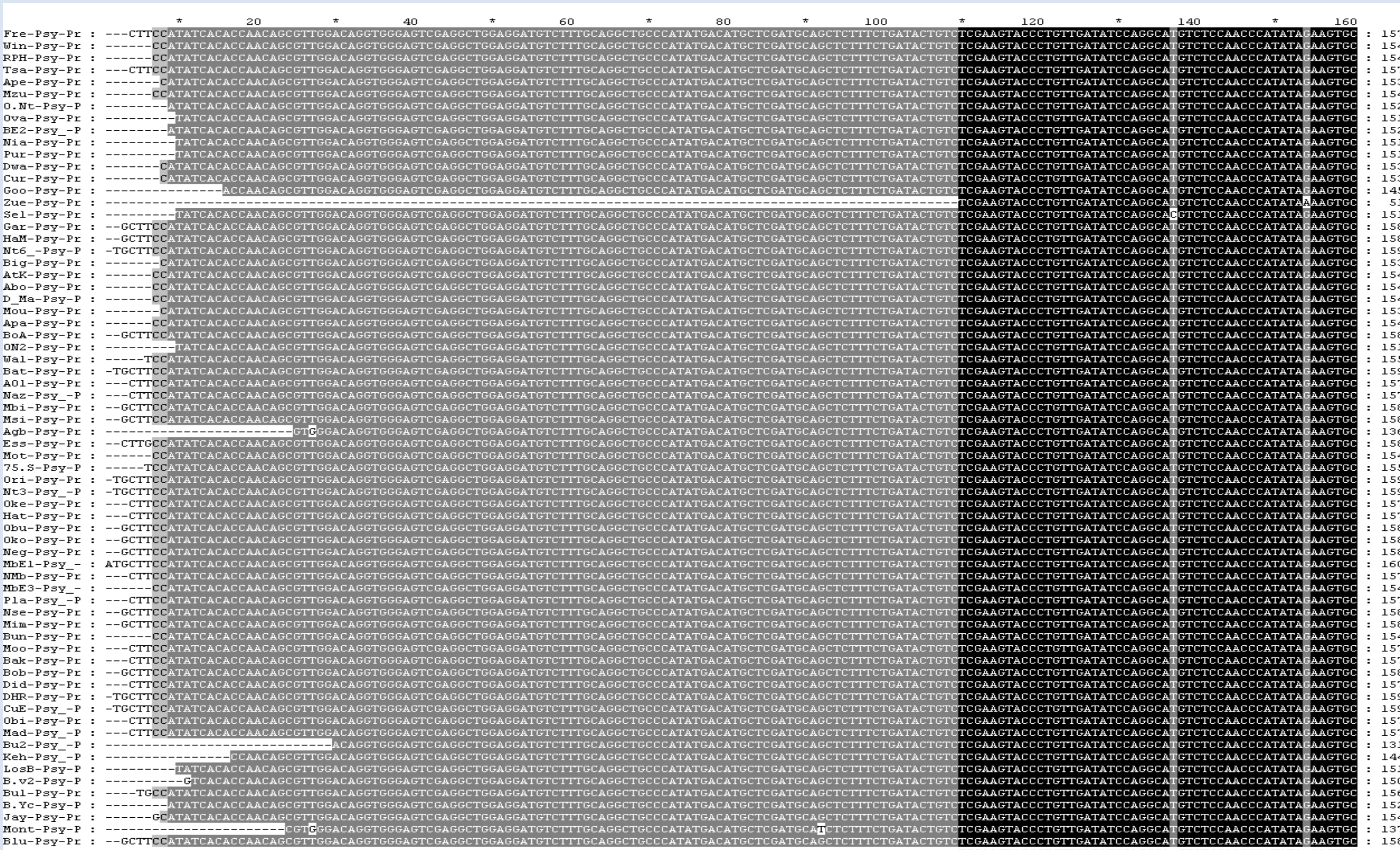

Table 1. SNPs detected at two mutant sites of *Lycopene beta-cyclase 7* (*LYB7*) genes along the 160bp amplicon sequence of the genotypes

SNP site Genotypes	398	430	No of Mutant
Dwa	***A***	C	1
Losb	T	***T***	1
No of Mutant per loci	1	1	
SNP TYPE	V	T	2

V= transversion T=transition

The *PSY 11* gene for beta-carotene biosynthetic pathway is less polymorphic. From the 160 bp sequences of the multiple alignment of 68 genotypes (Fig. 2), five SNP sites were obtained (Table 2) within the ORF region at loci 11, 27, 92, 137 and 154. The base pair in bold italics indicates the mutant alleles (SNPs). Mont has the highest number of SNP loci (2) and Agb, B.v2, Sel and Zue have one each. No Indel was detected within the 160bp sequences analysed.

Table 2. SNPs detected at various six mutant sites of *Phytoene synthase 11* (*PSY11*) genes along the 160 bp amplicon sequence of the genotypes

SNP site Genotypes	11	27	92	137	154	No of Mut
Agb	A	***G***	G	T	G	1
Mont	A	***G***	***T***	T	G	2
B.v2	***G***	T	G	T	G	1
Sel	A	T	G	***C***	G	1
Zue	A	T	G	T	***A***	1
No of Mutant per loci	1	2	1	1	1	
SNP TYPE	T	V	V	T	T	6

V= Transversions T=Transitions

In *LYB* 7, 50% each of SNPs detected was as a result of transition (purine-purine or pyrimidine-pyrimidine interchange) and transversion (purine-pyrimidine interchange) events. In *PSY 11*, 60% of SNPs detected was as a result of transition and 40% due to transversion.

Table 3. SNPs found along the beta-carotene pathway for *Lycopene beta-cyclase* and *Phytoene synthase* genes

Gene		Average per sequence	Average per loci	Minimum per loci	Maximum per loci	Minimum per sequence	Maximum per sequence	Total base sequence analysed	% variation
LYB 7	SNPs	0.057	0.013	0	1	0	1	160 (1 per 80bp)	1.25
PSY 11	SNPs	0.0735	0.025	0	2	0	2	160 (1 per 32bp)	3.125

The frequency of occurrence of the SNPs (Table 3) at each SNP locus was at 1 SNP per 80bp (1.25%) for *LYB 7* gene and one SNP in every 32bp (3.125%) for *PSY 11* gene. An average of 0.057 SNPs were found at each sequence of *LYB 7* with maximum number of 1 SNP per sequence and locus respectively. There is an average of 0.0735 SNP per sequence with a maximum number of 2 SNPs per locus and 2 SNPs per sequence for *PSY 11* gene.

Allelic and Genetic Diversity

The SNPs are biallelic in nature so can have two possible alleles at a locus. The level of heterozygosity (h) ranged from one mutant allele for *LYB 7* gene, 1.47% for one mutant allele to 2.94% for two mutant alleles in *PSY 11*. The power of discrimination (PD) of a mutant allele of a genotype at a locus calculates the ability to distinguish between genotypes at a locus based on the frequency of mutant alleles and from one locus to another. The power of discrimination of the mutant allele at each SNP locus were estimated (Table 4) which varied from 0.8163 for *PSY 11* (27) to 0.9998 for *PSY11* (11, 92, 137, 154) with an average of 0.9734.

Table 4. Features and Frequencies of the new SNPs

Gene	SNPs	SNP Type	Observed Heterozygosity, h (%)	Frequency of SNP allele	Power of discrimination, PD (%), $[1-\sum_{i=1}^{g} f_i^2]$
LYB7	LYB7 398*	T/A	2.86	1	99.92
	LYB7 430	C/T	2.86	1	99.92
PSY 11	PSY11 11	A/G	1.47	1	99.98
	PSY11 27	T/G	2.94	2	81.63
	PSY11 92	G/T	1.47	1	99.98
	PSY11 137	T/C	1.47	1	99.98
	PSY11 154	G/A	1.47	1	99.98

*relative to the nucleotide sequence number (see fig. 1 and 2) h is a measure of allelic diversity of the SNP. *PD* = Power of discrimination

Phylogenetic Relationship

The phylogenetic tree for the different genes using MrBayes software of Maximum likelihood with Bayesian analysis showed that the genotypes are all monophyletic originating from a common ancestor.

For *LYB 7* gene (Figure 3), Hat (AAB), Msi (AAB), MPL (BB), Bv2 (BB), Mou (AAB), Bat (AAB), Ser (AAB), Mad (AAB), Jay (BB), Blu (ABB), Big (AAB) genotypes follow the same line of evolution. Big diverging first from the node, followed by Blu, then Jay. The triploids Hat, Msi and Mou are sister taxa of which the diploids MPL (BB) and B.v2 (BB) must have one of their parents because of the relatedness. Bat, Ser and Mad are closely related though Mad genotype for *LYB 7* gene is the most advanced. In the second line of evolution, DMa (AAB) and D500 (AAB) are related and distinct from the rest, followed by Gar (AAB), then Mol (AAB), Nse (AAB), Fre (AAB), Mal (AA), LosB (BB), Atk (AAB), and Moo (AAB). Oke (AAB), Cant (AAB), BoA (AAB), Bob (AAB) and Cur (AAB) (sister taxa) are closely related from which Wal (AAB), A01 (AAB), Mot(AAB) and Ape (AAB) diverged from and are the most recent of their group. The diploids Mal (AA) and LosB (BB) might have been distant parents to the triploids Atk, Moo, Oke, Cant, BoA, Bob, Cur, Wal, A01, Mot and Ape.

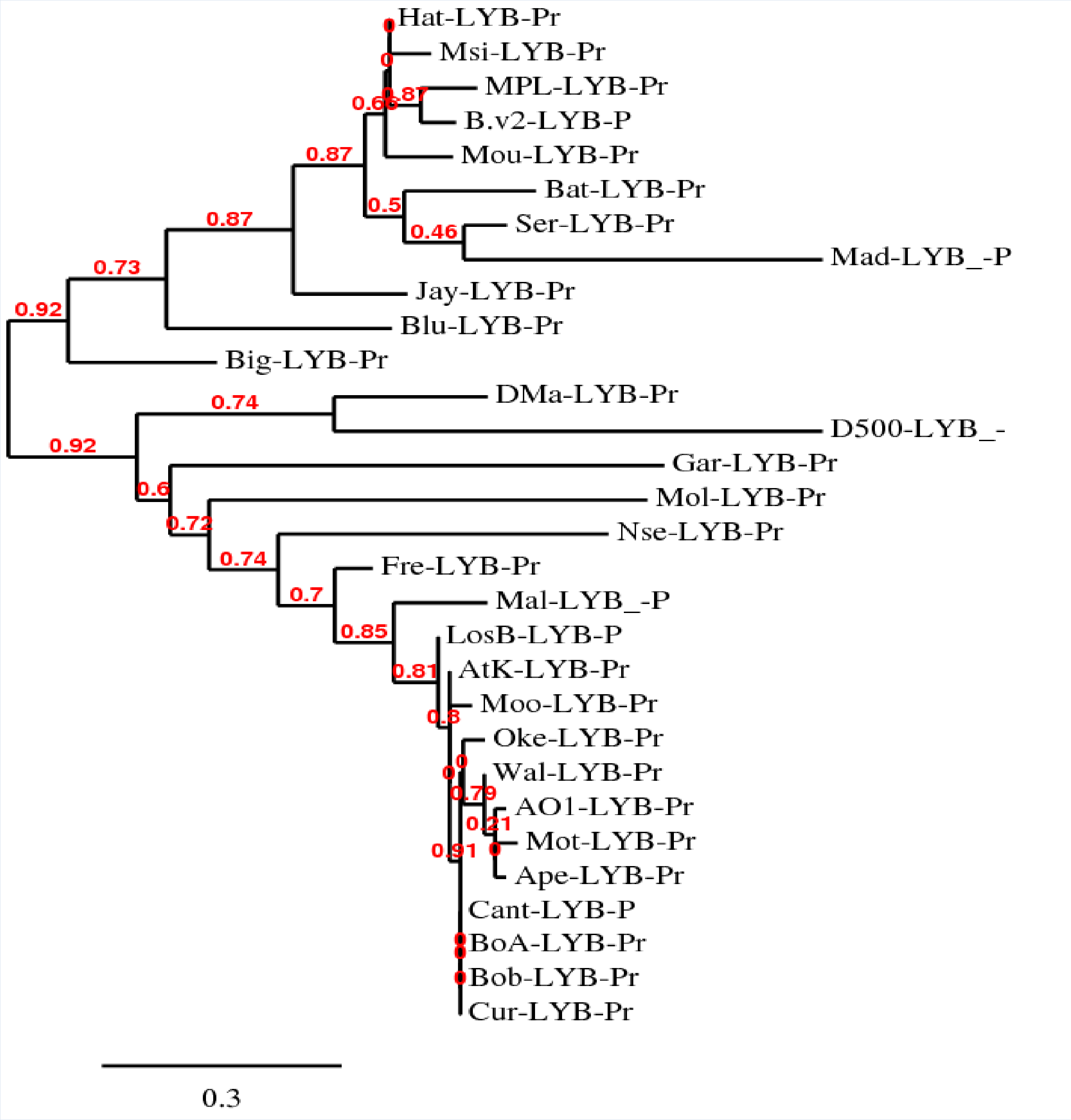

Fig. 3. Phylogenetic tree for *LYB 7* gene (p=0.3)
Source [35]

For *PSY 11* gene (Fig. 4), all the genotypes are almost uniform though sel (AA) and Zue (AAB) are the most advanced within the group. All the genotypes are related at 99% (p=0.01) level of significance.

Fig. 4. Phylogenetic tree for *PSY 11* gene (p=0.01)   Source [35]

DISCUSSION

The high frequency of transition to transversion found in the SNPs for *PSY 11* and *LYB 7* gene (table 1 and 2) along the beta-carotene biosynthetic pathway showed that there are more transition events to transversion for the SNPs discovered which is in conformation with the reports of [18, 33]. SNPs of Dwa 398 and Losb 430 were the only mutant allele found along *LYB* gene sequence coding for beta-carotene. So these two SNPs might be potential markers for high beta-carotene production. Also for PSY gene, Agb and Zue having one SNP each are triploids. SNP found in Agb is also found in the wild plantain (Mont) so can have high beta-carotene content. Zue has a SNP not present in the wild plantains so may be a potential marker for high carotene production. Wild plantain genotypes like Mont, Yv1, MPL and triploid plantains with a fair level of SNP loci can be integrated into breeding work of *Musa*. This is done by cultivating the triploids in close links with those diploids (wild plantains) found to have high SNP loci [37].

The SNP types C/T, T/G,G/T,A/C,C/A,A/T,T/A,G/A,A/G have effects on the amino acids resulting from gene translation. Welsch *et al* [38] have shown that the SNP at the 57bp of *PSY2* gene is associated with yellow root color in cassava. So these SNPs identified can have synonymous effect when it affects the gene product or non-synonymous or silent effect when it has no effect on the gene product. Comparing the Phylogenetic analysis among the Musa genotypes for the two genes, the phylogenetic tree was able to depict the line of evolution of some diploids together with triploid plantain landraces assumed to have originated from them [5]. The triploids were generally observed to be related with little difference due to the problem of homologues i.e. non- allelic, versions of genes residing on homologous chromosomes [39] and also because they are vegetatively propagated unlike the diploids that have more genes interchange due to sexual reproduction. For *LYB 7* (Fig 3), the genotypes used followed two distinct line of evolution with A01, Mot, and Ape been the most recent in terms of the *LYB* gene. Whereas in the *PSY* (Fig. 4) phylogenetic tree, the genotypes are similar to each other though Sel and Zue have advanced a bit. The uniformity of the genotypes for *PSY 11* confirmed the role of *PSY* gene as a single gene controlling the presence or absence of any carotene [25, 26, 38, 40].

In conclusion, different SNPs were identified which explored the polymorphisms at the conserved sequences of *Musa* genes. The SNPs also identified the genotypes therefore solving the problems of Homonymy and synonym especially in *Musa* genotypes. So SNP Markers would help in reducing genotyping costs and provide a rapid and easy way to establish fingerprint of each landrace use in genotype identification and for the different biosynthetic pathway mobility. This research will find important application in breeding, agronomic practice and ecosystem research.

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REFERENCES

[1] Hippolyte, I. and Roux,N. (2005). Molecular Markers for Allele Mining *Proceedings of a workshop, 22–26 August 2005, MS Swaminathan Research Foundation, Chennai,* India M. Carmen de Vicente, M and Glaszmann, J *editors* International Plant Genetic Resources Institute, Generation Challenge Programme. P26.

[2] Wong. J. (2011)."The Pursuit of Happiness (A.K.A. It Appears That The Writer Wrote About Bananas After Eating A Few Too Many)". The Science Creative Quarterly, University of British Columbia. Available online at http://www.scq.ubc.ca/the-pursuit-of-happiness-aka-it-appears-that-the-writer-wrote-about-bananas-after-eating-a-few-too-many/.

[3] Wikipedia encyclopedia (2011). Banana. Retrieved online on 18th May, 2011 from http://en.wikipedia.org/wiki/Banana

[4] Kumar, P. (2010). Biotech Bananas. Biotech Protecting the Banana Plant from Diseases. Available online at http://www.biotecharticles.com/

[5] Adesoye, A., Mmeka, E. and Vroh, B. (2012). Single Nucleotide Polymorphism Markers Discovery in *Musa Spp* (Plantain Landraces, AAB Genome) and its Potentials for Use in Gibberellic Acid and Parthenocarpy Trait Mapping. *J Plant Mol Biol Biotechnol 3*(1): 9-21

[6] Ren J, Sun D, Chen L, You FM, Wang J, Peng Y, Nevo E, Sun D, Luo MC, Peng J. (2013). Genetic diversity revealed by single nucleotide polymorphism markers in a worldwide germplasm collection of durum wheat. *Int J Mol Sci.* 14(4):7061-88.

[7] Utomo, H. S. and Linscombe, S. D. (2009). Current Patents and Future Development Underlying Marker –Assisted Breeding in Major Grain Crops. *Recent Patents on DNA & Gene Sequences 3*: 53-62.

[8] Carreel, F., Fauré, S., Gonzalez De Leon, D., Lagoda, P., Perrier, X., Bakry, F., Tézenas du Montcel, H., Lanaud, C. and Horry, J.P. (1994). Evaluation de la diversité génétique chez les bananiers diploïdes (*Musa sp*.). *Genetics Selection Evolution 26*:125-136.

[9] Gawel, N.J., Jarret, R and Wittemore, A.P. (1992). Restriction fragment length polymorphism (RFLP)-based phylogenetic analysis of *Musa. Theoretical and Applied Genetics 84*:286-290.

[10] Jarret, R., Gawel, N., Wittemore, A.P., and Sharrock, S. (1994). RFLP-based phylogeny of *Musa* species in Papua New Guinea. *Theoretical and Applied Genetics* 84:579-584

[11] Noyer, J.L., Causse, S., Tomekpe, K., Bouet, A. and Baurens, F.C. (2005). A new image of plantain diversity assessed by SSR, AFLP and MSAP markers. *Genetica 124*: 61–69.

[12] Ude, G., Pillay, M., Nwakanma D. and Tenkouano, A. (2002b). Genetic diversity in *Musa acuminata* Colla and *Musa balbisiana* Colla and some of their natural hybrids using AFLP markers. *Theoretical and Applied Genetics* 104:1246-1252.

[13] Ude, G., Pillay, M., Nwakanma D. and Tenkouano, A. (2002a). Analysis of genetic diversity and sectional relationships in *Musa* using AFLP markers. *Theoretical and Applied Genetics 104*:1239-1245.

[14] Wong. C., Kiew, R., Argent, G., Set, O. Lee , S.K and Gan, Y.Y. (2002). Assessment of the validity of the sections in *Musa* (Musaceae) using AFLP. *Annals of Botany 90*:231-238.

[15] Creste, S., A. Tulmann , N., Vencovsky, S.O. Silva and Figueira, A. (2004). Genetic diversity of *Musa* diploid and triploid accessions from the Brazilian banana breeding program estimated by microsatellite markers. *Genetic Resources and Crop Evolution 51*:723-733.

[16] Grapin, A., Noyer,J.J., Carreel, F., Dambier, D., Baurens, F.C., Lanaud, C and Lagoda, P.J.L. (1998). Diploid *Musa acuminata* genetic diversity assayed with sequence tagged microsatellite sites. *Electrophoresis* 19:1374- 1380.

[17] Lagoda, P.J.L., Noyer, J.L., Dambier, D., Baurens, F.C., Grapin, A. and Lanaud, C. (1998). Primer note – Sequence tagged microsatellite site (STMS) markers in the Musaceae. *Molecular Ecology* 7:659-663

[18] Hearne, S. J., Lorenzen , J., Town, C., and Zhuang, E. (2009). EST derived genomic resources for Musa. *IITA Report* .2008. www.IITA.org.

[19] Perrier, X., Bakry, F., Carreel, F., Jenny, C., Horry, J., Lebot, V. and Hippolyte, I (2009). Combining Biological Approaches to Shed Light on the Evolution of Edible Bananas *Ethnobotany Research & Applications 7*:199-216. Available online at www.ethnobotanyjournal.org/vol7/i1547-3465-07-199.pdf

[20] Wang, D. G., Fan J. B., Siao, C. J, Berno, A., Young, P., Sapolsky, R., Ghandour, G., Perkins, N., Wincheter, E., Spencer, J., Kruglyak, L., Stein, L., Hsie, L., Topaloglou, T., Hubbell, E., Robinson ,E., Mittmann, M., Morris M.S., Shen, N. P., Kilburn, D., Rioux, J., Nusbaum, C., Rozen, S., Hudson, T. J, Lipshutz, R., Chee, M., Lander E. S. (1998). Large-scale identification, mapping and genotyping of SNP in the human genome. *Science*, *280*:1077-1082.

[21] Magnid, C. R. (2006). Comparing techniques Review: AFLP Data Interpretation and Analysis. Sequence-tagged site markers, RFLPs, RAPDs/Arbitrary techniques, SNPs, Diversity Arrays, Microsatellite. Dr. Cs. Forestales Depto. de Silvicultura Facultad de Cs. Forestales Universidad de Chile Santiago de Chile

[22] Bhat, K.V. (2005). *DNA fingerprinting and cultivar identification.* National Research Center on DNA fingerprinting, N.B.P.G.R, New Delhi -011 012

[23] Nageswara-Rao, M. and Soneji, J. R. (2008). Molecular Genetic Markers: What? Why? Which one for Exploring Genetic Diversity? Retrieved online from www.scienceboard.net/community/perspectives.210.html

[24] Handelman, G.J. (2001). The evolving role of carotenoids in human biochemistry. *Nutrition 17*:818-822.

[25] Mayer, J.E. (2007). Golden Rice, Golden Crops, Golden Prospects. *Rev. Colomb. Biotecnol. 9* (1): 22-34.

[26] Warburton, M. L. (2010). Identification and Use of Rare Natural Genetic Sequence Variation to Improve Levels of β-Carotene in Maize. *ISB News Reports* June 2010.

[27] Mayer, J. E., Pfeiffer, W.H. and Beyer, P. (2008). Biofortified Crops to Alleviate Micronutrient Malnutrition. *Journal of Current Opinion in Plant Biology* 11:166-170.

WHO database of vitamin A deficiency; http://www.who.int/vmnis/vitamina/data/en/index.html).

[28] FAOSTAT (2009). *Acting together against banana diseases.* Food and Agricultural Organization Statistics. Available online at http://www.fao.org

[29] Doyle J J, Doyle J L, 1990. Isolation of plant DNA from fresh tissue. Focus 12:13-15

[30] National Center for Biotechnology Information, NCBI. (2011). http://www.ncbi.nlm.nih.gov

[31] EBI (2011). European Bioinformatics Institution (http://www.ebi.ac.uk/Tools/Services/web_Clustal2).

[32] GeneDoc (2011). www.psc.edu/biomed/genedoc

[33] Kloosteman , A. D., Budowle, B. and Daselaar, P.(1993). PCR-amplification and detection of the human DIS80 VNTR locus. Amplification conditions, population genetics and amplification in forensic analysis. *International Journal for Legal Medicine*, 7: 257-264.

[34] Dereeper, A., Guignon, V, Blanc, G., Audic S, Buffet S, Chevenet F, Dufayard, J.F, Guindon, S, Lefort V, Lescot M, Claverie J.M, Gascuel, O. (2008). Phylogeny.fr: robust phyogenetic analysis for the non-specialist. Nucleic Acids Res, 1; 36 (Web server issue) W 465-9 (http://www.phylogeny.fr/version 2_cgi.index.cgi)

[35] Shaheen, T., Zafar, Y. and Mehboob-ur, R. (2010). Detection of Single Nucleotide Polymorphisms in the conserved ESTs regions of Gossypium arboretum. *Electronic Journal of Biotechnology, 13*: 1-10. Available online at http://www.ejbiotechnology.info.

[36] De Langhe, E., Hribova, E., Carpentier, S., Dolezel, J., and Swennen, R. (2010). Did backcrossing contribute to the origin of hybrid edible bananas? Annals of Botany Page 1 of 9 doi:10.1093/aob/mcq187, available online at www.aob.oxfordjournals.org

[37] Welsch, R., Arango, J., Bar. C., Salazar. B., Al-Babili. S., Beltra. J., Ba. R., Salazar. B., Chavanrriaga. P., Ceballos. H., Tohme. J., and Beyer. P. (2010). Provitamin A Accumulation in cassava (*Manihot esculenta*) Roots Driven by a Single Nucleotide Polymorphism in a Phytoene Synthase Gene. *Plant Cell*. 22(10) 3348-3356.

[38] Henry R, Edwards K. 2009. New tools for single nucleotide polymorphism (SNP) discovery and analysis accelerating plant biotechnology. Plant Biotechnology Journal 7(4): 311

[39] Welsch. R. (2011). A Single Nucleotide Polymorphism in a Phytoene Synthase Gene can Simplify Provitamin A Biofortification of Cassava. *ISB News Reports* March 2011. 1-3

Shelf Life Extension of *Telfairia occidentalis* Hook 'ugu' Leaves in Novel Cooler Baskets in Nigeria

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ABSTRACT

Telfairia occidentalis Hook ('ugu') is an important indigenous vegetable which is widely eaten in Nigeria and cultivated for its edible succulent shoots and leaves. The vegetable is recognized as a national vegetable and recommended by medical doctors, nutritionists, and dieticians for treatment of anaemia. This study investigated the shelf life extension of freshly harvested *T. occidentalis* leaves in cooler vegetable baskets developed in the Nigerian Stored Products Research Institute. *Telfairia occidentalis* was harvested and purchased from Imaisong farm. The coolers were constructed with 75L capacity perforated plastic baskets and covers overlaid outside with polystyrene foam and covered inside and outside with polypropylene sheet. The cooler baskets were wetted with potable water and drained before use to remain moist. About 1.5kg portions of the vegetables were stored in the conditioned cooler baskets in three replicates. The control batch was stored in plastic vegetable crates and covered with mango leaves in a ventilated fruit and vegetable shed. Each batch was examined and their physical parameters: relative humidity and temperature were monitored for 8 days. The vegetables stored in the cooler baskets maintained freshness for 7 days compared to 3 days for control. The relative humidity in the cooler baskets was higher than that of the ambient and this enabled the vegetable to store longer than the stakeholders' usual practice in handling the vegetables. The weight loss recorded for those stored in the baskets was 43.8% while the control was 89.6% on the eight day of the experiment. The cooler basket stored the vegetables better than the usual method adopted by the farmers and marketers of *T. occidentalis.* This study shows that the technology has prospects for value addition in postharvest handling and storage of *T. occidentalis* with emphasis on food research for diet and health for vulnerable group of the society; children, women, the elderly and the sick to prevent anaemia.

INTRODUCTION

Telfairia occidentalis is a tropical vine grown in West Africa as a leaf vegetable and for its edible seeds. Common names for the plant include Fluted gourd, Fluted pumpkin, and Ugu. *Telfairia occidentalis* Hook. F. (Fluted pumpkin), member of the family Cucurbitaceae is a cotyledonous plants (2n=24) with about 90 genera and more than 700 species, which are distributed all over the warm parts of the world [1, 2]. It is an important leaf and seed vegetable indigenous to southeastern Nigeria, and found throughout the former forested areas from Sierra Leone to Angola and up to Uganda in East Africa. *T. occidentalis* is closely related to *Telfairia pedata* (Sims) Hook. (Oyster nut) [3] found in Zanzibar and along the coast of Kenya, Tanzania and Mozambique.

Among the important indigenous vegetables, *Telfairia* seems to be widely eaten in Nigeria and cultivated for its edible succulent shoots and leaves as commercial crop during the wet and dry season. *Telfairia* leaves are rich in Mg, Fe and fibres [4]. The vegetable is recognized as a national vegetable as is a good source of vitamin C, micronutrients and roughage in diet and recommended by medical doctors, nutritionists, and dietiticians for treatment of anemia Due to the awareness created on the importance of the nutritional values, *Telfairia occidentalis* is now widely cultivated, traded and eaten in almost all the parts of Nigeria [5]. The young shoots and leaves of the female plant are the main ingredients of a Nigerian soup, *edikang ikong*. The large (up to 5 cm), dark-red seed is rich in fat and protein, are in high demand as they serve as food oil for making margarine and can be eaten whole, ground into powder for another kind of soup, or made into a fermented porridge [6].

The response of *T. occidentalis* in respect to storage in hot and humid condition is rotting and decaying while it wilts rapidly under a dry condition. *Telfairia* leaves can be stored in a polypropylene sack for 3 days in a cool place like other leafy vegetables [6].
This study is aimed at extending the shelf life of freshly harvested *Telfairia occidentalis* in a novel cooler basket developed by the Nigerian Stored Products Research Institute.

MATERIALS AND METHODS

A passive evaporated cooler was constructed by lining plastic basket on the outer surface with tight polystyrene foams of 5mm thickness and covered with polypropylene sacks. The cover of the plastic was done likewise. The novel basket was wet with water. *Telfairia occidentalis* were harvested from Imaisong farm in Ilorin metropolis. The novel baskets were conditioned for storage before use by dipping both basket and lid in potable water and draining for 1hr. The vines were cut to lengths of 55cm to include the tendrils. About 1.5kg portions of the vegetables were stored in the conditioned cooler baskets in three replicates avoiding pressures on the vegetables. Similarly 1.5kg portions of the vegetables which served as the control batch was stored in plastic vegetable crates and covered with mango leaves in a ventilated fruit and vegetable shed. The experiments were set up in the fruit and vegetable shed. Temperature and relative humidity sensors were used for monitoring the temperature and relative humidity of the vegetables in the cooler baskets and the fruit and vegetable shed. The experiment was monitored on daily basis for the temperature and relative humidity. The polystyrene used for wrapping the cooler basket was monitored to ensure it was always wet. Quality assessment of the vegetables stored inside the cooler baskets and those stored at ambient were carried out.

RESULTS AND DISCUSSION

The results of the temperature and relative humidity of the storage environments of the vegetables are in Table 1. The test batches of *T. occidentalis* stored in the cooler baskets had temperature ranges 26 – 32^o C and relative humidity range of 58%- 85%. The control exhibited temperature range of 26 -36 ^{o} C and relative humidity of 47% - 82% while the ambient recorded 26 -33^{o}C and relative humidity of 48% -79%. Table 1 below shows that the cooler basket has an average temperature of 27.32 ^{o}C while the average temperature of the control experiment and ambient temperature are 31.55 ^{o}C and 32.55 ^{o}C respectively over the period of 8 days. This implies that the cooler basket has a temperature differential of 4.23 ^{o}C. Also, the average relative humidity of the cooler basket, control experiment and ambient were 63.75%, 55.82% and 57.39% respectively. The lower relative humidity and high temperature of the ambient makes evaporative cooling to take place in the basket resulting in a drop in the air temperature and increase in relative humidity within the cooler baskets.

Figures 1 and 2 illustrate the graphical relationship of the temperatures and relative humidity of the different storage facilities for the *T. occidentalis* leaves. The temperature in the cooler basket (Fig. 1) was lowest while the control and ambient temperature were higher respectively. Figure 2 depicts that the relative humidity of the cooler basket was the highest while the relative humidity of the control experiment and the ambient were lower and lowest respectively. The control experiment lasted for 3days and had a final weight of 10.4% of its initial weight as recovered while the experiment in baskets lasted for 8 days and had a final weight of 56.2% of its actual weight recovered. This is in agreement with the work of [6] who reported that *Telfairia* leaves wrapped with a polypropylene sack in a cool place stored for 3 days like other leafy vegetables as practiced by the consumers and marketers.

The weight loss for those stored in the basket was 43.8% while the control recorded 89.6% loss on the day eight of the experiment. The vegetables stored in the cooler baskets were fresh for 7 days and consumers and marketers using these cooler baskets will have their value for the initial cost of the leaves. The advantage of storing *Telfairia* leaves in the cooler basket is seen in the reduction of losses of the leaves, availability of the leaves and extension of shelf life, which culminates in retention, aesthetics and market value of *Telfairia* leaves. The cooler basket has been able to store the vegetable better than the usual method adopted by the traders of *Telfairia* leaves. Hence it will serve as a better facility for commercial purposes if adopted by the market women and also reduce spoilage rate and increase income as well.

Table 1. Temperatures and Relative humidity of *Telfairia occidentalis* leaves stored in cooler basket, control and ambient for 8 days

	Cooler Basket		Control		Ambient	
Day	Temp.	Rh %	Temp.	Rh%	Temp.	Rh %
1	32	82	32	76	31	69
2	29	82	29	79	28	68
3	27	86	29.5	82	29	79
4	26	78	26	76	26	77
5	28	71	29	63	32	61
6	30	64	32	56	32	56
7	28	70	32	62	32	58
8	28	70	32	64	32	64

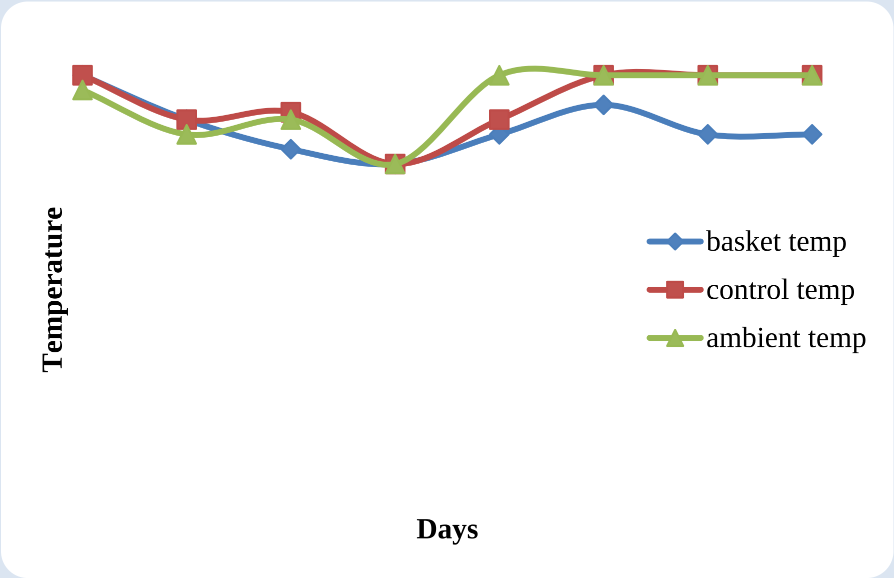

FIG. 1. Temperatures of the different storage environment

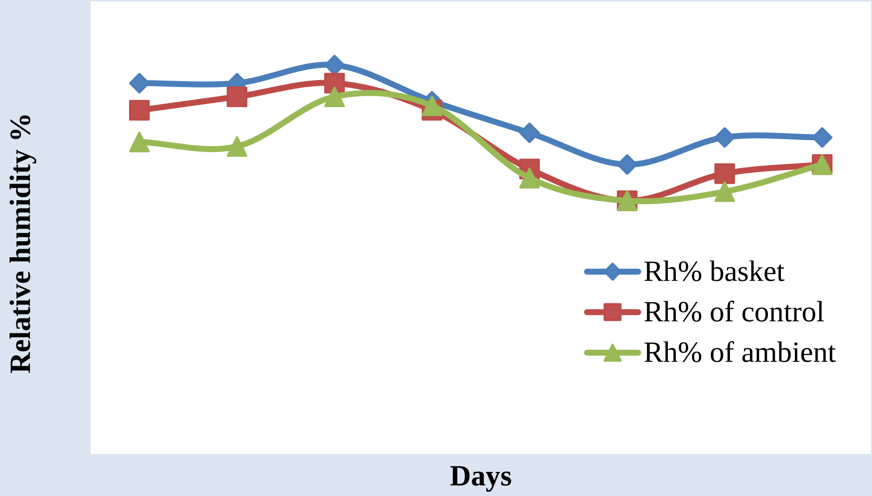

FIG.2. Relative humidity of the different storage environment

REFERENCES

1. Okoli, B. E.and Mgbeogu, C. M. (1983). Fluted Pumpkin *Telfairia occidentalis*. West African Vegetable Crop. *Economic Botany* 37(2): 145-147

2. Purseglove, J. W. (1977). Tropical crops dicotyledons (Volumes 1 and 2 combined). Longman, London.

3. Okoli, B. E. (1987). Morphological and cytological studies in *Telfairia* Hook (Cucurbitaceae) *Feddes Repertorium* 98: 9-10.
4. Olaofe, O., Adayemi, F. O. and Adediran, G. O. (1994). Amino acid and mineral composition and functional properities of some oil seeds. *Journal of Agric and Food Chemistry* 42:878 -881.
5. Akorede, M. O. (1990). Ethnobotany of *Telfairia occidentalis* (Cucurbitaceae) among Igbos of Nigeria. *Economic Botany* 44 (1):29 -39.
6. Odiaka, N. I., Akorede, M. O. and Odiaka, E. C. (2008). Diversity and production methods of fluted pumpkin *Telfairia occidentalis* (Hook F.): Experience with vegetable farmers in Makurdi, Nigeria. *African journal of Biotechnology* 7(8): 944- 954.

Proximate Composition and Palatability of Kilishi, Balangu and Kundi, Intermediate Moisture Meat, Using Smoke and Sun – Dried Method, for Food Security and its Effect on Climate Change

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ABSTRACT

Food security exists when all people at all times have access to safe nutritious food to maintain healthy and active life. To agree with food security animal protein are needed and processing meat into products to increase intake of animal protein have a lot do with climate change. Climate change in Africa, have led to chronic low animal protein intake in developing countries where about 60% of the populace are suffering from animal protein deficiency already. Though, the world is agitating for low meat and more plant eater to reduce emulsion from animal agriculture to the environment. But plant protein can't provide human with all necessary essential nutrients needed as it provides a relatively rich source of well absorbed iron and also improves the absorption of iron from other foods, its amino acid composition complements that of many plant foods, and it is a concentrated source of B vitamins, including vitamin B_{12} which is absent from plant foods. In processing meat into suitable form to upgrade food security, emission of CH_4 and N_2O are released, thereby contributing to climate change in Africa. The objective of this study was to compare the chemical composition and palatability of *Kilishi, Balangu and Kundi* (meat products) for food security, and how it affects climate change. About 15 kg of semimembranosus muscles of White Fulani were used for this study. The meat was trimmed off of all external fat and connective tissues, cut/sliced, sundried and smoked dried. The samples were then evaluated for proximate and palatability status in a completely randomized design. Results showed that, there were significant differences in proximate composition values among all the products, with Kilishi, having the highest value of 5.31% ash, 7.40% ether extract and 79.33% protein content compared to other products, 2.05% ash, 6.67% ether extract and 76.57% for Balangu and 2.40% ash, 4.86% ether extract and 63.07% for Kundi product. For palatability status, saltiness and overall acceptability was not significantly different (P>0.05) for all products but Balangu was observed to have the highest value for colour, tenderness and Juiciness of, (6.50, 6.67 and 6.30), respectively with Kilishi product having (4.10, 3.30 and 6.80) and (6.00, 5.20 and 5.60) for Kundi, respectively. Products were observed to have high protein content or nutrients and low moisture content, with longer shelf life apart from Balangu. The total protein intake from the products could help to improve on food security in the country but during processing certain compound were release from the heat source which could add to global warming and thereby contributing to climate change.

Key words : Kundi, Kilishi, Balangu, Proximate composition, and palatability status

INTRODUCTION

The intergovernmental Panel on Climate Change defined Climate change as: a change in the state of the climate that can be identified by changes in the means and or the variability of its properties and that persists for an extended period decades or longer (IPCC, 2007). It is also refers to changes in climate over time, whether due to natural variability or as a result of human activity. It is cause by climate changes arises from global warming and unequivocal evidence of a persistent rise in global temperature, sea level and fall in northern hemisphere snow cover. It is driving by Greenhouse gasses, aerosols, leading to temperature changes, precipitation changes, sea level rise, increasing frequency of extreme weather events and adverse impact on human security, ecosystem and water resources. Climate change means a change in climate that persists over a sustained period of time (IPCC, 2001), and examples of climate change include increase in global surface temperature (global warming), changes in rainfall patterns and in the frequency of extreme weather event. And these changes in climate may be due to natural cause and human activities, that is, the process in which peoples get their ends meet, and also every other human-induced activity could cause change too, causing natural climate variation (IPCC, 2007).

The impact of climate change in Africa includes; exposure of 75 to 250 million people of increased water stress and yield from agriculture output could be reduced up to 50%, increase in sea level rise, which could affect low – lying coastal areas with large populations and an increase of 5 to 8% of arid and semi- arid land by 2020. Some changes that also occur from climate change could results in increasing environmental temperature globally with a primary rise record between 1950 till date, biological changes impact on habitat, population, food supply and increasing loss of biodiversity.

Meat causes more global warming than everything else combined, and it contributes 51 percent of the greenhouse gasses response for climate change**.** Also, (Steinfeld *et al*., 2006) have estimated that livestock production contributed between 15% and 24% of global greenhouse gas (GHG) emissions. In fact, Agriculture is a major contributor to greenhouse gas emissions, principally from methane and nitrous oxide, in terms of climate change. Meat industry is responsible for a lot of climate change and global warming, which has been posing a risk to the welfare of humanity, as well as every other species in the face of the planet. On like beef production, which is the top contributors to climate changes among meat industry for instance, cattle manure produces very high qualities of nitrous oxide, a greenhouse gas, which could also be found in all animal manure. Nitrous oxide is a greenhouse gas, 298 times more powerful than carbondioxde. Livestock production is also implicated as a significant source of greenhouse gas GHG, Methane (CH4) and nitrous oxide (N_2O). IPCC estimation of emissions from Agriculture sector was reported as having an uncertainty of ± 30 – 50%, also, in the livestock production, the balance of emissions is related to production systems with ruminant system dominated by CH_4, from enteric fermentation in pigs by N_2O from manures. Also as ruminant systems become more intensive, there is shift in the balance from CH_4 towards N_2O. Most of the emissions of both CH_4 and N_2O arise on farm, with only 3% from meat processing, 5% for transportation and 12% for the consumer component.With the global demand for food which is expected to increase by 70% by 2050 (FAO, 2009) as a result of population growth, and to meet up with this demand, the global production of meat is projected more than double from 229 million tonnes in 1999/2001 to 470 million tonnes in 2050. This move is cause by the increased demand for animal products, as increasing sectors of the population become more affluent. Food supply must increase sustainably to meet this demand and in this respect, there could severely be constrained by climate change impacts (Godfray *et al*., 2010).

It is regrettable that approximately 870 million out of 7 billion people (12.5% of the global population) are estimated to have been undernourished from 2010 to 2012. And the global human population is expected to reach over 9 billion people by the year 2050 (UN, 2006). As the world population continues to increase, food security on a global scale must become a greater priority (Clint Krehbiel 2013). Along with population growth, economic growth and the rise of the middle class is developing countries are expected to further increase demand for meat, milk and egg (FAO, 2009). It is projected that approximately twice as much animal protein will be needed globally by 2050 than is currently produced today (FAO, 2012). Although addressing food security on a global scale, will require everyone working together to address economic, financial, government and political way, in an environmentally and economically sustainable manner which needs to be a priority for animal agriculture. In order to meet the projected food demand by 2050, new knowledge of genomics, physiological processes, nutrient utilization, animal wellbeing, meat processing and improving on the traditional meat products, which may lead to new management practices that are economically, environmentally and socially sustainable.

In Nigeria, to distribute evenly, safety, preserves and cheap meat to the populace, meat are preserved into products of different kind for example; Balangu, Kilishi, Kundi, Suya, Danbunama, Jire, Asun, Ndariko, Jioge, Inug, all these type of meat are shelf stable, semi – dried meat, referred

to as intermediate moisture meat (IMM). Are called IMM because, they are low in moisture content, contain 3 to 4 times their raw protein equivalent, hence they are less bulky (Egbunike and Okubanjo, 1999). The mineral and vitamin contents are retained unchanged and the nutritional quality of freshly prepared IMM is similar to that of ordinary cooked meat (Kinsman, 1982), they are palatable and can be eaten with or without rehydration.
It is therefore, the aim of this study to evaluate the qualities (proximate composition and palatability) of meat products (Kilishi, Kundi and Balangu) for food security and it effect on climate change.

MATERIALS AND METHODS

Source of meat

15 Kg of Semimembranosus muscles from White Fulani cattle of 2 years old animals,from teaching and research farm, of College of Agriculture, Osun State University Nigeria, was used for this study.

Production of Balangu, Kundi and Kilishi

Smoking method (charcoal) was used to prepared the meat products but at different cooking time and temperature. For Balangu, meat was cut in little tiny pieces, greased in groundnut oil and placed on wire mesh to smoked and then spiced, for Kundi, meat was cut in cube shape and first boiled for 20 minutes at 100^0C, and then placed on wire mesh to smoke for 1-2 hours, while for Kilishi, meat was sliced flat and very tiny and spiced with grounded groundnut, pepper with Africa spices, also placed on the wire mesh to smoked till it dried, for 1 hour. Charcoal burns from 200 ^{0}C to about 360 ^{0}C, to give the product proper dryness.

Proximate composition

Protein, Ash, Moisture and Ether extract were evaluated according to A.O.A.C. Association of Official Analytical Chemists (2000), official method of analysis Gather burg M.D. USA. A. O. A. C.

Palatability characteristics

A total number of 40 panelist were used, male (n = 25) and female (n =15) range in age of 30 -38 years. They were randomly allocated to the three meat products with 4 replicates, each bite size from each treatments were coded and served in an odorless plastic container. Each sample was evaluated independently of the other. The panelists rated sample on a 9 points hedonic scale for colour, flavour, tenderness, juiciness and overall acceptability.

Statistical Analysis

All data obtained were subjected to analysis of variance and where statistical significance was observed, the means were compared using the Duncan's Multiple Range (DMR) test. The SAS computer software package (1999) was used for all statistical analysis.

TABLE 1:PROXIMATE ANALYSIS OF KILISHI, BALANGU AND KUNDI, .

PARAMETERS	RAW BEEF	KILISHI	BALANGU	KUNDI	SEM
MOISTURE	72.69^{a}	7.00^{c}	15.20^{b}	11.00^{b}	1.45
ETHER EXTRACT	6.34^{b}	8 .50^{a}	7.05^{b}	2.50^{c}	0.96
ASH	1.30^{d}	9.00^{a}	7.00^{a}	3.50^{b}	4.65
PROTEIN	18.95^{d}	82.95^{a}	70.11^{c}	78.96^{b}	1.76

$^{a, b, c,}$ means in the same row different superscript significantly different (P<0.05).

Table 2 Some Smoked Components found in Wood / Charcoal Smoked

CHEMICAL COMPONENT	APPROXIMATE AMOUNT (%)
Phenols	45
Carbonyl (ketone and aldehydes	70
Acid	20
furans	11
Alcohol and esters	13
Lactones	13
Polycyclic aromatic hydrocarbon	27

SOURCE ;Wikipedia (2002), Elizabeth (1995), Hedrick et al., (1994), Alonge (1984

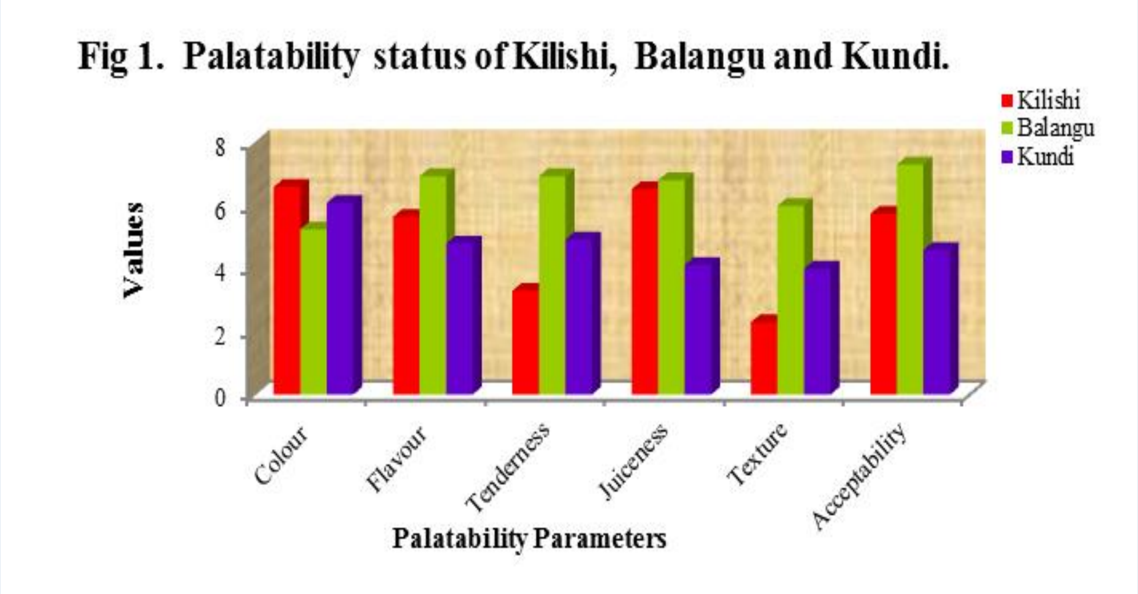

Fig 1. Smoke component emitting from the charcoal used to smoke meat.

DISCUSSION

The moisture content of raw meat obtained in this study can't be compared with the moisture content of the three products, from table 1, it was observed that moisture content of the product reduced drastically, to about three times reduction, which this may be cause by the type of processing used. Kilishi and Kundi, having the lowest value of 7.00 and 11.00, resulting from two processing method used: smoking and drying, thereby eradicating more moisture from the meat to the atmosphere. However the value of the raw meat fell within the range of 65 – 80 % reported by Hedrick *et al.*, (1994) and 72.4 – 76.2 % Ezekwe *et al.*, (1997) for Muturu and Ndama meat at ages of 2 -3 years respectively. But was observed to be lower than 75.2 %, 75 % and 75.9 % for longissimus dorsi muscles, semitendinosus muscles and triceps brachi muscle of camel meat and higher than the ranges of 70.3 -71.0 % reported by Kadrim *et al.*, (2006). While the value observed from the three products fell within the range of 7.2 - 11.1 % reported for oven - dried and sun dried Kilishi reported by Egbunike and Okubanjo (1999) but lower than 21.6 – 26.8 % for moisture content of Majoran Sausage and Salami as reported by Fernandez – Salguero (1993). Hedrick *et al.*, (1994) reported an inverse relationship between the moisture and fat contents of meat. The high moisture content of fresh meat may thus be due in part to the low lipid content and vise visa, Solomon *et al*., (1994). The importance of moisture in meats lies in its pronounced effects on the shelf life of meat, processing potential and sensory characteristic.

The result of fat content for raw meat and the three products was comparable to 1.5 - 3.3 %, 6.4 – 8.3 % and 10.9 – 29.6 % reported by Hedrick *et al*., (1994), Kadim *et al*., (2006) and Vania, (2006). The mean protein content obtained fell within the ranges of 18.9 - 19.7 % observed for protein content of mature Sokoto Gudali cattle meat, but lower than 22.0 – 22.5 % for Muturu beef. Exekwe *et al*.,(1997). It was observed that, Kilishi had the highest value of protein content, follow by Kundi and then Balangu products. These results could be related to the accumulation of nutrient in relation to moisture loss, increase in moisture loss resulting in increase in protein content. Ash content talks about the mineral present in the meat, it was observed that Kilishi has the highest, follows by Balangu and then Kundi product to fresh meat. The values obtained in this study were greater than 1.3 % reported by Paleari *et al*, (2003), but had the same value with the value observed for the fresh meat. The work proves that more minerals component were acumulated during the processing of fresh meat into products, also the addition of spices during processing to Kilishi and

Balangu may be the cause of the increase in the ash content of the products, also from the smoke, minerals could be added, that may cause increase in the mineral content. Fig 1, shows the palatability status of the products, it was observed that Balangu product had the highest significant values compared to other two products, from the results of this table, it appears that Balangu products was not attractive and acceptable to others. Like flavour was rated highest by the panelist for Balangu than others, tenderness was also rated the highest for Balangu, since it had the highest percentage of moisture content, which is one of the parameters that influence tenderness in meat and its products. Juiciness was rated highest for Kilishi and Balangu products compare to others, which could be as the results more fat content and the spices added during processing may be a contributor, while Balangu had the highest value for texture which may also be as a result of highest moisture content. For overall acceptability, flavour, texture and juiciness are the three major parameters that could judge the panelist aright. Safari *et al*., (2001) noted that consumer surveys have shown that the most important contributing sensory attributes to eating qualities are flavour, texture and juiciness. Hedrick *et al*, (1994), reported that the flavour of a product is responsible for psychological and physiological responses which determine acceptability resulting from meat consumption and that of sensation of juiciness is primary conveying the general impression of palatability to the consumer. It was noted that lack of juiciness in meat products limits it acceptability. In this study, Balangu product was rated highest for the overall acceptability, having the highest value for flavour, juiciness and texture.

The processing involved converting fresh meat into products, smoke components resulting from the charcoal used may cause increase in global temperature (global warming) and so affecting climate change. Solomon *et al*., (1994) stated that compounds like amines, ammonia, hydrogen sulphide and many organic acids are often production from smoking chamber during processing of meat products. Alonge (1984), observed that phenols are produced from smoke during processing.

Smoke from wood or charcoal has more than 300 different compounds which are produced at different stages as the temperature of combustion rises, conditions in combustion chamber and oxidative changes in compound formed (Wilipedia, 2002). Elizabeth (1995) observed that more than 390 individual chemical compounds have been detected in wood smoke; over 70 of these compounds have been found in smoked foods. While, Hedrick *et al*., (1994), reported that more than 200 individual compound have been identified in wood smoke. Some of the compounds include 45 phenolic compounds, more than 70 carbonyls (ketones and aldehydes), 20 acids, 11 furans, 13 alcohols and esters, 13 lactones and 27 polycyclic aromatic hydrocarbons. Though most of the phenols contribute the followings to meat products; act as antioxidants, contribute to colour, gives smoky taste, as bacteriostatic effect and contribute to the flavour of the products when smoked under 380^0C, but above this temperature to 600 and 700^0C, (Toths et al., 1984) phenols produced may contribute to global warming and thereby contributing to climate change in such area. About 20 carbonyls have been identified in smokes which occur in steam distillable fraction and particles phase. Alonge (1984) observed 70 carbonyls (ketones and aldehyde) which are lost from the smoke components. Also, organic acid (1 -10 carbon organic acid) are presents in whole smoke but about 1- 4 carbon acids are commonly found in the vapour phase of the smoke while 5

– 10 carbon acid are in the particle phase of whole smoke, (Wikipedia, 2002). Hydrocarbon present in smoke components were about 27 poly – cyclic aromatic hydrocarbon, they are organic compound containing two or more benzene ring. There are several polycyclic hydrocarbons present in smoke, out of these are benz(a)prene and dibenz(a,h)anthracene. Ikeme (1990) observed that the decomposition of lignin and production of phenols are greatest at temperature above 400^0C. Such high smoking temperatures also favour the production of benz(a)pyrene and other poly – cyclic hydrocarbons which are known to be health hazard. It is however desirable to reduce the level of these substances in smoke as much as possible by keeping the smoke production temperature below 400 ^{0}C. The best quality smoke is produced at a combination temperature range of 300^0C – 400 ^{0}C to reduce the level of carcinogenic substances, (Ikeme, 1990).

All chemicals produced from the smoke at whatever temperature could add to the global temperature (global warming) and thereby contributing to climate change. It could therefore be suggested that since the meat products are nutritious and palatable, with heavily concentrated nutrients, other forms of drying could be use, like sun drying, oven drying etc, which have little or no effect to the climate change.

Should we stop eating meat and its products and go for plant consumption???

REFERENCES

Alonge, D. O. (19984). Smoke preservation of meats in Nigeria: quality and public health aspects Ph.D. Thesis University of Ibadan, Ibadan.

A.O.A.C., Association of official Analytical Chemists, (2000). Official method of analysis Gatherburg, M.D. USA; A.O A.C.

Clint Krehbiel, (2013). The role of new technologies global food security: improving animal production efficiency and minimizing impacts, from Department of Animal Science Oklahoma State University, Stillwater, OK 74078. Article written in ANIMAL FRONTIERS: the review magazine of animal agriculture, July 2013, Vol 3, no 3.

Egbunike G. N. and Okunbanjo A. O. (1999). Effects of processing upon the quality of Nigerian meat products. Livestock production Sci. 59 (1999). Elsevier 155 -163.

Elizabeth Boyle (1995) Kosher Meat, PhD work from the Department of Animal Sciences and industry, Kansas State University.

Ezekwe A. G., Okonkwo T. M., Ukaegbu U. G., and Sangode A. A. (1997). Preliminary study of meat quality characteristic of young Ndama and Muturu bulls. Nigerian J. Anim. Prod. 24 (1); 79 - 85.

Fernandez –Salguezo, J., Rafael Gomez and Miguel A. C. (1993). Water activity of SPANISH Intermediate - Moisture meat product. Meat Sci. 38 (1993) 341 – 346.

FAO (2009). The state of food and agriculture: Livestock in the balance, http;//www.fao.org/docrep/012/i0680c/i0680e00.htm (Accessed 22 May 2013.)

FAO (2012). The state of food insecurity in the world 2012: http;//www.fao.org/docrep/016/i3027e/i3027e00.htm (Accessed 22 May 2013.)

Godfray H.C.J., Beddington, J.R. Carute, I. R., Haddad L. Laurence, D, Mauir, A.J.F.,

Pretty, J. Robbinson S. Thomas S. M. and Toulmins C. (2010) Food Security: The challenge of feeding a billion people. Science 327, 812 - 818.

Ikeme A. I. (1990). Meat science and Technology, A comprehensive approach. Onitsha: publisher Ltd. Nigeria Africana Fep. 320.

IPCC, (2001). Climate change 2001, working group 11: impacts adaption and vulnerability in McCarthy, J. J., Canziani O. F., Leary N. A., Dokken D. J. and White K.S.

IPCC, (2007), Climate change 2007, impacts, adaptation and vulnerability, IN party, M. L., Canziani O.F. Palutikof, J. P., Van der Linden, P.J., Van der Linden, P.J. and Hanson, C. E. (eds). Cambridge, UK, contribution of working group 11 TO THE FORTH Assessment Aeport of the intergovernmental panel on climate change. Cambride University Press.

Kadrim I.T., Mahgoub , O., Al-Mar-Zoogi. W., Al-zadjali. S., Annamalai K., and Mansour M. H., (2006). Effects of age on composition and quality of muscle longissinus thoracis of the Omani Arabian Camel. 9Camelus dromedaries). Meat Sci 73; 619 -625 wwwsciencedneet.com.

Kinsman D. M., (1982). A fresh look at processed meats; Food and Nutrition 53; (5).

Paleri, M. A., Morilti, V. M. Buretta G., Mentasati T. and Bersani C. (2003) cured products from different animal species. . Meat Sci 63: 485 - 489.

Safari E., Fogarty N. M., Ferrier G. R.., Hopkins L.D. and Gilmour A. (2001). Diverse lamb genotypes. 3. Eating quality and the relationship between its objective measurement and sensory assessment. Meat Sci. 52, (2);153-159.

S.A.S. (1999). Statistical Anlyisis System Institutes. Users guide Institute Inc. carry N. C.

Solomon I.P., Ekanem E. O. and Okubanjo A. O. (1994). Effects of salt (Nacl) level and smoke application on chemical and sensory characteristics of Unam Inug, a cured Nigerian Pork product Der Tripenindwirt. Zeitschrift for die landwinschaft in den Tropen and Subtropen 95. Jahrgang OKTOBER 1994,5;157-169.

Steindeld, H., Gerber P. w Assenaar T., Castel V, Rosales, M, and Dehaan, C. (2006). Livestocks long shadow: environmental issues and options. Rome Italy, food and Agriculture Organization of the United stations

Toths L. (1990). Influence of smoke – house technology on phenols in the smoke. Die fleishwirtsh 60; (8) pp 1422 -1477.

Venia F., Joana B. Sandra V., Ana M., Fatima S., Maria J. M. Tim H., Paul G and Paula T. (2006). Chemical and microbiological characterization of alheira: Atypical Portuguese fermented sausage with particular reference to factor relating to food safety. Meat Sci. J. 73: (4). 570 – 575.

Wikipedia (2006). Meat Wikipedia the free encyclopedia. http://en wikepedia.org/wiki/meat.

Food Security Challenges in the Niger Delta Region, Nigeria

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ABSTRACT

The paper discusses the food security challenges and causes in the Niger Delta region of Nigeria. The challenges as outlined are not only due to climate change variability but also technological (requiring the development new, highly productive, environmentally sustainable production systems) and political (requiring policies that do not discriminate against the vulnerable peasant householders in the rural areas). It notes that the region is predisposed to adverse effect of climate change due to its physical location, geopolitical and socio-economic characteristics. The paper further illustrates that food shortages in Nigeria, particularly in the Niger Delta are due to the fragility of its economy among other factors such as; the unpleasant side effect of industrialization. The loss of luxurious vegetation/farmland in the Niger Delta, due to both human activities and oil exploration led to large scale deforestation, biodiversity depletion and environmental degradation, contributing immensely to low agricultural production. Finally, recommendations for the way forward towards meeting the food needs of the people and ensuring food security are given.

Keywords: Food security, Environmental degradation, Oil spillage, Industrialization, Deforestation

INTRODUCTION

Call it suffering and hardship in the midst of abundance or poverty and lack in the midst of tremendous wealth and you will not be far from the truth. Food, food everywhere, but none on the table to eat! There is enough food for all globally, but more than 780 million people are chronically undernourished world-wide (FAO, 2003). In West Africa, Nigeria has the highest number of undernourished people and over 40% of Nigerians are food insecure (Adegbola *et al.,* 2012) particularly the rural poor.

The Niger Delta Region Nigeria, West Africa is an oil rich, densely populated area extending over 70,000 square kilometers and endowed with abundant human and natural resources, luxurious vegetation, large water bodies, fertile agricultural land and wetlands (Ubom *et al*, 2010). It is habited by about 20 million people of more than 40 ethnic groups whose occupations are predominantly fishing and farming (Kinanee, 2010). It is the fulcrum of Nigeria's oil and gas exploitation, providing the economic hub of the country. Ironically, the inhabitants of this region particularly the rural poor are denied the privilege of enjoying the vast resources and tremendous wealth accrued from their God given natural resources as they are faced with several environmental and health challenges occasioned by years of environmental exploitation, maritime criminality, under production and limited access to basic amenities of life. The Niger Delta region borders the coast of the Atlantic Ocean and is situated within the tropical rainforest zone characterized by heavy rainfall pattern (AIACC, 2006). Recent global warming and climate change scenarios have greatly altered the rainfall pattern of this region and change(s) in crop yield in response to climate variability will be a function of how early or late rainy season comes and go. The region is currently faced with a gamut of environmental problems, including soil and coastal erosion, oil pollution, population pressure and flooding which is on the increase due to global climate change.

Prior to the discovery of oil in 1956 in this region, agriculture had been the mainstay of the Nigerian Economy and played a dominant role in the provision of adequate, nutritious food for its populace; rural employment, raw materials for its industries, source of public revenue, source of foreign exchange and internal market for agricultural related tools. Nigerian farmers produced 70% of Nigerian exports and 95% of its food needs (Adegbola *et al*., 2012). However, the large scale investments and development of the oil sector resulted in nose-diving decline in agricultural production and subsequent increase in their vulnerability to food insecurity.

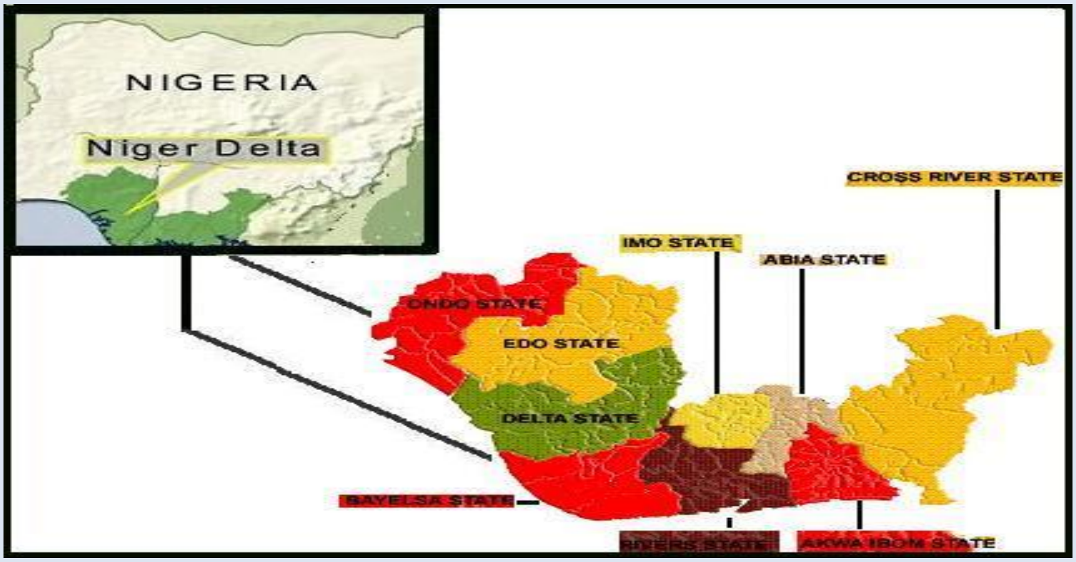

Fig1. Map of Nigeria showing the states in the Niger Delta region

IMPACT OF CLIMATE CHANGE ON FOOD SECURITY IN THE NIGER DELTA

Climate change, being a global phenomenon is a new reality with attendant deleterious effects and socio-economic consequences. The impact of climate change can be vast, with increased vulnerabilities of the ecosystem resulting in rise in sea-level, fiercer weather conditions, increased frequency and intensity of storms and fires, floods, hurricanes, drought, disruptions in seasonal cycles and several adverse effects on portable water availability, energy supply, housing, health, agriculture and food production (AIACC,2006). Projected climate change impacts and declining agriculture productivity may compound the risk of food insecurity in the African continent (FOA, 2010). Agricultural production and food security in many African countries are likely to be severely compromised by climate change and climate variability (IPCC, 2007). The major impact of climate change in the Niger Delta, being a coastal area is flooding. This affects both the urban residents and the rural dwellers and is a threat to physical infrastructure, roads and bridges. It also destroys farmlands, including standing crops and livestock.




Food security in a broad sense has to do with having at all times an adequate level of food products to meet increasing consumption demand and to mitigate fluctuation in output and price (Igberaese and Okojie-Okoede, 2010). It is generally defined as access by all people at all times to enough food for an active and healthy life (FAO, 2010). Unfortunately, in the Niger Delta region the livelihood of large numbers of the rural poor and peasant households are washed away by flood waters and their vulnerability to food insecurity increased as all four dimensions of food security (food availability, food accessibility, food utilization, and food affordability) are adversely affected in different ways.

Table 1. Estimated Impact of Climate Change on Food Security Components in the Niger Delta

Food Security Component	Impact of Climate Change (%)	Instruments Affected
Food Accessibility	70	Markets and sales outlet (allocation and distribution mechanisms)
Food Availability	80	Crop yield and Storage (location dependent)
Food Affordability	86	Income and Food Choices (preferability)
Food Utilization	60	Essential food nutrients (food safety and human health)

Source: Oti, 2013 (Keynote Address)

Table 2.0: Ranking of Environmental issues in the Niger Delta by the World Bank

Category	High Priority	Moderate Priority	Lower Priority
Land Resource Degradation	Agricultural land degradation Flooding (Moderate high)	Coastal erosion Riverbank erosion	Sea level rise
Renewable Resource Degradation	Fisheries depletion. Deforestation Biodiversity loss Water hyacinth expansion	Fisheries habitat Degradation	Mangrove Degradation Nypa palm expansion
Environmental Pollution	Sewage Vehicular emissions Municipal solid wastes Toxic and hazardous substances	Oil polution Industrial effluents Industrial air emissions Industrial solid wastes	Gas flaring

Food Security Challenges and Causes in the Niger Delta Region

Food shortages or food security challenges in this region are caused by a combination of environmental, technological, political factors and climate change variability. They include:

1 Environmental degradation and deterioration due to oil exploration activities exposes the top soil to desiccation, erosion by rain and wind, resulting in loss of habitat for numerous soil fauna and flora.



2 Inadequate application of biotechnology/capacity building in research institutions to develop new improved crop varieties and hybrids that are high yielding and resistant to pest and diseases.

  

3 Depletion of natural resources and reduction in agricultural production: vegetation and forest reserves serves as sources of fuel wood extraction, shifting cultivation and nomadic cattle rearing.

  

4 Lack of good access roads to transport food and farm produce from farm to market, thus limiting food accessibility.

  

5 Inadequate preservation and storage facilities to prevent post harvest loss of food products, especially fruits and vegetables.



6 Lack of mechanization as many rural farmers indulge in manual farming which depletes physical strength, resulting in under production.



7 Insecurity, civil unrest and youth restiveness discourages huge foreign investment and assistance in food in production and development of the agricultural subsector.



8 Increased population increases child dependency burden and pressures on social infrastructure and constrains on ability to acquire technological capacity.


9 Increased vulnerability of peasant households to climate change variability due to high level of poverty and relatively low level of educational attainment which limits adaptive capacities.



10 Changes in rainfall patterns which caused flooding of farmlands, destruction of crops and various forms of livelihood.



11 Human induced increases in concentration of greenhouse gases in the atmosphere resulting from emissions from generating sets, automobiles, incinerations and gas flaring.

  

ADAPTATION AND MITIGATION STRATEGIES: THE WAY FORWARD

1. Capacity building, adequate information and public enlightenment on the management of climate sensitive resources particularly among women would reduce vulnerability, build resilience and increase their adaptive capacities.
2. Developing local appropriate technologies to move agriculture from manual to mechanization would increase production output and reduce time wastage and exhaustion of physical strength.
3. Adequate investment in food processing and storage technologies would ensure good post harvest practices and avoid food wastages due to poor preservation and storage.
4. Developing gender friendly strategies that would enable women access credit facilities and agricultural extension services.
5. Promoting agro-forestry and conservation agriculture would improve ecosystem health, enhance soil fertility and increase crop yields.
6. Laws on environmental protection should be strictly enforced and government policies on Agricultural Development Programme (ADP) should be fully implemented in the rural communities.
7. Environmental sustainability should be ensured by effective and efficient management of natural resources, reducing the impact of urbanization and industrialization through converting waste to wealth and processing of food into other forms or products.
8. Development of early warning system and deployment of ICT to enlighten the vulnerable rural dwellers on the impact of climate change variability.
9. Physical and infrastructure developments for improved living conditions should be put in place and displaced inhabitants of the Niger delta should be properly resettled and provided with lucrative economic alternatives through capacity building entrepreneurial education.

CONCLUSION

The co-existence of crude oil in large commercial quantity and the vast agricultural potentials in Niger-Delta region suggest that the region should have a potential economic comparative advantage. However, the agrarian communities which constitute over 50% of the inhabitants have been most disadvantaged in terms of prospect for agricultural growth, transformation and development. However all hope is not lost, because with the recent government's diversification interest, matters of low investment in agricultural sector, poor in incentives and infrastructure, inadequate trade and pricing policies, mechanization, food processing and storage, and capacity building for adaptation to climate change variability are all receiving prompt attention.

REFERENCES

Adegbola, J. A., Bamishaiye, E I. and Daura, A. M. 2012. *Food Security in Nigeria: Government's Intervention and the Place of Effective Storage.* Advances in Food and Energy Security **2**: 1-9

AIACC. 2006. *Food Security Climate Variability and Climate Change in Sub Saharan West Africa .A Final Report Submitted to Assessments of Impact and Adaptation to Climate Change*. (AIACC) Project NO.AF23 by James Adejuwon. Department of Geography, Obafemi Awolowo University Ile-Ife, Nigeria.

Brody,A,, Demetriades, J. and Esplen,E. 2008. *Gender and Climate Change: Mapping the Linkages*. A Scoping Study on Knowledge and Gaps BRIDGE, UK; Institute Of Development Studies IDS.

FAO 2003.Food and Agricultural Organization (2003) *The State of Food in the World* (FAO) Rome.

FAO 2008a. *Challenges for Sustainable Land Management (SLM) for Food Security in Africa*. 25th Regional Conference for Africa, Nairobi, Kenya. Information Paper 5. 15pp

FAO 2010. *Climate Change Implications for Food Security and Natural Resources Management in Africa*.26th Regional Conference for Africa, Luanda, Angola, ARC/10/8 22pp

FOS 1999b. *Poverty and Agriculture Sector in Nigeria.* Federal Office of Statistics, Abuja, Nigeria. Annual Series 31pp

Igberaese, F. I. and Okojie-Okoede 2010. *Food and Hunger Everywhere: A Nigeria Paradox of Poverty.* International Review of Business Research Papers **6**(4): 3-7

IPCC 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth assessment Report of the Intergovernmental Panel on Climate Change, M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (Eds.) Cambridge University Press, Cambridge, UK. 976pp

Kinanee, J. B. 2010. *Environmental Security and Related Health Challenges in the Niger Delta Region of Nigeria: Counseling Implications.* Nigerian Journal of Agriculture, Food and Environment **6**(3):66-72

Niasse, M., Afoud, A. and Amani, A (Eds.) 2004. *Reducing West Africa's Vulnerability to Climate Impacts on Water Resources, Wetlands and Desertification: Elements of Regional Preparedness and Adaptation.* IUCN, Gland , Switzerland and Cambridge, UK xvii + 66ppp

Oti, N. N.2013. *The Gender Face of Hunger and Poverty: The Way Forward.* A keynote Address presented at the Ist International Conference and Exhibition, Uyo, by the Organization for Women in Science for the Developing World (OWSD), June 3-6, 2013 at Uyo, Nigeria

Ubom, A. E., Idris, H. O. and Ekpo, C. 2010 *Environmental Challenges in Nigeria's Delta Region and Agriculture.* Journal of Research in National Development 8(2):45-49

Evaluation of Some Breeding Lines of Cowpea for Nutritional and Functional Properties

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ABSTRACT

Cowpea [(*Vigna unguiculata* L.) Walp.] is a protein-rich food crop largely cultivated in the dry savanna regions of West Africa. It is a warm weather crop which requires less rainfall, tolerant to drought and requires dry weather for harvesting than most crops. Its cultivation is important in food security and poverty reduction though affected by flooding and extreme temperature. Cowpea production is challenged by *Striga gesnerioides* parasitic effects in the phase of climate change given rise to poor yield. In attempt to control this parasitic weed, recombinant inbred lines of cowpea have been developed and advanced to F_7 generation from IT97K-499-35 (*Striga*-resistant parent) and SARC-L02 (susceptible parent). The nutritional and functional properties of dry seeds of selected F7 lines UC96-141, UC96-292, UC96-02, UC96-10 were analyzed using standard biochemical methods and compared with that of the parental genotypes and a local accession, GH3684 (*Striga*-resistant). Moisture and carbohydrate content were low in UC96-141, UC96-292, UC96-02, UC96-10 and GH3684 compared with IT97K-499-35, SARC-L02. There were significantly ($P < 0.05$) high protein and lipid contents in the inbred lines. UC96-141, UC96-292, UC96-2 and GH3684 had higher fiber content ranging from 5.50 - 6.10% while that of UC96-10, IT97K-499-35 and SARC-L02 were in the range of 2.30 -2.70%. Ash content ranged from 0.867% to 5.227% with GH3684 having the highest. Seed swelling power ranged from 3.374 to 5.104 g/g, foam capacity from 8.667 ml to 16.664 ml, water absorptive from 1.599 g/g to 2.269 g/g, and oil absorption from 0.786 g/g to 0.986 g/g. The recombinant inbred lines showed variable amount of nutritional and functional properties hence the need to explore the desirable variabilities in these properties of the novel cowpeas associated with *Striga*-resistance and good agronomic traits for farmers to cultivate in the *Striga* endemic regions of Ghana.

Keywords: Cowpea, *Striga gesnerioides*, Resistant, Subseptible, Climate Change, Nutritional, Functional

INTRODUCTION

Cowpea (*Vigna unguiculata* L Walp.) is a major staple and a very important protein food consumed by most Ghanaians. It is widely grown all over the world though it is perceived to have originated from Africa [1]. It is a common leguminous plant which belongs to the family fabaceae and it is largely cultivated in sub-Sahara Africa, especially in the dry savanna regions of West Africa. The seeds are a major source of plant proteins and vitamins for human consumption, serve as feed for animals, and also a source of cash income to both farmers and traders. Cowpea provide essential nutrients and high level of protein (about 25%) making it extremely valuable where many people cannot afford protein foods such as meat and fish [2]. The young leaves and immature pods are eaten as vegetables [3]. Studies have shown that cowpea dietary fibre has some health benefits in the prevention of risks of chronic diseases such as cancer, and diabetes mellitus [4].

In Ghana, cowpea is generally prepared and eaten as a whole or as part of a meal. It is the main raw material in meals like 'koose' (cowpea fritters) and 'gari' and beans (roasted graded fermented cassava and cooked beans). It is also used for preparing soup and stew. In some countries cowpea is processed into flour and used as protein concentrate and animal feed formulations [5]. The economic uses of cowpea makes it a choice crop for serving food security needs of societies [6].

The cultivation of cowpea is important in food security and poverty reduction. It is a warm weather crop and requires less rainfall than most crops. It is particularly tolerant to drought during vegetative growth and requires dry weather for harvesting. Unfortunately areas where it is mostly cultivated suffer great deal with flooding and extreme temperature. This is due to the change in the climate conditions. Studies have shown that temperature and rainfall are prominent climate factor that affects cowpea production. [7]. Despite these climate conditions, cowpea cultivation unlike other grain crops still favour farmers.

There are other factors like biotic factors that are affecting cowpea cultivation. Among these biotic factors is the parasitic attack by *Striga gesnerioide*s. This is a major constraint to t cowpea production by the *Striga* parasite and it gives rise to poor yield. Various cultural practices have been attempted to control this parasitic effect on the crop. However, the most reliable approach to contronl *S. gesnerioides* infection is the development of resistant varieties. Currently, recombinant inbred lines involving Striga-resistant parent cowpea, IT97K-499-35 [8] as donor and *Striga*-susceptible parent cowpea, SARC-L02, as receipient have been developed and advanced to F_7 generation but awaiting nutritional evaluation . Variations in the nutritional and functional properties of these novel genotypes of cowpea could influence the potential use of the crop. The functional and nutritional properties of cowpeas may vary according to their genotype and environmental influence. Hence, for effective utilization of newly developed cowpea cultivars for human nutrition, the evaluation of their nutritional properties is necessary [9], and more importantly to compare with those of a local accession of cowpea, GH3684, found to have resistance to *S. gesnerioides* [10].

The objective was to evaluate nutritional composition and functional properties of four genotypes of the recombinant inbred lines of cowpea to establish potential usage compared with that of the parental genotypes and the local accession, GH3684.

MATERIALS AND METHODS

Sample collection and preparation

The samples of cowpea used were obtained from the Department of Molecular Biology and Biotechnology, University of Cape Coast. Four recombinant inbred lines of cowpea (*Vigna unguiculata*) were used in this study, two of these were resistant and two susceptible to *Striga* infection. These recombinant inbred lines were developed from IT97K-499-35 (*Striga*-resistant parent) and SARC-L02 (susceptible parent). One local cowpea accession (GH3684) and the two parents (SARC-L02 and IT97K-499-35) were also included in this study.

Sample preparation

All the samples were sun-dried two hours daily for 5 days. All foreign materials such as dust, stones, chaff, immature and broken seeds as well as bad seeds were removed by picking. The samples were then milled into powder using the stainless steel heavy duty blender (Snijders Scienctific, 24CB9E-220-240V). The powdered samples were then packaged in zip-lock polyethylene bags, weighed, labeled and kept for analysis.

Determination of Nutritional Properties

The recommended methods of the Association of Official Analytical Chemists (AOAC) [11] were used for the determination of moisture, ash, protein, lipid, fiber, and carbohydrate contents respectively. All analysis were done in triplicate

- **Moisture**

Dried crucibles were weighed and 2g of the each sample was placed in it. Samples and crucibles were weighed again and placed in an oven for 3 hours at 105^{0}C. After drying, the samples were removed and kept in a desiccator to cool down. Weights were taken again and moisture content calculated as percentage for each sample. Drying and weighing were repeated several times until a constant weight was obtained

- **Ash**

Approximately 5.0 g of the sample were weighed into porcelain crucibles which had already been ignited and cooled. The crucibles and their content were ignited gently on a bursen burner until they charred. They were then transferred to a muffle furnace at 550^{o}C for six hours until ash was formed. The crucibles and their content were allowed to cool in a desicator. They were reweighed and amount of ash was calculated as:

$$\% \text{ Ash content} = \frac{\text{weight of ash } \times 100}{\text{weight of sample}}$$

- **Lipid**

About 2g each of the dried seeds were weighed into the cellulose extraction thimble of the Soxhlet extractor with the mouth plugged with cotton wool. The thimble placed in the extraction chamber was suspended above the weighed receiving flask containing petroleum ether (40/60) below the condenser. The flask was heated for six hours after which the set-up was allowed to cool and dismantled. The petroleum ether extract was concentrated in vacuum and the crude lipid from each sample was further dried in the oven at 100^{0}C. The weight of the flask was taken after cooling and recorded. The difference in weight is expressed as percentage crude lipid content.

- **Protein**

Crude protein was determined by the Kjeldahl method [11] as the amount of nitrogen in percentage present in each sample.

- **Fiber**

This was done using the gravimetric method described by Pearson *et al*, [12]**.**

- **Carbohydrate**

Available carbohydrate was calculated using the difference method, by subtracting total or sum of crude protein, crude lipid, crude fiber and ash from 100% dry weight sample as:

$$\% \text{ Carbohydrate} = 100 - (\% \text{ Moisture } + \% \text{ Ash} + \% \text{Protein } + \% \text{Lipid } + \% \text{Fibre})$$

Determination of Functional Properties

The recommended methods of the Association of Official Analytical Chemists [11] were used for the determination of water and oil absorption, foaming capacity, swelling power. All analysis were done in triplicate

- **Water and oil absorption capacities**

The water and oil absorption capacities were determined using the method by [6]**.** About 1.0g of the sample was mixed with 10ml of distilled water in 20ml labeled centrifuge tube. The slurry was agitated for 2 minutes and allowed to stand at 28°C for 30 minutes and then centrifuged at 500rpm for 20 minutes. The clear supernatant was decanted and discarded. The adhering drops of water or oil in the centrifuge tube were removed with cotton wool and the tubes were weighed. The weight of water or oil absorbed by 1g of cowpea flour was calculated and expressed using the formula:

$$\frac{\text{Weight of water or oil absorbed (g)}}{\text{Weight of dry flour (g)}} \times 100\%$$

- **Foaming capacity**

Approximately 1.0g of cowpea flour was weighed and whipped vigorously with 100ml distilled water in a graduated cylinder for 5 minutes. The volume of foam at 30 seconds after whipping was expressed as the foam capacity using the formula [6]**:**

$$\text{Foam capacity } = \frac{\text{volume of foam (ml)}}{\text{Mass of sample (g)}}$$

- **Swelling power**

Approximately 1.0g of cowpea flour was weighed and mixed with 10ml distilled water in a centrifuged tube and heated in a hot water bath at 80°Cfor 30 minutes while continuously shaking the tube. After heating, it was centrifuged at 1000 rpm for 15 minutes. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated using the formula [6]**:**

$$\text{Swelling power} = \frac{\text{weight of paste (g)}}{\text{weight of dry flour (g)}}$$

RESULTS AND DISCUSSION

One way independent Analysis of Variance was conducted to determine significance of the differences between the cowpea lines for the various parameters determined. The results obtained shows that there were significant differences in the means of both functional properties and nutritional properties among the varieties of cowpeas with the exception of foaming capacity.

The result of the functional properties (Table 1) shows that the water absorption was highest for SAC-L02 (2.27g/g) while UC 96-292 was lowest (1.60 g/g). Some of these findings were similar to 1.9, 2.1 and 2.2 g/g reported by Appiah *et al.* [6] for some cowpea varieties in Ghana. Oil absorption capacity among the cowpea genotypes were below 1 g/g with the exception of SARC-L02 (1.15g/g). The oil absorption capacity of these genotypes were higher than those reported by Chinma *et al*. [5] in Nigeria but similar to those reported by Appiah *et al*. [6] in Ghana. In addition, there were significant differences in oil absorption capacity between SAC-L02 and the rest of the cowpea genotypes except IT97K-499-35 though the latter was not significant with UC 96-141, UC 96-292 and UC 96-2. On the other hand, the oil absorption capacity of IT97K-499-35 was significantly higher than UC 96-10 and GH3684 . According to Ojukwu *et al*. [15], protein has both hydrophilic and hydrophobic properties, and so can interact with water and oil in foods. Variation in water and oil absorption activity may be due to different protein concentration, their degree of interaction with water and oil, and possibly, the conformational characteristics [15].

Table 1. Functional Properties of some cowpea genotypes

Samples	Water Absorption g/g Mean ± SD	Oil Absorption g/g Mean ± SD	Foaming Capacity ml Mean ± SD	Swelling Power g/g Mean ± SD
UC 96-141	.982±0.41^{a}	0.913±0.03^{ab}	9.000±1.00^{a}	4.180±0.42^{b}
UC 96-292	1.599±0.26^{a}	0.822±0.11^{ab}	10.333±0.58^{ab}	5.074±0.32^{c}
UC 96-10	1.662±0.36^{a}	0.786±0.11^{a}	11.667±1.53^{ab}	5.104±0.04^{c}
UC 96-2	2.094±0.11^{a}	0.883±0.02^{ab}	8.667±1.53^{a}	3.886±0.19^{ab}
GH 3684	1.766±0.10^{a}	0.789±0.01^{a}	10.333±2.08^{ab}	3.668±0.27^{ab}
SAC-LO2	2.269±0.16^{a}	1.148±0.03^{c}	9.667±0.58^{a}	4.261±0.05^{b}
IT97K-499-35	1.649±.021^{a}	0.986±.001^{bc}	16.664±5.205^{b}	3.374±.007^{a}

Mean values across column with same superscripts are not significantly different with p value > 0.05.
Mean Values across column with different superscripts are significantly different from each other with p value < 0.05

Maximum foaming capacity was observed in the IT97K-499-35 (16.66 ml) which was significantly higher than the rest except UC96-292, UC96-10 and GH3684 though these three genotypes (UC96-292, UC96-10 and GH3684) were not significantly different from the rest. According to Kinsella [16] and Ojukwu *et al*. [15], foaming is a surface active function of protein. A colloidal system which forms the incorporation of air (gas) into a soluble surface-active agent is foam. The swelling power of the cowpea genotypes range from 3.37 to 5.10 g/g. UC 96-292 and UC 96-10 which had swelling power above 5.00 g/g, were significantly different from the rest. The lowest swelling capacity was observed in IT97K-499-35 genotype which was significantly lower than UC96-141 and SAC-L02, but not UC 96-2 and GH 3684 though UC 96-2 and GH 3684 were also not significantly different from the UC96-141 and SAC-L02. Swelling power is the ability to increase in volume when foamed. The swelling ability of cowpea in the presence of water may be influenced by temperature, availability of water, species of starch, extent of starch damage due to thermal and mechanical processes and other carbohydrates and protein such as pectins, hemicelluloses and cellulose **[17]** and [15]**.**

Table 2 Nutritional Properties of the cowpea genotypes

Samples	Moisture % Mean ± SD	Ash % Mean ± SD	Protein % Mean ± SD	Fat % Mean ± SD	Fiber % Mean ± SD	Carbohydrate % Mean ± SD
UC 96-141	0.107±0.02^{a}	0.867±0.02^{a}	19.860±0.44^{ab}	0.804±0.54^{a}	6.066±0.27^{b}	27.623±2.23^{a}
UC 96-292	0.095±0.01^{a}	0.879±0.01^{a}	21.658±0.91^{b}	0.640±0.82^{a}	5.459±0.68^{b}	29.634±1.60^{b}
UC 96-10	0.064±0.05^{a}	1.072±0.16^{a}	19.437±0.53^{ab}	1.034±0.23^{a}	2.685±0.20^{a}	35.139±3.48^{ab}
UC 96-2	0.098±0.00^{a}	0.869±0.01^{a}	21.275±1.30^{b}	0.624±0.61^{a}	5.825±1.15^{b}	34.230±4.41^{ab}
GH 3684	0.052±0.01^{a}	0.740±0.17^{a}	19.417±1.65^{ab}	0.534±0.13^{a}	5.445±0.09^{b}	34.343±4.78^{ab}
SAC-L02	0.234±0.04^{b}	0.729±0.60^{a}	18.273±0.21^{a}	0.7490±0.12^{a}	2.458±0.27^{a}	44.184±6.92^{b}
IT97K-499-35	5.003±.006^{c}	5.227±.006^{b}	20.373±.038^{ab}	0.804±0.54^{a}	2.227±.031^{a}	65.813±.040^{c}

Mean values across column with same superscripts are not significantly different with p value > 0.05.
Mean Values across column with different superscripts are significantly different from each other with p value < 0.05

The moisture content of the cowpea genotypes varied between 0.05 to 5.00% with only IT97K-499-35 being above 1.00% and it was significantly higher than all of the genotypes studied. Besides, the moisture content of SAC-L02 was also significantly higher than the rest of the cowpea genotypes but lower than that of IT97K-499-35. Similarly, only IT97K-499-35 was significantly different from the rest of the cowpeas in terms of percentage ash content. IT97K-499-35 having the highest ash content (5.23%) followed by UC 96-10 (1.07%), ash content of the rest was below 1.00%.

The total protein among the selected genotypes varied from 18.27 to 21.66%. The genotypes with protein content above 20.00% were IT97K-499-35 (20.37%), UC 96-2 (21.28%) and UC 96-292 (21.66%). Carvalho *et al*. [8], Appiah *et al*. [6] and Onwulivi and Obu [19] have reported values as high as 28, 29 and 39% respectively, but protein contents of over 20%, as were observed in some of the genotypes were considered quite high [20].

With these variations, UC 96-292 which has the highest observed protein content, was significantly different from the lowest observed protein content in SAC-L02 (18.27%). There was no significant difference in the fat content among the cowpeas which ranged from 0.54 (GH 3684) to 1.034% (UC 96-10). Appiah *et al*. [6] also found fat content of selected cowpeas to be between 2.5 and 4.0%. all the genotypes studied were below their findings

The fibre content, which is one of the macronutrients in cowpeas showed variation between 2.23 and 6.07% among the cowpea genotypes. The fibre content of four genotypes varied significantly; UC 96-141 (6.07%), UC 96-2 (5.83%), UC 96-292 (5.46%) and GH 3684 (5.45%) and above 5.00% which appeared higher than those reported by Appiah *et al*. [6]. The highest carbohydrate content was observed in IT97K-499-35 (65.81%) and the least was observed in UC 96-141 (27.62%).

CONCLUSION

Nutritionally**,** cowpeas are well noted for their high protein and fibre contents. In this study, The recombinant inbred lines showed variable amount of nutritional and functional properties. The novel cowpea (UC-96-292 and UC96-2) were found to have higher protein contents than all other genotypes and the parents. Similarly, all the new cowpea genotypes except UC96-10 were found to have very high fibre content as compared to the parents and the local. UC96-292 and UC96-10 were also found to have higher swelling powers while UC96-141 and UC96-2 had higher water absortions than others. Hence, there is therefore the need to explore desirable variabilities in these properties of the novel cowpeas associated with *Striga*-resistance and good agronomic traits for farmers to cultivate in the *Striga* endemic regions of Ghana. These new inbred lines could also be recommended for use in the preparations of foods such as *´Koose´* (cowpea fritters) and *´Waakye´* (rice and bean cooked together) which are typical Ghanaian dishes.

REFERENCES

1. DAVIS, D. W., OELKE, E. A., OPLINGER, E. S., DOL, J. D., HANSON, C. E., PUTNAM, D. H. 1991. Cowpea. Alternative Field Crops Manual. Available from: http://www.hort.purdue.edu/newcrop/afcm/cowpea.html
2. AKPAPUNAM, M. A., SEFA-DEDEH, S. 1997. Jack bean (Canavalia ensiformis) Nutrition related. Aspects and needed research. J. Plant Food Human Nutr., 10, 123-127
3. DUGIE, I. Y., OMOISUI L. O., EKETENEME, F., KAMARA, A.Y. 2009. Farmers Guide to Cowpea production in West Africa pp 46-48 IITA, Ibadan, Nigeria
4. TRINIDAD, P. T., MALLILLIN, A. C., LOYOLA, A. S., SAGUM, R. S., ENCABO, R. R. 2010. The potential health benefits of legumes as a good source of dietary fibre. *British Journal of Nutrition 103, 569–574*
5. CHINMA, C. E., ALEME, I., EMELIFE, I. G. 2008. Physicochemical and Functional Properties of Some Nigerian Cowpea, Varieties. *Pak. J.Nutr.,* 7(1), 186-190.

6. APPIAH, F., KUMAH, P., SEBE, A. T., ASIBUO, J. Y. 2011. Physicochemical and functional properties of seeds of three local cowpea (vigna unguilata l. Walp) cultivars in Ghana. Acta Hort. (ISHS) 911:437-446.
7. Ayanwuyi, E. Akintonde, J. O. 2012, Effect of climate change on cowpea production in kuje area council, abuja, nigeria. *International J. Adv.Res. Manage. Soc. Sci.,* Vol. 1, No. 2, 273-283,
8. IITA (2007). Cowpea. www.iita.org/cms/details/cereal_legumesaspx?=a86&2=63
9. GIAMI, S.Y. 2005. Compositional and nutritional properties of selected newly developed lines of Cowpea (Vigna unguiculata L. Walp). *Journal of Food Composition and Analysis* 18, 665–673.
10. ASARE, A. T., GOWDA, B. S., GALYUON, I. K. A., ABOAGYE, L. M., TAKRAMA, J. F., PADI, F. K., TIMKO, M. P. 2013. Identification of potential sources of *Striga* resistance in cowpea [*Vigna unguiculata* (L.) walp] accessions from Ghana. *Microbiol. Biotech. Res*., 3 (1), 14-22
11. AOAC. 2000. Official Methods of Analysis, Association of Official Analytical Chemists, Washington DC, 16th Edition.
12. OJUKWU, M., OLAWUNI, I., IWOUNO, J. O. 2012. The Proximate Composition and Functional Properties of Full-Fat Flour, and Protein Isolate of Lima Bean (*Phaseolus Lunatus*) *Open Access Scientific Reports*, 1:349. doi:10.4172/scientificreports.349
13. KINSELLA, J. E. 1979. Functional properties of soy protein. *J. Am Oil Chemists' Society* 56, 242-258.
14. EZEMA, 1989. Effect of heat on in-vitro digestibility of navy beans (*P.vulgaris*). *Michigan Quaterly Bull* 46, 87.
15. CARVALHO, A. F. U., MATEUS DE SOUSA, N., FARIAS, D. F., BRITO, D. A., ROCHA-BEZERRA, L.C, PEREIRA, D. A., SILVA, R. M., VIANA, M. P., GOUVEIA S. T., SAMPAIO, S. S., BARBOSA DE SOUSA, M., GOMES DE LIMA, G. P., MAIA DE MORAIS, S., BARROS, C. C., FILHO, F. R. F. 2012. Nutritional ranking of 30 Brazilian genotypes of cowpeas including determination of antioxidant capacity and vitamins. *Journal of Food Composition and Analysis*, 26 (1-2), 81-88
16. Onwuliri VA, Obu JA (2002). Lipids and other constituents of *Vigna unguiculata* and *Phaseolus vulgaris* grown in northern Nigeria. Food Chem. 78(1): 1-7.
17. IQBAL, A., KHALIL, T. A., ATEEQ, N., KHAN, M. S. 2006. Nutritional quality of important food legumes. *Food Chemistry* 9
18. VASCONCELOS, I. M., MAIA, F. M. M., FARIAS, D. F., CAMPELLO, C. C., CARVALHO, A. F. U., MOREIRA, R. A., OLIVEIRA, J. T. A. 2010. Protein fractions, amino acid composition and antinutritional constituents of high-yielding cowpea cultivars. *Journal of Food Composition and Analysis* 23 (1), 54–60.
19. SINGH, B. B., AJEIGBE, H. A., TARAWALI, S. A., FERNANDEZ-RIVERA, S., ABUBAKAR, M. 2003. Improving the production and utilization of cowpea as food and fodder. Field Crops Research 84, 169–150
20. KUNTZ, I. D. 1971. Hydration of macromolecules. III. Hydration of polypeptides. J Am Chem Soc 93: 514-516.

Effect of Lime on Some Soil Chemical Characteristics and Growth of Soybeans (GLYCINE MAX.L.MERR)

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ABSTRACT

A field experiment was carried out in the late rains at the Teaching and Research Farm of the University of Benin to determine the effect of lime ($CaCO_3$) on some soil chemical properties and some agronomic characteristics of soybean (Glycine max .L).Six rates of lime ($CaCO_3$); 0, 1,2,3,4 and 5 ton/ha were applied and replicated four times in a randomized complete block design. Results indicated that, there were significant differences ($P<0.05$) among treatments compared to the control, although a definite pattern of change was not observed. Treatments 3 tons/ha and 4 tons/ha produced significant increase in plant height, leaf area, number of leaves and collar girth of the soybean plant in lime treated soil. However, at 4tons/ha growth parameters were significantly higher at various weeks after planting. There was increase in pH, calcium, potassium, effective cation exchange capacity, organic carbon content of the soil. Slight change in sodium content of the soil was observed. Decrease in phosphorus content of the soil occurred at pH>6 while that of magnesium decreased at pH 6.5 and 6.9. Total nitrogen and exchangeable acidity decreased with increase in lime application. At low pH<6 the soil was acidic probably due to the presence of aluminium and hydrogen ions accumulation resulting in unavailability of nutrients(macro and micro) for plant uptake and maximum growth of soybean. The application of lime to the soil helps to reduce the toxic level of aluminium and hydrogen ions, raise pH of soil to a tolerable level that enhances the release of nutrients for plant. We are dealing with an environment with humid climate where rainfall plays a major role as a factor of change. Increased rainfall increases the intensity of leaching of calcium and magnesium ions resulting in increase in soil acidity. Consequently, the need to lime the soil is imminent.

INTRODUCTION

One of the major limitations to agricultural productivity and reason why tropical soils are underutilised for farming is soil acidity (Rao *et al.*, 1993). Acid soil contains high or toxic amount of aluminium ($Al3^{+}$) and hydrogen (H^+). The actual presence of toxic levels of aluminium and hydrogen ions and the inherent low nutrient status of soil affects the cation exchange capacity (CEC) Grewal *et al.*, (2001). All over the world, poor growth of soybean in acid soils has been attributed to a number of factors that include, low pH high level of Al, Mn and H, low levels of Ca, Mg, P, K (Fageria, 1994). Consequently to reduce acidity and improve the chemical status or condition of the soil, liming surface soil is an available option (Grewal *et al*., 2001).Osei (1995) reported that liming reduces or eliminates acidity by decreasing aluminium saturation and raising soil pH and extends soybeans production (*Glycine max* .L.).

Aghatise and Tayo,(1995) recorded that liming at 0.2 kg/ha, significantly increased plant height, leaf area, number of branches, nodes and modules of soybean in an ultisol. They also reported increase in the availability of macronutrient, such as calcium, magnesium and potassium. Yamoah *et al.,* (1992) reported that liming of oxisols enhanced the release of phosphorus from existing organic matter making large amount of these nutrients available for plant uptake. Peter, (2000) also reported that liming acid soils from pH 4.5 to 6.0, increased the yield of soybean. Phosphorus (p) and potassium (k), calcium, magnesium and sulphur nutrients are needed for proper growth and well being of soybean and these needs are fulfilled by maintaining favourable soil pH (Regis, 1994).

However, surface application of liming materials helps to reduce the toxic levels of Al^{3+} and H^{+} in the soil thereby preventing formation of complexes with some of the elements such as P in the soil. Hence, liming provides adequate nutrients for growth and creates a favourable environment for other properties such as organic matter decomposition in the soil for sustainable crop production and reasonable yield. Therefore, the objective of this study was to determine the effect of lime on some of the agronomic characteristics of soybean (*Glycine Max* L.) and some chemical properties of the soil.

MATERIALS AND METHODS

The field trial was conducted at the faculty of Agricultural Experimental Field at University of Benin, Benin City. Benin City is located within Latitude 6.50N and Longitude 5.8^{0}E . The city exhibits a tropical climate with two major seasons namely the rain which last between April – October and dry (November-March). The peak of the rainy season is usually July – September with brief drop in August. The mean annual rainfall is 2,300mm while the average tempt is 23^{0}C. Benin City has a mean relative humidity of about 70% and the City is both commercial and agrarian city producing assorted crops.

Field trial was organised in September 2001 and Randomised complete block design with four replicates was used in the trial. The dimension of each bed was 2m x 2m and each bed represented by a treatment level. The beds and the replicates were separated from each other by an alley of 50cm. The lime ($CaC0_3$) was applied at rates of 0, 1, 2,3,4,5 tons/ha.The applied lime was mixed thoroughly and left for two weeks for proper mixing and equilibration with the soil. Thereafter two seeds were planted at a spacing of 60cm x 5cm. The trial lasted for 12 weeks. The plant height, number of leaves per plant, leaf area and collar girth of the plant were measured. The soil was analysed before and after trials.

The pH, organic carbon, total nitrogen, phosphorus, potassium, calcium, magnesium, sodium exchangeable bases (CEC), Exchangeable Acidity (EA) and effective cation exchange capacity (ECEC) of the soil were analysed by the standard methods of Udo *et al*., (2009).Particle size analysis was carried out by the hydrometer method of Bouyocous (1951) as modified by Day (1965). The data obtained were analysed by Genstat statistical version while the Duncan multiple range test was used in separating the means at 5% level of probability.

RESULTS AND DISCUSSION

Pre-trial soil properties

The pre-trial soil properties of soil used are depicted in Table 1. The soil low in fertility with moderate acidity of 5.4. The N was within the range of the critical values of 0.15 – 20g/kg^{-1} (Solubo and Osiname, 1981). P was below the critical value range of 10-16mg/kg (Adeoye and Osiname 1981). The magnesium and calcium were below 0.2- 0.4 cmol/kg (Adeoye and Agboola, 1985) and 2.50cmol/kg (Akirinde and Obegbesan, 2000) respectively. The exchangeable acidity was 0.24cmol/kg. The soil texture is sandy loam.

Post trial soil properties

The post trial properties as influenced by the application of lime are depicted in Table 2. The pH of the soil increased with increasing rate of lime treatment. This increase may be tied to reduction in the level of aluminium toxicity. This confirmed the report of Osei (1995) and Achalu *et al.,* (2012). The organic carbon was not consistent with the rate of lime treatment, the organic carbon in the control was however higher than in the treated soil. This decrease is possible since application of lime encourages decomposition of organic matter by soil microbes which to a large proportion are active at (pH 6-7). This result is similar to earlier findings of Aghimien et al (1988) and Regis (1994). A decrease in the total nitrogen from 0.77g/kg to 0.53g/kg with increase in lime rates could have been as a result of increase in activity of micro-organism breaking down organic matter to release nitrogen which in turn is lost either by volatilisation to the atmosphere as N_2O or leached out of the soil. The available phosphorus increased with increase in pH from 10.04mg/kg to 17.11mg/kg then decrease at pH 7.2.

This could have been possible since phosphorus precipitate reaction with calcium at higher pH. Similar results have earlier been reported by Sanchez *et al* (1981), Enwezor *et al* (1981) and Rao *et al* (1993). There was no noticeable change in the concentration of sodium as the lime treatment gradually increased in quantity. Potassium content of the soil however, decreased with application of 1ton/ha of lime to 3ton/ha of lime application an increased was then observed as 4ton/ha of lime treatment was applied, however the pattern of change was not consistent. The magnesium content pattern of increase was not consistent with increase lime treatment. The exchangeable acidity decreased with increase in lime treatments.

This result is similar to the findings of Osei (1995).

Similarly, the mean Na content of the lime treated soil was also higher than that of the control. Except for 4 ton/ha treatment, the K Component in other treatments was lower compared to control. Exchangeable acidity also decreased with lime application while the ECEC increased with increased lime application. The Mg and Ca components in the lime treated soils were higher than that of the control. The calcium content however, increased with increasing lime treatment.

Table 1: Pre-trial physical and chemical properties of the soil use

Soil	Properties
pH(H_20)	5.4
Organic Carbon gkg^{-1}	8.2
Total Nitrogen gkg^{-1}	0.50
Available Phosphorus $mgkg^{-1}$	7.63
Magnesium $cmolkg^{-1}$	0.33
Calcium $cmolkg^{-1}$	1.42
Sodium $cmolkg^{-1}$	0.16
Potassium $cmolkg^{-1}$	0.51
Exchangeable Acidity $cmolkg^{-1}$	0.24
Effective Cation Exchange Capacity $cmolkg^{-1}$	2.66
Sand gkg^{-1}	880
Silt gkg^{-1}	20
Clay gkg^{-1}	100
Textural Class	Sandy Loam

EFFECT OF LIME ON THE GROWTH PARAMETERS OF SOYBEAN PLANT (*GLYCINE MAX*. L)

Except for 1 ton/ha treatment, all other treatments were significantly higher (P<0.05) than the control treatments in plant height (Table 3), Leaf area (Table 4),numbers of leaves (Table 5) and collar girth (Table 6). Throughout the period of trial the improvement in growth parameters may be attributed to higher uptake of nutrients. Similar results were earlier reported by Aghatise and Tayo,(1995) and Workneh *et al* (2013) in soybean plot treated with lime in an ultisol.

Table 2: Effect of lime on soil physical and chemical properties

Some Soil Chemical Characteristics														
Treatment	**t/ha**	**pH(H20)**	**Organic Carbon gkg-1**	**Total N gkg-1**	**Av P Mgkg-1**	**Mg**	**Ca**	**Na**	**K**	**E.A**	**ECEC**	**Sand**	**Silt**	**Clay**
						Cmolkg-1						gkg-1		
After Planting	0	5.5	9.6	0.50	7.630	1.03	1.62	0.14	0.70	0.24	3.73	860	20	120
	1	5.8	10.1	0.77	10.044	1.17	3.08	0.16	0.52	0.20	5.13	870	20	110
	2	6.0	6.4	0.66	11.995	2.11	4.20	0.16	0.45	0.16	7.08	870	10	120
	3	6.5	8.4	0.60	17.707	3.40	5.38	0.21	0.27	0.14	6.34	860	20	120
	4	6.9	8.8	0.55	11.281	1.20	6.42	0.18	1.13	0.12	9.05	860	40	100
	5	7.2	9.8	0.53	8.425	1.42	7.50	0.16	0.93	0.08	10.09	860	20	120

Table 3: Effect of lime on plant height (cm) of soybean (*Glycine max* .L)

Means with similar letters are not significantly different from one another at 5% level of probability

Treatment	Weeks After Planting				
Tons/ha	**2**	**4**	**6**	**8**	**10**
0	5.73[e]	12.60[e]	21.32[e]	32.88[e]	33.03[d]
1	6.30[de]	13.38[de]	22.72[de]	32.89[de]	33.25[cd]
2	6.70[cd]	13.46[cd]	23.62[cd]	33.53[cd]	33.58[c]
3	6.80[bc]	13.60[bc]	25.06[ab]	34.08[bc]	35.76[b]
4	7.11[a]	14.00[a]	27.07[a]	35.08[a]	36.40[a]
5	6.84[ab]	13.65[ab]	24.72[bc]	34.40[ab]	36.35[ab]

Table 4: Effect of lime on leaf area (cm^2) of soybean (*Glycine max* .L)
Mean values similar letters are not significantly different from one another at 5% level of probability.

Treatments	**Weeks After Planting**				
Tons/ha	**2**	**4**	**6**	**8**	**10**
0	8.36[e]	16.72[e]	31.40[de]	28.00[e]	32.70[e]
1	10.51[cd]	21.08[cd]	33.67[cd]	34.81[de]	31.50[de]
2	11.04[ab]	22.08[bc]	34.22[ab]	35.32[de]	31.77[cd]
3	11.90[ab]	23.78[ab]	35.87[ab]	37.93[ab]	31.93[c]
4	12.98[a]	26.03[a]	36.20[a]	39.29[a]	35.95[a]
5	10.39[be]	20.74[de]	30 .93[e]	34.97[cd]	32.38[ab]

Table 5: Effect of lime on number of leaves (cm) of soybean (*Glycine max*.L)

Treatments	Weeks After Planting				
Tons/ha	2	4	6	8	10
0	7.73^{e}	15.21^{e}	29.38^{e}	61.90^{e}	73.48^{e}
1	7.76^{de}	15.28^{de}	31.19^{de}	64.58^{de}	73.85^{de}
2	7.83^{cd}	15.40^{cd}	32.56^{cd}	66.15^{cd}	75.51^{cd}
3	8.08^{bc}	16.15^{bc}	35.75^{bc}	68.28^{be}	84.33^{ab}
4	8.73^{a}	17.45^{a}	36.75^{a}	70.60^{a}	87.20^{a}
5	8.35^{ab}	16.70^{ab}	36.13^{ab}	69.45^{ab}	77.78^{bc}

Means with similar letters are not significantly different from one another at 5% level of probability

Table 6: Effect of lime on collar girth (cm) of soybean (*Glycine max*.L)

Treatments	Weeks After Planting				
Tons/ha	2	4	6	8	10
0	0.57^{e}	1.14^{d}	1.60^{e}	2.14^{e}	3.14^{e}
1	0.63^{bc}	1.25^{cd}	1.73^{de}	2.22^{de}	3.20^{de}
2	0.65^{ab}	1.29^{bc}	1.79^{cd}	2.37^{be}	3.34^{bc}
3	0.68^{a}	1.35^{ab}	1.87^{be}	2.44^{ab}	3.37^{ab}
4	0.68^{a}	1.36^{a}	1.94^{a}	2.47^{a}	3.51^{a}
5	0.68^{a}	1.36^{a}	1.88^{ab}	2.34^{cd}	3.31^{dc}

Means with similar letters are not significantly different from one another at 5% level of probability

CONCLUSION

The results of the present study showed that lime treatment gave optimum plant height, leaf area, number of leaves and collar girth of soybean plant and that liming the soil at 4tons/ha will ameliorate the acid condition of the soil. Over liming should be avoided as it may cause the deficiency of some major nutrients.

REFERENCES

Achalu, C., Heluf, G. Kibebew,K and Abi, T. (2012) Effects of liming on acidity Related chemical properties of soil of different land use system in western Oromia, Ethiopia World Journal of Agricultural Sciences 8(6). 560-567

Adeoye, G.O. and Agboola A.A. (1985) Critical levels for soil pH, available P,K Zn and Mg and ear leaf content of P, Cu and Mn in sedimentary soil of south western Nigeria. Fertilizer Research 6:65-71.

Aghatise V.O. and Tayo (1995) Response of Soybean (Glycine max) to lime application in an acid. Rainforest soil of Nigeria Indian Journal of Agricultural Science 65(12) 883-887.

Aghimien, E.A., Udo, E.J. and Ataga .O. (1988) Profile distribution of forms of iron and aluminium in hydromorphic soils of Southern Nigeria Journal of West Africa Science Association 31:57-70

Akinrinde, E.A and Obegbesan, G.O. (2000) Evaluation of fertility status of selected soil for crop production in five ecological zones of Western Nigeria. Proceeding of the 26th Annual Conference of Soil Science Society of Nigeria, University of Ibadan, October 30th November 3, 279-288.

Day, P. R. (1965) Particle fractionation and particle size analysis in method of soil analysis. Part 1:549-552 ASA Mongra. 9 ASA, Madison WI.

Fageria, N.K. (1994) Soil acidity affects availability of Nitrogen, Phosphorus and potassium better. Crops International 10:8-9

Grewal, H.S. and R. Williams (2001) Lucerne varieties differ in their response to liming in an acid soil. Proceedings of the 10th Australian Agronomy Conference Concurrent Session 3: 3130-1300.

Guo, Y., Niyu, Y. Ling and Jianguo, H. (2009) Effect of liming and sinorhizobium innoculation on growth, modulation and nutrient concentrations of Lucerne in acid soil tropical Grass Land 43:112-117.

Negi, S. Singh, R.V. and Dwived, O.K. (2006) effect of Biofertilizers, nutrient sources and lime on growth and yield of garden pea Legume Response 29: 282-285.

Osei, B.A. (1995) Effect of different lime application rates and time on some chemical properties of an Acid Soil in Ghana. Soil use and Management 11, 25-29.

Peter, C. Scarf (2000) Liming Missouri Soil Agricultural Publication Go 9102 pp 7

Rao, I.M. (1993) Selection and Breeding of Acid Soil Tolerance in Crops. Bioscience, Vol. 13, 454-465

Regis, D. V. (1994) Soybean Soil Fertility Extension Agronomist, Department of Agronomy IOWA State University pp. 11

Workneh, B., Tesfu, K and Jafer, d. (2013) Growth and Nodulation Response of soybean (*Glycine Max* L.) to lime, Bradyrihizobium. Japonicum and Nitrogen fertilizer in Acid Soil at Melko, South Western Ethiopia. International Journal of Soil Science, 8: 25- 31

Yamoah, C. (1992 Correction of Acid, Infertility in Rwandan Oxisols with Lime from an Indigenous source for sustainable Cropping. Experimental Agriculture; Vol. 28, 417-424

Characterization of phenolic contents and their antioxidant properties in some selected cocoa pod husks

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Abstract
Cocoa-pod husk is a by-product of the cocoa harvesting industry and it forms about 80% of the cocoa fruit and it is essentially a waste product. However, many local areas in Nigeria convert the negligible amount of it in the manufacture of local soap and feeding of livestock. Various researches have revealed a significant level of useful components in cocoa pod husk through proximate analysis that quantify the amount of protein, energy and fibre etc. This and many other analyses carried out has directed the interest of researchers and has considerably raised the interest of farmers in using cocoa pod husk as livestock ingredients in Nigeria owing to its abundance availability even at this, there is still a lack of large scale commercial application. This research has proceeded to examine some selected cocoa pod husks (from Taya A, F_3 Amazon and Aminolado) for their total phenol, total flavonoid and ferric reducing properties as well as reveal some phenolic content of cocoa pod husk using GC-MS. The cocoa pod husks were dried and milled. The aqueous extracts (0.5g/10ml each) were prepared. The result showed that the assayed selected husks had significant ($P<0.05$) amount of antioxidant properties and some arrays of displayed phenolics on the GC spectra. By extrapolation, it will be beneficial to the wellbeing of farm animals. With its great abundance, the use of cocoa pod husk could be of great importance in (a) the area of waste reduction in order to further bring greenhouse effect under control. (b) Efforts should be directed at incorporating it into animal diet through the use of modern technology to improve its consumption by animals to further maximize its use. (c) Further studies should be continued to reveal other hidden treasures in them.

Key words: Taya A, F_3 Amazon, total phenol, Aminolado, total flavonoid.

Introduction

The devastating effect of climate change as it affects most populations in the next decades has put the lives and wellbeing of billions of people at increased health risk. Among the outlined major threats to global health from climate change have been termed as both direct and indirect to through changing patterns of disease, water and food insecurity, vulnerable shelter and human settlements, extreme climatic events, and population growth and migration [1] while the main indirect characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity – due to seawater absorbing heat and carbon dioxide from the atmosphere [1]. A new drive towards public health awareness has urgently brought together governments, international agencies, non-governmental organisation (NGOs), communities, and academics from all disciplines to adapt to the effects of climate change on health. One of the adopted adaptative means include the need to improve on the reuse of agricultural waste products [2]. Food insecurity has engulfed most developing nations; including Nigeria. This, has accentuated the critical animal dietary protein deficiency [3].

Recent high cost of livestock products limits the capacity of an average Nigerian to consume adequate quantity and quality of animal protein. The competition between man and his animals for such foods as cereals, pulses and oil seeds is partly responsible for the ever-increasing livestock feed cost. Consequently, a great number of livestock farmers all over Nigeria is not producing to capacity [3]. The fact that the availability of the world's raw materials is dwindling as population grows exponentially, together with the real threat of global food shortages, contributes to a growing awareness of the need for conservation and the re-use of things which once would have been thrown away without a second thought [4]. Many by-products from cocoa, kola, coffee, cashew, tea and cotton among others constitute disposal problem at the factory sites in producing countries. These by products are no longer considered as wastes and on the contrary are discovered to have great potentials as feed ingredients, owing to their abundant availability, non-consumption by humans and richness in nutritional compounds [5, 6].

Cocoa (*Theobroma cacao* L.), is known to form the basis for production of chocolate and it is an important agricultural export commodity [7]. However, Cocoa pod husk (CPH) forms a higher of the whole matured cocoa fruit which is a major by-product from the cocoa industry but is currently under-utilised. As a result of this, enormous quantities of CPH produced at every cocoa harvesting season, become available but discarded as waste [8]. Aside the earlier reports that have revealed the viable use of cocoa pod husk as an unconventional low-cost feed ingredient for animal nutrition; they have been exploited in use for bioremediation or biodegradation [9] and biofertilization [10]. The aim of this drive is to (a) find a substitute that will be cheap (b) serve as a nutrient rich ingredient for the reduction in cost of animal feed [11, 12], (c) form part of solid waste to be reduced or eliminated due to their adverse impacts on the environment and human health and (d) supports economic development and improved quality of life [13].

However, there is a major limitation to its replacement value in animal diets due to its low protein composition coupled with the high content of lignin and non-starch polysaccharides which include hemicellulose and cellulose which are poorly utilised by many farm animals [14]. An extension work of Wood and Fermor [15] had reported an approach in the use fungal biotechnology for the improvement of the nutritional value of CPH. Higher fungi or mushrooms for instance have the ability to bio-transform fibrous agro-residues into nutrient rich products through their extracellular enzyme activities [16].

Most previous research efforts on these by-products were limited to determining the proximate composition, mineral and complete amino acid profiles [17] while there was little or no information about the biological activities of their phytochemical contents. Antioxidants are compounds of natural and synthetic origin with the capacity to scavenge free radicals and they have been studied intensively [18].

Free radicals are very reactive chemical species with an unpaired electron. Because of their reactivity, lipids, proteins and DNA can be damaged by the radicals' action. In consequence, they are responsible for many diseases. Recent interest in these substances has been stimulated by the potential health benefits present in bioactive compounds such as phenol acids and flavonoids which are widely distributed in various parts of plants [19]. Cocoa (Theobroma cacao) as a crop had long been identified as a polyphenols-rich food [20]. An attraction of cocoa polyphenols became more extensive with the discovery of major low molecular weight polyphenols in cocoa, namely epicatechin and catechin, dimer, trimer, and tetramer by reverse-phase liquid chromatography mass spectometry (RP LC-MS) [21]. It has been reported that flavonols (epicatechin and catechin) were predominant compounds in cocoa powder [22]. Epicatechin was predominant in all chocolates, with a ratio of 1:0.1, compared to catechin [23]. The chemical structures of flavonols and procyanidins are important for their antioxidant activity as they possess both free radical trapping and chelation of redox-active metals properties [24].

Antioxidant analyses on various plant samples are carried out on their extracts. The extraction of flavonoids or phenolic acids is usually carried out by using polar solvents, such as hot water, methanol, ethanol, acetone or ethyl acetate, either alone or in combination [25, 26]. The present study was therefore intended to report on the antioxidant activities of aqueous extracts of cocoa pod husk by determining its total phenol, total flavonoid, reducing properties and DPPH radical scavenging ability and also the characterize the phenolic content using GC. This could serve as a further diversion to maximize the use of cocoa pod husk.

MATERIALS AND METHODS

Plant materials

The study was carried out in Ondo State. Nigeria. The state is one of the highest cocoa producers in Nigeria. Three different species of cocoa pod husks of Taya A, Aminolado and F3 Amazon were collected from cocoa research institute in Nigeria (CRIN) at Owena. Ondo State.

Chemicals and equipment

Folin-Ciocalteu's phenol reagent, gallic acid and anhydrous sodium carbonate used were products of Fluka (Buchs, Switzerland). Quercetin and DPPH were products of Merck (Darmstadt, Germany), Iron (II) sulphate, H_2O_2 were products of Sigma (Aldrich, USA). Iron (III) chloride 6-Hydrate is a Fisher product. All other chemicals used were purchased from Rovet Scientific Limited, Benin City, Edo State, Nigeria. The distilled water used was obtained from the Chemistry Department at Federal University of Technology, Akure. Optical absorbance was measured with a ultraviolet (UV)-Visible spectrophotometer (Model 6305; Jenway, Barloworld Scientific, Dunmow, United Kingdom).

Preparations of samples

Each of the cocoa pod husk species were crushed into bits and air dried to constant dryness and then ground into flour. The samples were kept in an air tight container for future analysis.

Aqueous extract preparation

0.5g of each milled sample was soaked in 10ml of distilled water for about 24 h. The mixture was filtered. In a situation where the filtrate appeared to be very cloudy, the filtrate was centrifuged to obtain a clear supernatant liquid, which was subsequently used for the various assays [27]. All antioxidant tests and analyses were performed in triplicate, and results were averaged.

Determination of total phenol content

The total phenol content of extracts was determined according to the method of Singleton et al [28]. Each sample extract was oxidized with 2.5 mL 10% Folin-Ciocalteau's reagent (v/v) for 5 min and neutralized by 2.0 mL of 7.5% sodium carbonate. The reaction mixture was incubated for 40 min at 45°C and the absorbance was measured at 765 nm in the spectrophotometer (JENWAY 6305). The total phenol content was subsequently calculated as gallic acid.

Determination of total flavonoid content

The total flavonoid content of the cocoa pod husk extracts was determined using a slightly modified method of Meda et al. [29]. Briefly, a volume of 0.5 mL of each sample extract was mixed with 0.5 mL methanol, 50 µl of 10% AlCl3, 50 µL of 1 mol/L potassium acetate and 1.4 mL distilled water, was incubated at room temperature for 30 min. Thereafter, the absorbance of the reaction mixture was measured at 415 nm in the spectrophotometer (JENWAY, 6305). Total flavonoid content was calculated using quercetin as a standard.

Reducing power

The reducing activity of the cocoa pod husk extracts was determined by assessing the ability to reduce $FeCl_3$ solution as described by Pulido et al. [30]. A volume of 2.5 mL aliquot was mixed with 2.5 mL of 200 mM sodium phosphate buffer (pH 6.6) and 2.5 mL of 1% potassium ferricyanide. The mixture was incubated at 50°C for 20 min and then 2.5 mL of 10% trichloroacetic acid was added. This mixture was then centrifuged at 805 *g* for 10 min. A volume of 1 mL of different concentrations (50, 100, 150 and 200 µL) of the supernatant was mixed with an equal volume of water and 1 mL of 0.1% ferric chloride. The absorbance was measured at 700 nm in the spectrophotometer (JENWAY 6305) after allowing the solution to stand for 30 min. A graph of absorbance vs. concentration of extract was plotted to observe the reducing power where a higher
absorbance values indicates a higher reducing power.

DPPH radical scavenging ability

The free radical-scavenging ability of the extracts against DPPH free radical was measured by measuring the decrease in absorbance of methanolic DPPH solution at 517 nm in the presence of each sample extract as described by Gyamfi et al. [31]. Briefly, 1 mL of different concentrations (400, 300, 200 and 100 μL) of extracts were added to 1 mL of 0.4 mM methanolic solution containing DPPH radicals. The mixture was left in the dark for 30 min and the absorbance was measured at 516 nm in the spectrophotometer using (JENWAY 6305). The DPPH free radical scavenging ability was subsequently calculated by comparing the results of the test with those of the control (not treated with the extract). The ability of the sample to scavenge was calculated relative to the control using the formula [32]:

% disappearance = [(Acontrol - Asample) / Acontrol] x 100%

GC-characterization of constituent phenolics in the cocoa pod husks

The qualitative-quantitative analysis of the phenolic compounds of the samples was carried out using the method reported by Kelley et al. [33]. The phenolic compounds were extracted from each sample as described by Kelley et al. [33]. After extraction, the purified phenolic extracts (1 μL: 10:1 split) were analyzed for composition by comparison with phenolic standards (Aldrich Chemical Co., Milwaukee, W1) and a cochromatography with standards on a Hewlett-Packard 6890 gas chromatograph (Hewlett-Packard Corp., Palo Alto, CA) equipped with a derivatized, nonpacked injection liner, a Rtx-5MS (5% DIPHENTL-95% Dimethyl polysiloxane) capillary column (30 m length, 0.25 mm column id., 0.25 μm film thickness), and detected with a flame ionization detector (FID). The following conditions were employed PA separation; injector temperature, 230^{o}C; temperature ramp, 80^{0}C for 5 min then ramped to 250^{0}C at 30^{0}C/min; and a detector temperature of 320^{0}C.

Analysis of data

The results of the replicates were pooled and expressed as mean ± Standard Error (SE). Differences were evaluated by 1-way analysis of variance, followed by the Duncan multiple test [34]. EC50 (concentration of extract that will cause 50% concentration activity) was determined using linear regression analysis. P<0.05 was considered statistically significant. Microsoft excel 2003 and origin 6.1 version software was used.

Results

The result of the phenolic contents of the cocoa pod husks is shown in figure 1 and reported as gallic acid equivalent (GAE) for total phenol content and quercetin equivalent antioxidant capacity (QEAC) for total flavonoid (Figure 2). The result revealed that there is no significant difference (P<0.05) in distribution of total phenol content between Taya A and Aminolado but for the total flavonoid content, there is an observed difference (P<0.05) in three species. However, the total phenol and total flavonoid content of F3 Amazon is the highest of the three cocoa pod husks examined.

Figure 3 depicts the reducing power capacity of the cocoa pod husks aqueous extracts to reduce Fe^{3+} to Fe^{2+}, was determined. The result shows significant difference (P<0.05) among the examined cocoa pod husks and that they all have display the capacity to reduce Fe^{3+} to Fe^{2+}.

However, F3 Amazon has the highest reducing power properties. This trend followed what was observed in the total phenol and total flavonoid content.
The DPPH radical scavenging ability of the samples is represented in Figure 4. There is also a significant difference ($P<0.05$) among the samples under study. The result shows that all the examined cocoa pod husks have the ability to scavenge radicals. Contrary to the results observed in other in total phenol, total flavonoid and reducing power, Aminolado has the highest DPPH radical scavenging ability.
The constituent phenolic compounds in the cocoa pod husks using the GC-Characterization are summarized in Table 1. The highest quantities per each cocoa pod husk were reported on Table 1. The result shows that vanillic acid, p-coumaric acid, ferullic acid, sinapinic acid, caffeic acid, coumestein, shogaol and quercetin were identified predominantly in F3 Amazon. Piperic acid, caffeic acid, shogaol and kaempferol were found predominantly in Taya A. Piperic acid, caffeic acid, coumestein, kaempferol and quercetin were also identified to be majorly present in Aminolado.

Discussion

Studies on the health benefits of cocoa and cocoa products have been conducted over the past decades, with a major focus on degenerative diseases. These benefits could be due to their significant amounts of flavonoid monomers (catechin and epicatechin) up to tetradecamers [35]. It was noted that all polyphenols possessed antioxidant action *in vitro*, but do not necessarily exert antioxidant potential *in vivo* [36]. Most of the early studies focusing on health benefits of cocoa polyphenols came from human clinical trials [36]. Moreover, the study on health benefits of cocoa was not limited to that of human intervention but had also been extensively studied in animals by determining cocoa polyphenols content and their protective effect against degenerative diseases [37, 38].

Earlier reported work on polyphenolic compounds has revealed the fact that polyphenols accumulate in the outer parts of plants such as shells, skins, etc. [39]. However, there is limited information on the polyphenolic content of cocoa husks vis-à-vis their quantification and the health benefitting role that they could exert in the body system. In general, phenolics are one of the most widely studied groups of phytochemicals because of their remarkable antioxidant and medicinal properties. Most of the antioxidant and medicinal properties of phenolics have been attributed to flavonoids [40]. In addition, total phemolic content measures the total amount of phenolics which include the flavonoids. The total phenol and total flavonoid contents of extracts have been repeatedly reported as promising medicinal and nutritional ingredients [41]. The phenolic contents of the cocoa pod husk under study are higher than the earlier reported total phenol and total flavonoid content of cocoa powder [42]. Indicating that cocoa pod husks have potent antioxidant activity. The antiradical activity of flavonoids and phenols is principally based on the structural relationship between different parts of their chemical structure [43]. However, the highest ($P<0.05$) content displayed by the F3 Amazon could be attributed to the highest quantities of identified phenolics (Table 1) which also goes in line with what was observed with its flavonoid.

Reducing power is one of the antioxidant activities exerted by plants by electron and hydrogen atom transfer [44]. The highest reducing powers of F3 Amazon could also be attributed to the quantities of the identified phenolics (Table 1). Substances that are capable of scavenging the peroxy radicals which are propagators of autooxidation of lipid molecules are considered as antioxidants [31].

Moreover, the DPPH radical scavenging ability of the aqueous extract could be attributed to hydrogen donating ability of the hydroxyl groups of the phenolics [44]. The present cocoa pod husks results show a promising source of radical scavengers as indicated in our present research.

Bioactive compounds in each sample of cocoa pod husk was identified by means of Gas Chromatography. The results indicated the presence of p-coumaric acid. Trans p-coumaric acid has been discovered to be present in bamboo leaves [18], microorganisms, animals [45] and is synthesized in the human liver [46]. Antioxidant properties of the *trans*-*p*-coumaric acid had earlier been studied experimentally and theoretically [46]. As a result of its radical scavenging activity, *trans*-*p*-coumaric acid can reduce serum cholesterol level and decrease lipid peroxidation [46]. Interestingly, the combination of trans-p-comaric acid with caffeic and ferulic acids can promote the excretion of natural sterols which could lead to a decrease in the absorption of dietary cholesterol [47]. Another compound is sinapinic acid. *Trans*- -sinapinic acid was reported to be present in edible plants and fruits such as broccoli, leafy brassicas and citrus juices [48]. The *trans*-sinapinic acid is a strong antioxidant [49], which is endowed also with anxiolytic and anti-inflammatory properties [50]. The ability of the sinapinic acid to inhibit peroxynitrite-mediated oxidation related with its antioxidant properties has been confirmed by *in vitro* experiments [51]. In comparison to other identified phenolic antioxidants, the sinapinic acid has stronger antioxidant properties than the ferulic acid and p-coumaric acid but lower than caffeic and gallic acids [52]. This is in agreement with our findings. In a simple explanation, all the identified polyphenols are distributed in the cocoa pod husk but in varied quantities and this variance could be suggested to have influenced the antioxidant activities displayed in each of the examined assay

Conclusion

Characterization of cocoa pod husks has revealed some polyphenols of profound antioxidant activities that are protective against free radical species. Aside this, the reuse of cocoa pod husk could solve some of the problems of farmers by using it as a cheap and nutrient rich ingredients in producing animal feeds. This will reduce the cost of animal feed production thus, making it affordable to farmers. Nevertheless, the increased interest in the reuse of agro-industrial waste (like cocoa pod husk) will become one of the methods of waste reduction in order to manage waste. There are many environmental benefits that can be derived from the use of this method. They reduce or prevent greenhouse gas emissions, reduce the release of pollutants, conserve resources and save energy.

References

1. Weart SR. The discovery of global warming. Cambridge: Harvard University Press, 2004.
2. Intergovernmental Panel on Climate Change. Climate change 2007. The physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Solomon S, Qin D, Manning M, et al, eds. Cambridge University Press, 2007.
3. Food and Agricultural organization (FAO) (1998). The state of food and Agriculture. Agric. Series, Rome Italy. 33: 10-12.
4. Abioye J, Fanimo AO, Bamgbose AM, Dipeolu MA, Olubamiwa O (2006). Nutrient utilization, growth and carcass performance of broiler chickens fed graded levels of kolanut husk. J. Poult. Sci., 43: 365-370.
5. Hamzat RA, Longe OG (2000). Potentials of kola testa as a sole feed for Archachatina marginata snails raised under kola plantation. Nigerian J. Tree Crops Res., 4: (2) 1-19.
6. Uwagboe EO, Hamzat RA Olumide MD, LA, Akinbile (2010). Utilization of cocoa podhusk as a substitute for maize in layer's mash and poultry farmers' perception in Nigeria. Inter. J. Sci.Nature. 1(2): 272-275.
7. Hammerstone, J. F., Lazarus, S. A., Mitchell, A. E., Rucker, R., & Schmitz, H. H. (1999). Identification of procyanidins in cocoa (Theobroma cacao) and chocolate using high-performance liquid chromatography/mass spectrometry. Journal of Agricultural and Food Chemistry, 47, 490–496.
8. ICCO (International Cocoa Organisation) (2003). ICCO Quarterly Bulletin of Cocoa Statistics. Vol. XXX No. 4. Cocoa year 2003/04.
9. Agbor, R. B, Ekpo, I.A, Udofia, U.U, Okpako E.C and Ekanem E.B. (2012). Potentials of cocoa pod husk and plantain peels in the degradation of total petroleum hydrocarbon content of crude oil polluted soil, Archives of Applied Science Research; 4 (3): 1372-1375.
10. Agbeniyi, S.O, Oluyole K.A and Ogunlade M.O. (2011). Impact of Cocoa Pod Husk Fertilizer on Cocoa Production in Nigeria. World Journal of Agricultural Sciences 7 (2): 113-116.
11. Atuahene CC, Adams C, Adomako D (1984). Cocoa Pod Husk in Starter Diets of Broiler Chicken. In: Cros E (ed) Proceedings of 9th International Cocoa Research Conference, Lome Togo.
12. Sobamiwa O (1998). Performance and Egg Quality of Laying Hens Fed Cocoa Husk Based Diets. Nig. J. Anim. Prod. 25: 22-24.
13. (SSWPU) Sewerage and Solid Waste Project Unit. (2000). The solid waste management. Sewerage and Solid Waste Project Unit, Barbados. http://www.solid.gov.bb/Resources/Brochures/Programme/program02.asp
14. Sobamiwa O (1993). Use of Cocoa-Pod Husk in Poultry Feeds: A Particular Reference to the Nigerian Situation. In: De Lafforest J (ed) Proceedings of 11th International Cocoa Research Conference,
Yamoussoukro Cote D'Ivoire, 18-24.

15. Wood DA, Fermor TR (1982). Nutrition of *Agaricus bisporous* in Compost. Mushroom J. 114: 194-197.
16. Kuforiji, O. O. and Fasidi, I.O. (2008). Enzyme activities of *Pleurotus tuber-regium* (Fries) Singer cultivated on selected agricultural wastes. Bioreources Technology 99, 4275-4278.
17. Hamzat R. A. and Adeola O. (2011). Chemical Evaluation of Co-products of Cocoa and Kola as Livestock Feeding Stuffs. J. Anim. Sci. Adv., 2011, 1(1):61-68.
18. Zhang Y, Tie X, Bao , Wu X and Zhang Y. (2007). Metabolism of flavone C-glucosides and p-coumaric acid from antioxidant of bamboo leaves (AOB) in rats. B. J. Nutr. 97, 484-494.
19. Nelson R.L. (1992). *Dietary iron and colorectal cancer risk*. Free Radical Biol. Med. 12, 161-168
20. Ultee, A.J. (1909) van Dorsen, J. Bijdrage tot de kennis der op Java gecultiveerde cacaosooten. In *Java Agric Station Report*, *33*.
21. Natsume, M.; Osakabe, N.; Yamagishi, M.; Takizawa, T.; Nakamura, T.; Miyatake, H.; Hatano, T.; Yoshida, T. (2000) Analyses of polyphenols in cacao liquor, cocoa, and chocolate by normal-phase and reversed-phase HPLC. *Biosci. Biotechnol. Biochem.*, *64*, 2581-2587.
22. Natsume, M. Osakabe, N., Takizawa, T., Nakamura, T., Miyatake, H., Hatano, T. Yoshida, T. (2002). Analysis of polyphenol constituents in cocoa and chocolate. In *Quality Management of Nutraceuticals*; Ho. C-T.; Zeng, Q.Y., Eds.; ACS Symposium Series 803; American Chemical Society: Washington, DC, USA,; pp. 180-198.
23. Cooper, K.A. Campos-Gimenez, E.; Alvarez, D.J.; Nagy, K.; Donovan, J.L. Williamson, G. (2007) Rapid reverse-phase ultra-performance liquid chromatography analysis of the major cocoa polyphenols and inter-relationship of their concentration in chocolate. *J. Agric. Food Chem.*, *55*, 2841-2847.
24. Verstraeten S.V. Oteiza, P.I.; Fraga, C.G. (2004). Membrane effects of cocoa procyanidins in liposomes and Jurkat T cells. *Biol. Res.*, 37, 293-300.
25. Robbins, R.J. (2003) Phenolic acids in foods. J. Agric. Food Chem., 51, 2866–2887.
26. Qian, J.Y.; Liu, D. (2004) Huang, A.G. The efficiency of flavonoids in polar extracts of Lycium Chinese Mill fruit as free radical scavenger. Food Chem., 87, 283–288.
27. Oboh G, Rocha J.B.T. (2007) Polyphenols in red pepper [Capsicum annuum var. aviculare (tepin)] and their protective effect on some pro-oxidants induced lipid peroxidation in brain and liver. European Food Research and Technology; 225: 239–247.
28. Singleton V.L, Orthofer R, Lamuela-Raventos R.M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin–Ciocalteu reagent. In: Methods in Enzymology, vol. 299. (Packer L, ed.). Academic Press, San Diego, CA, USA, pp. 152–178.
29. Meda A, Lamien C.E, Romito M, Millogo J, Nacoulma O.G. (2005). Determination of the total phenolic, flavonoid and proline contents in Burkina Faso honey, as well as their radical scavenging activity. Food Chem; 91:571–577.

30. Pulido, R., Bravo, L. and Saura-Calixto, F. (2000). Antioxidant activity of dietary polyphenols as determined by a modified ferric reducing/antioxidant power assay. J.Agric. Food Chem. 48, 3396–3402.
31. Gyamfi M.A, Yonamine M, Aniya Y. (1999). Free-radical scavenging action of medicinal herbs from Ghana: Thonningia sanguinea on experimentally-induced liver injuries. Gen Pharmacol; 32: 661–667.
32. Krings U, Berger RG (2001). Antioxidant activity of some roasted foods. Food Chem., 72: 223-229
33. Kelley W.T.D., Coffey D.L., and Mueller T.C. (1994). Lipid chromatographic determination of phenolic acids in soil. The Journal of AOAC International; 77: 805 – 809.
34. Zar J.H. (1984). Biostatistical Analysis. New Jersey, US: Prentice-Hall Inc.
35. Kelm M.A.; Johnson, J.C.; Robbins, R.J.; Hammerstone, J.F. (2006) Schmitz, H.H. High-performance liquid chromatography separation and purification of cacao (*Theobroma cacao* L.) procyanidins according to degree of polymerization using a diol stationary phase. *J. Agric. Food Chem*, 54, 1571-1576.
36. Cooper K.A.; Donovan, J.L. (2008) Waterhouse, A.L.; Williamson, G. Cocoa and health: a decade of research. *Bri. J. Nutr*, *99*, 1-11.
37. Mathur S.; Devaraj, S. (2002) Grundy, S.M.; Jialal, I. Cocoa products decrease low density lipoprotein oxidative susceptibility but do not affect biomarkers of inflammation in humans. *J. Nutr*, *132*, 3663-3667.
38. Karim M.; McCormick, K. (2000) Kappagoda**,** C.T. Effects of cocoa extracts on endothelium-dependent relaxation. *J. Nutr, 130*, 2105S-2108S.
39. Bravo L. (1998). Polyphenols: chemistry, dietary sources, metabolism and nutritional significance. Nutrition Reviews, 56, 317–333.
40. Tapas A.R, Sakarkar D.M, Kakde R.B. (2008). Flavonoids as Nutraceuticals: A Review. Trop J Pharm Res; 7 (3): 1089-1099.
41. Akinmoladun A.C, Obuotor E.M, Farombi E.O. (2010) Evaluation of Antioxidant and Free Radical Scavenging Capacities of Some Nigerian Indigenous Medicinal Plants. J Med Food; 13: 444-451.
42. Abbe MaleykI M.J and. Ismail A. (2010). Antioxidant Properties of Cocoa Powder. Journal of Food Biochemistry 34; 111–128.
43. Rice-Evans, C., Miller, N.J. and Paganga, G. (1996). Structure-antioxidant activity relationships of flavonoids and phenolic acids. Free Radic. Biol.Med. *20*, 933–956.
44. Hu C, Zhang Y, Kitts D.D. (2000) Evaluation of antioxidant and prooxidant activities of bamboo Phyllostachys niger var. henonis leaf extract in vitro. J Agricult Food Chem; 48:3170–3176.
45. Borges F, Roleira F, Milhazes N. Santana L and Uriarte E. (2005). Simple coumarins and analogues in medicinal chemistry: occurrence, synthesis and biologicalactivity, Curr. Med. Chem. 12, 887-916.
46. Zang L.Y, Cosma G, Gardner H,. Shi X,. Castranova, and Vallyathan V. (2000). Effect of antioxidant protection by p-coumaric acid on low-density lipoprotein cholesterol oxidation. A. J. Physiol.-Cell Physiol. 279, C954-C960

47. YehY.H, Lee Y.T,. Hsieh H.S and Hwang D.F. (2009). Dietary Caffeic Acid, Ferulic Acid and Coumaric Acid Supplements on Cholesterol Metabolism and Antioxidant Activity in Rats. J. Food and Drug Anal. 17, 123-132
48. Dabrowski K.J. and Sosulski F.W. (1984). Quantitation of Free and Hydrolyzable Phenolic Acids in Seeds by Capillary Gas-Liquid Chromatography. J. Agric. Food Chem. 32, 123–127.
49. Galano A, Francisco-Marquez M and Raul Alvarez-Idaboy J. (2011). Mechanism and kinetics studies on the antioxidant activity of sinapinic acid. Phys. Chem. Chem. Phys. 13, 11199–11205.
50. Yoon B.H, Jung,J.W J.. Lee J.J. Cho Y.W and. Jang C.G, Jin C, Oh T.H and Ryu G.H. (2007). *Anxiolytic-like effects of sinapic acid in mice*. Life Sci. 81, 234–240
51. Niwa T, Doi U, Kato Y and Osawa T. *Inhibitory mechanism of sinapinic acid against peroxynitrite-mediated tyrosine nitration of protein in vitro*. FEBS Lett. 459, 43-46 (1999).
52. Cuvelier M.E, Richard H and Berset C. *Comparison of the antioxidative activity of some acid-phenols: structure-activity relationship*. Biosci. Biotechnol. Biochem. 56, 324-325 (1992).

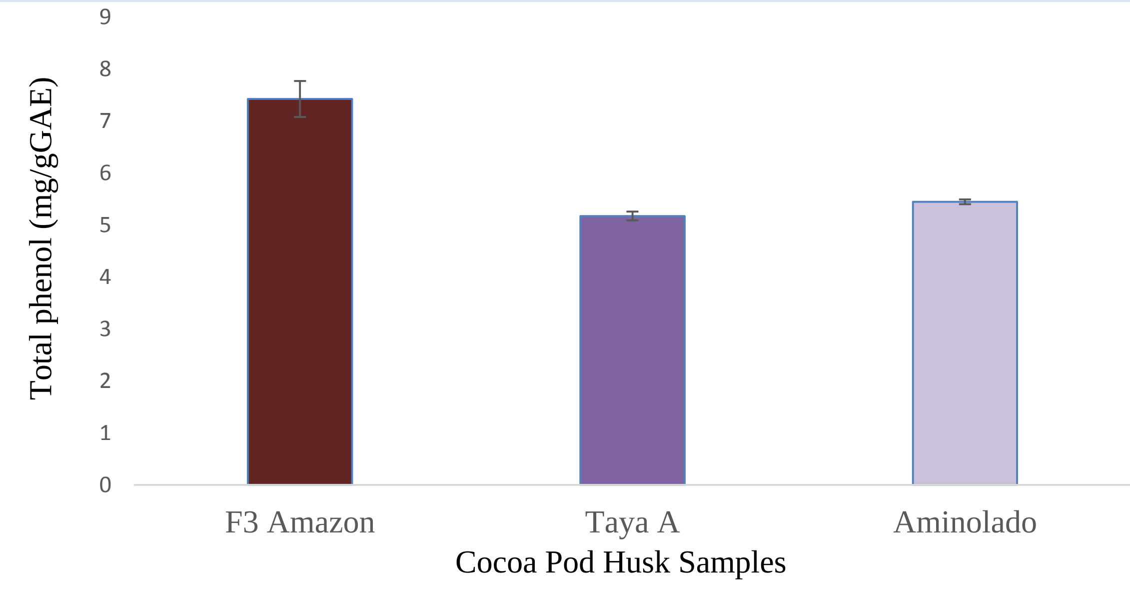

Figure 1. Total Phenol Content of Selected Cocoa Pod Husks

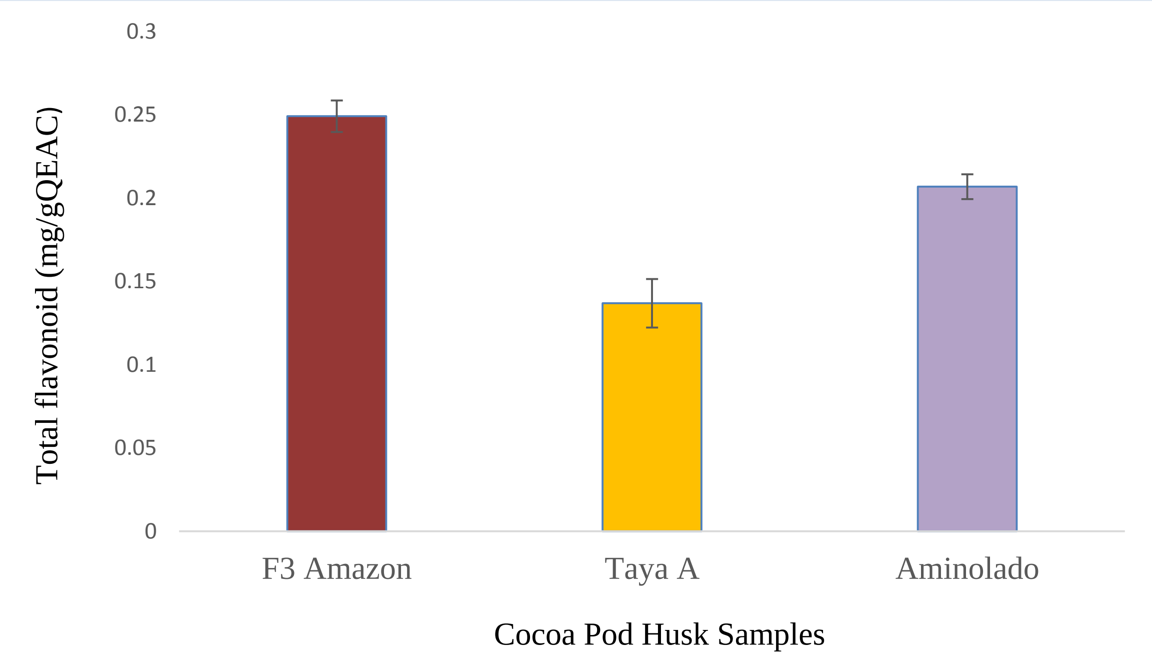

Figure 2. Total Flavonoid Content of Selected Cocoa Pod Husks

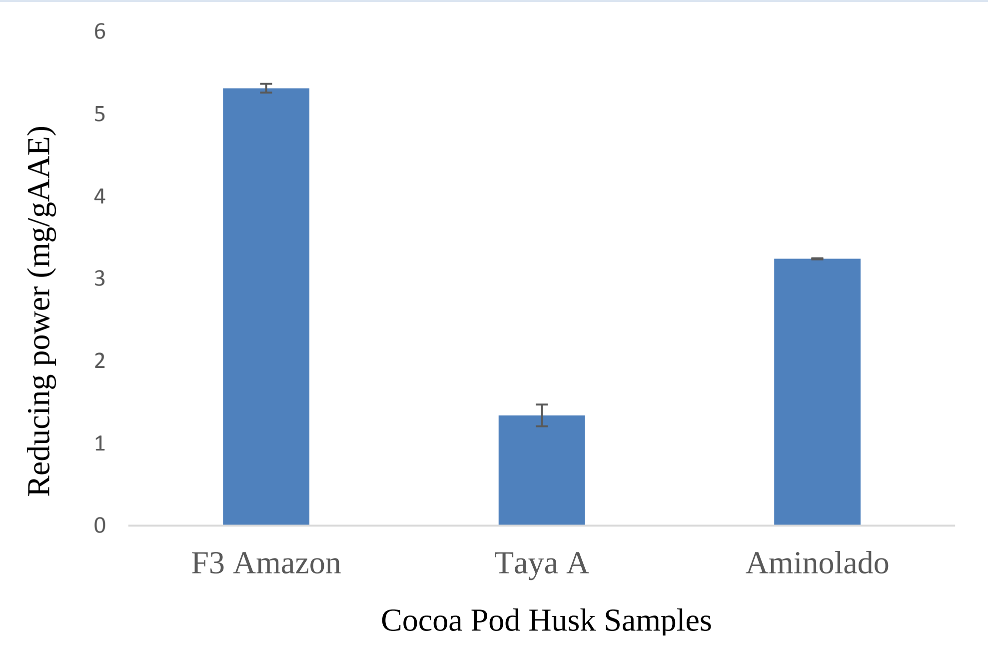

Figure 3. Reducing Power Content of Selected Cocoa Pod Husks

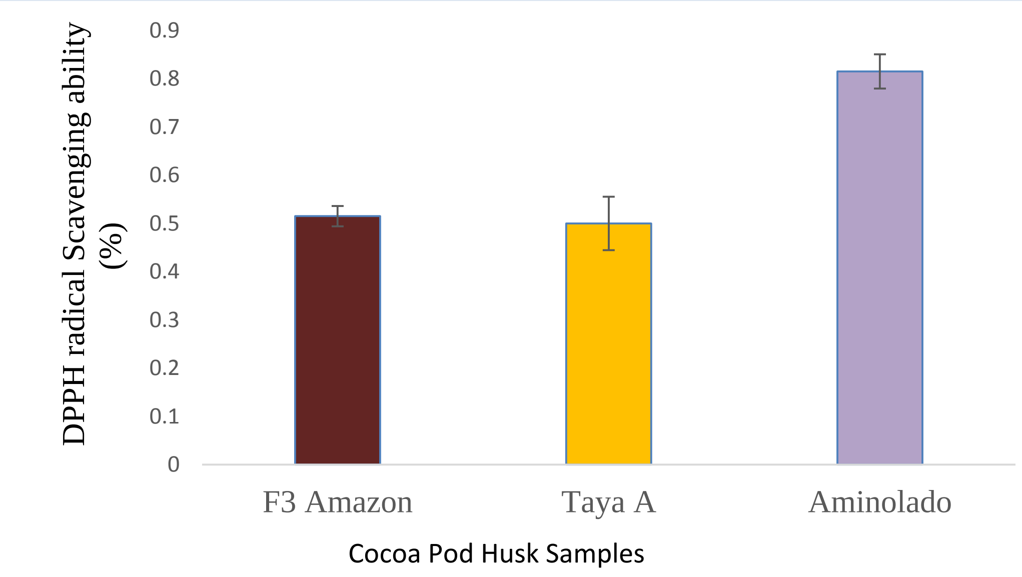

Figure 4. DPPH radical scavenging ability of Selected Cocoa Pod Husks

Table 1. Main constituents of phenolics present in cocoa pod husks mg/100g

Phenolics identified	F3 Amazon	Taya A	Amimolado
Vnillic Acid	5.11	6.29x10-3	4.83x10-3
p-coumaric Acid	4.02	1.40x10-3	6.34x10-3
FerulicAcid	4.74	2x10-3	2.09x10-2
Sinaplric Acid	6.58	4.91x10-2	3.52x10-3
Piperic Acid	2.00x10-2	2.61	5.34
Caffeic Acid	8.42	5.62	5.58
Coumestein	2.37	3.42x10-3	0.51
Shogaol	6.30	1.05	5.34x10-3
Kaempferol	3.69x10-2	2.12	3.53
Quercetin	6.3	6.89x10-3	4.54

THEME 5: CLIMATE CHANGE AND GENDER MAINSTREAMING

Women, Indispensable Tools for Combating the Effects of Climate Change in Sub-Saharan Africa

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ABSTRACT

Climate is the pattern of variation in atmospheric pressure, temperature, humidity, precipitation, wind, atmospheric particle, etc. Climate change refers to a change in the average state of the climate and/or the variability of its properties. The Earth's climate has changed many times in response to natural causes. However, since the early 1900s, our climate has changed rapidly due to persistent man-made changes in the composition of the atmosphere or in land use. The impacts of climate change are diverse and could be damaging to billions of people across the world, particularly those in developing countries who are the most vulnerable. Many of the effects of climate change will have negative economic consequences. Effects of these changes include drought, global warming, flooding, heat waves, hurricanes, avalanches, windstorms etc. In all the above effects, women and children are mostly affected since it is the duty of the women in Africa to protect and take care of the home and children. In this paper, the woman's role in reducing, if not eradicating the drastic effects of climate change as it affects her environment, family and children and how she is set to achieve this uphill task are highlighted. Some of the ways include, empowering the girl child through education and acquiring vocational skills, reducing her burden through family planning and child spacing, involvement in agriculture for self sustenance and export, involvement in policy making decisions, eradicating some of Africa's dehumanizing cultural practices etc.

INTRODUCTION

Climate is the pattern of variation in atmospheric pressure, temperature, humidity, precipitation, wind etc. The world has seen changes in her climate even from creation. Over the years, history has recorded several changes in her climate leading most time to disastrous consequences. The world has in the last decade seen tremendous changes in her climate which have negative impact on the environment leading to flooding caused by excessive rainfall, heat stress, epidemics etc.

Causes of Climate Change

Earth is a very special planet – its orbits close enough to the sun to receive a lot of energy, but far enough away not to be scorched. It is located in a safe zone where the conditions are just right for life as we know it. To help keep these conditions constant, our planet is wrapped in a layer of greenhouse gases. This layer acts like a blanket, keeping the earth warm and shielding it from the cold of universe. This is commonly referred to as the greenhouse effect or ozone layer. Carbon dioxide (CO_2) is the main driver of the greenhouse effect.

When fossil fuels - coal, oil and natural gas - are burnt they release CO_2 into the atmosphere. There is a depletion of the protective layer causing the sun rays intensity to increase. In order to satisfy our endless hunger for energy we are burning unlimited quantities of fossil fuels. Thus the ongoing unlimited burning of fossil fuels is the major cause of climate change.CO_2 can be harmless enough when dissolved in a drink – it adds sparkle to mineral water, soft drinks and champagne. However, when excess amounts are released into the atmosphere it can cause untold damage.

The average coal-fired power plant wastes twice as much energy heating up the planet as it converts to useful electricity.

On the broadest scale, the rate at which energy is received from the sun and the rate at which it is lost to space determine the equilibrium temperature and climate of Earth. This energy is distributed around the globe by winds, ocean currents, and other mechanisms to affect the climates of different regions.

Factors that can shape climate are called climate forcings or "forcing mechanisms". These include processes such as variations in solar radiation, variations in the Earth's orbit, mountain-building and continental drift and changes in greenhouse gas concentrations. There are a variety of climate change feedbacks that can either amplify or diminish the initial forcing. Some parts of the climate system, such as the oceans and ice caps, respond slowly in reaction to climate forcings, while others respond more quickly. Forcing mechanisms can be either "internal" or "external". Internal forcing mechanisms are natural processes within the climate system itself (e.g., the thermohaline circulation). External forcing mechanisms can be either natural (e.g., changes in solar output) or anthropogenic (man made) e.g., increased emissions of greenhouse gases).

Whether the initial forcing mechanism is internal or external, the response of the climate system might be fast (e.g., a sudden cooling due to airborne volcanic ash reflecting sunlight), slow (e.g. thermal expansion of warming ocean water), or a combination (e.g., sudden loss of albedo in the arctic ocean as sea ice melts, followed by more gradual thermal expansion of the water). Therefore, the climate system can respond abruptly, but the full response to forcing mechanisms might not be fully developed for centuries or even longer.

Effects of Climate Change

We are already seeing changing weather patterns impacting food production and species migration. Storms and hurricanes destroy farmlands. Relief materials will be needed to re settle affected homes thus leading to shortages of food. Fresh water scarcity risks becoming even more acute in drought-stricken countries and flooding may increasingly threaten our coastal communities and directly impact hundreds of thousands of people each year.

Conflict is increasing over strained ecosystems and local communities are being forced from their homes as they are forced to vacate their homes and seek shelter elsewhere. Weather and climate play a significant role in people's health. Changes in climate affect the average weather conditions that we are accustomed to. Warmer average temperatures will likely lead to hotter days and more frequent and longer heat waves, heat stroke and dehydration. This could increase the number of heat-related illnesses like meningitis, chicken pox etc and deaths. The impacts of climate change on health will depend on many factors. These factors include the effectiveness of a community's public health and safety systems to address or prepare for the risk and the behavior, age, gender, and economic status of individuals affected. Impacts will likely vary by region, the sensitivity of populations, the extent and length of exposure to climate change impacts, and society's ability to adapt to change.

There will be interruption in communication, utility, and health care services. Storms destroy electric poles and wires hereby cutting off power supply and health care facilities dependent on them. Due to power outage, generators will be used to supply electricity which contributes to carbon monoxide poisoning from portable electric generators used during and after storms. Increase stomach and intestinal illness among evacuees. This is because; the level of hygiene will be reduced thus exposing the body to reduced immunity.

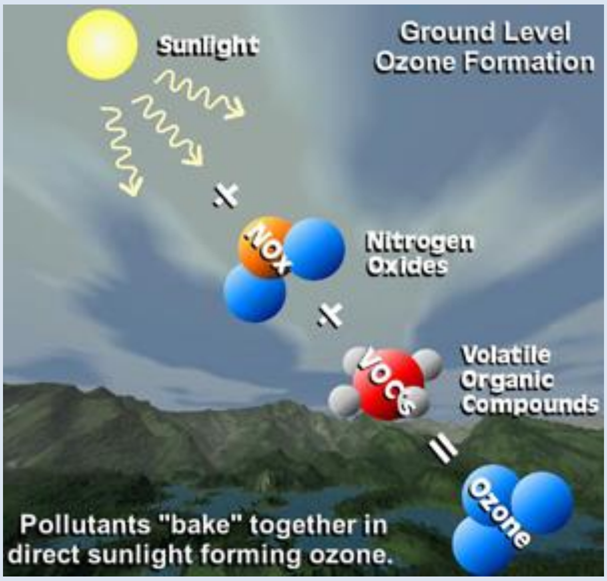
Contribute to mental health impacts such as depression and post-traumatic stress disorder (PTSD). People respond to changes in their environment n different ways. Some people do not withstand pressures and so are likely to be easily depressed due to the stress associated with a sudden change in their life pattern.

Impacts from Extreme Weather Events

Flooded streets in New Orleans after Hurricane Katrina in 2005. Source: FEMA (2005)

Scientists project that warmer temperatures from climate change will increase the frequency of days with unhealthy levels of ground-level ozone, a harmful air pollutant, and a component in smog.

Smog in Los Angeles decreases visibility and can be harmful to human health. Source: California Air Resources Board (2011)



Ozone chemistry. Source: NASA (2012)

Ground-level ozone can damage lung tissue and can reduce lung function and inflame airways. This can increase respiratory symptoms and aggravate asthma or other lung diseases. It is especially harmful to children, older adults, outdoor workers, and those with asthma and other chronic lung diseases. Ozone exposure also has been associated with increased susceptibility to respiratory infections, medication use, doctor visits, and emergency department visits and hospital admissions for individuals with lung disease. Some studies suggest that ozone may increase the risk of premature mortality, and possibly even the development of asthma. Ground-level ozone is formed when certain air pollutants, such as carbon monoxide, oxides of nitrogen (also called NOX), and volatile organic compounds, are exposed to each other in sunlight. Ground-level ozone is one of the pollutants in smog. Because warm, stagnant air tends to increase the formation of ozone, climate change is likely to increase levels of ground-level ozone in already-polluted areas. Higher air temperatures can increase cases of salmonella and other bacteria-related food poisoning because bacteria grow more rapidly in warm environments. These diseases can cause gastrointestinal distress and, in severe cases, death.

Flooding and heavy rainfall can cause overflows from sewage treatment plants into fresh water sources. Overflows could contaminate certain food crops with pathogen-containing feaces. Heavy rainfall or flooding can increase water-borne parasites such as Cryptosporidium and Giardia that are sometimes found in drinking water. These parasites can cause gastrointestinal distress and in severe cases, death. Heavy rainfall events cause storm water runoff that may contaminate water bodies used for recreation (such as lakes and beaches) with other bacteria. The most common illness contracted from contamination at beaches is gastroenteritis, an inflammation of the stomach and the intestines that can cause symptoms such as vomiting, headaches, and fever. Other minor illnesses include ear, eye, nose, and throat infections.

Mosquitoes favor warm, wet climates and can spread diseases such as malaria in sub-Saharan Africa. The spread of climate-sensitive diseases will depend on both climate and non-climate factors. The risks of climate-sensitive diseases can be much higher in poorer countries that have less capacity to prevent and treat illness.

Other linkages exist between climate change and human health. For example, changes in temperature and precipitation, as well as droughts and floods, will likely affect agricultural yields and production. In some regions of the world, these impacts may compromise food security and threaten human health through malnutrition, the spread of infectious diseases, and food poisoning. The worst of these effects are projected to occur in developing countries, among vulnerable populations. Declines in human health in other countries might affect the United States through trade, migration and immigration and have implications for national security. Although the impacts of climate change have the potential to affect human health in the United States and around the world, there is a lot we can do to prepare for and adapt to these changes.

Women to the Rescue

Given that women are engaged in more climate related change activities than what is recognized and valued in the community, their important role in the adaptation and search for safer communities, which leads them to understand better the causes and consequences of changes in climatic conditions. Women have important knowledge and skills for orienting the adaptation processes, a product of their roles in society (productive, reproductive and community); and the importance of gender equity in these processes cannot be over emphasized. These can be achieved through

a) Avoidance of overcrowding of the house hold. It is the responsibility of the local woman in a typical African setting to ensure that her house hold is comfortable so while doing that, she should ensure that there is cross ventilation in her homes to combat the hazardous effect of heat waves.
b) They ensure that buffer water storage is kept in place for use during the period of flooding to avoid use of contaminated or polluted water during flooding.
c) Women preserve food crops during the bumper and hey days for use in periods of drought and famine. This ensures that there is food when farmlands are destroyed by excessive rains and storms.

d) They practices safe home practices like proper disposal of domestic wastes to prevent the blockage of drainages which let out water from the streets and homes thus reducing the effect of flooding.

e) At the grass root level, most of the women are peasant farmers. They plant trees and food crops which help to create a balance in the ecosystem. The plants maintain the concentration of oxygen in the atmosphere thereby reducing the concentration of carbon dioxide in the atmosphere thus reducing the depletion of the ozone layer

f) They are part of the policy makers in the home so they use the opportunity to ensure that climate friendly activities are put in place at the grass root level. This inculcates such good practices in the children and the future generation.

RECOMMENDATIONS

1. Women and children are the most vulnerable in climate change so they should be involved in taking decisions in issues concerning climate change.
2. They should be empowered through education and awareness programs. Knowledge is power so when they know the impending dangers coming, they will device means of adaptation and also aversion.
3. Women should be involved in policy making. This ensures gender balance and equity in decisions which have been taken and which will also affect them.
4. Cultural practices which relegate women to the background should be abolished to ensure that women take part in issues concerning them.

REFERENCES

1. USGCRP (2009). *Global Climate Change Impacts in the United States* . Karl, T.R., J.M. Melillo, and T.C. Peterson (eds.). United States Global Change Research Program. Cambridge University Press, New York, NY, USA.

2. CCSP (2008). *Analyses of the effects of global change on human health and welfare and human systems* . A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Gamble, J.L. (ed.), K.L. Ebi, F.G. Sussman, T.J. Wilbanks, (Authors). U.S. Environmental Protection Agency, Washington, DC, USA.

3. EPA (2010). *Our Nation's Air: Status and Trends Through 2008* (PDF). U.S. Environmental Protection Agency. EPA -454/R -09-002.

4. NRC (2010). *Adapting to the Impacts of Climate Change* . National Research Council. The National Academies Press, Washington, DC, USA.

5. EPA (2006). *Air Quality Criteria for Ozone and Related Photochemical Oxidants (2006 Final)* . U.S. Environmental Protection Agency, Washington, DC, USA.

6. EPA (2009). *Integrated Science Assessment for Particulate Matter: Final Report* . U.S. Environmental Protection Agency, Washington, DC, USA.

7. NRC (2010). *Advancing the Science of Climate Change* . National Research Council. The National Academies Press, Washington, DC, USA.

8. EPA (2009). *Assessment of the Impacts of Global Change on Regional U.S. Air Quality: A Synthesis of Climate Change Impacts on Ground-Level Ozone (An Interim Report of the U.S. EPA Global Change Research Program)* . U.S. Environmental Protection Agency, Washington, DC, USA.
9. Confalonieri, U., B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revich and A. Woodward (2007). Human health. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability* . *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* Cambridge University Press, Cambridge, United Kingdom.
10. Y. Carvajal-Escobar1, M. Quintero-Angel1, and M. Garc´ıa-Vargas2 Women's role in adapting to climate change and variability

Gender Analysis of Impacts and Adaptation to Climate Change in Educational Institutions in Imo State, South East Nigeria

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ABSTRACT
While it is generally known that impacts of climate change differ by gender, the extent this applies to education institutions is not known. This study addressed two issues. The first is whether perceptions of the impact of climate change in education institutions differ by gender, and if so, the second issue, which is whether adaptation options are gender differentiated. These therefore led to identification of trend in changes in climate parameters, gender analysis of impacts of, and adaptation to climate change in educational institutions in Imo State Nigeria. Primary data was obtained from a cross sectional survey of two public secondary schools in each education zone of the State and the four tertiary institutions in the state. Secondary data were time series of climatic variables (temperature, volume of rainfall and number of rainy day) for a period of forty-one years [1972-2012]. Sixty science students (thirty male and thirty female students) from the six secondary schools and forty students (twenty male and twenty female students) from faculties/schools of environmental sciences in the four tertiary institutions were randomly selected for the survey. Six (three female and three male teachers) in each school were interviewed. Data collected were subjected to trend analysis and descriptive statistics. Results show that climate change is having significant

impact on teaching and learning activities in schools, and impacts are not gender neutral. Also, perception of autonomous adaptation practices and adaptation measures to climate change vary significantly across gender. It is therefore important that opinions of female and male teachers and students be taken into consideration when seeking to understand outcomes of environmental change, including climate change, and when developing mitigation and adaptation measures. Adaptation projects should address gender-specific impacts of climate change in design and implementation.

Keywords: Climate Change, Impacts, Adaptation Measures, Education Institutions, Gender

INTRODUCTION

Ensuring quality education is a major challenge [13]. Ensuring that classroom environment and teaching and learning activities, school physical plant (school buildings, location, and environment safety are in good condition and teachers who have capacity to adapt to changing social and environmental conditions is also critical. School climate free from risk and hazards keep students in school and improve accomodative management policies which are necessary conditions for ensuring quality schooling. Negative aspects of schools can make the students uncomfortable [10]. Climate change could therefore adversely affect conducive school environment necessary for teaching and learning.

Climate change is defined as a change in the state of the climate. This can be identified by changes in the mean and or the variability of climate properties that persists for an extended period, typically decades or longer [8,9]. Nigeria's climate is changing and is likely to see shifts in temperature, rainfall, storms, and sea levels throughout the twenty-first century [19, 4]. Variations in rainfall particularly have occurred for the different regions in Nigeria. In the south east, especially in Imo State, rainfall is observed to be increasing while temperature while fluctuating is also generally increasing [17]. It was assumed in this study that the fluctuations in rainfall and temperature regimes are the most relevant in Imo State of Nigeria.

Climate change could have widespread implications for the education sector. Institutions of learning face clear and growing risks from climate disruption and it is crucial that administrators and advocates of these institutions be aware of these risks. Addressing these risks by factoring in gender impacts and adaptation strategies can provide the opportunity to equip men and women in institutions of learning for the 21st century.

The gender dimensions of the impact and adaptation of climate change still has some gaps in knowledge. It takes into consideration that women and men react to and participate in social, economic and environmental realities differently depending on their age, socio-economic status and culture. It is believed that women and men have different interests and needs, and are obliged to acquire different capacities and knowledge.

Gender analysis of the perceptions on climate change, its impacts and adaptation measures in institutions of learning is therefore important.

In a nutshell there are some gaps in knowledge with respect to climate change and education institutions, especially within a gender frame. The first is whether perceptions of the impact of climate change in education institutions differ by gender. The second is whether adaptation options in education institutions are gender differentiated. On these premises therefore, this paper examined trends in some climate variables; examined perceptions of climate change by students; investigated perceptions of climate change impacts on classroom environment (teaching and learning activities in the classroom) and school buildings and environment; and ascertained adaptation measures adopted by educational institutions in Imo state.

METHODS

The study was conducted in Imo state in southeast Nigeria. Imo State is bounded on the east by Abia State, on west by Anambra State, on the north by Anambra and Abia States and on the south by Rivers State. The State is located between latitude $4^{o}45'$N and $7^{o}15'$N, and longitude $6^{0}50'$E and $7^{0}25'$E with an area of about 5,100 km^2. The state lies within the humid tropics and is generally characterized by a high surface air temperature regime year-round. Current mean maximum temperature is 32.1^{o}C while the current minimum temperature is 23.5 ^{o}C [17]. Two seasons, wet and dry, are observed in the year. The rainy seasons begins in April and lasts till October, with double maxima. The first maximum would be in June and the second in September. There is thus a “little dry season” in-between known as “August Break” brought about by the seasonal north and southward movement of the ITCZ (Inter-Tropical Convergence Zone).

Imo state has 27 Local Government Councils arranged in three education zones namely, Okigwe (Imo North), Orlu (Imo West) and Owerri (Imo East) [Fig. 1]. The administrative capital of the state is at Owerri (Owerri municipal), which is the most populated, commercialized and industrialized city in the state (Okorie*, et al*., 2012). The population of the state is about 3,937,563, consisting of 1,976,471 males and 1,951,092 females [15].

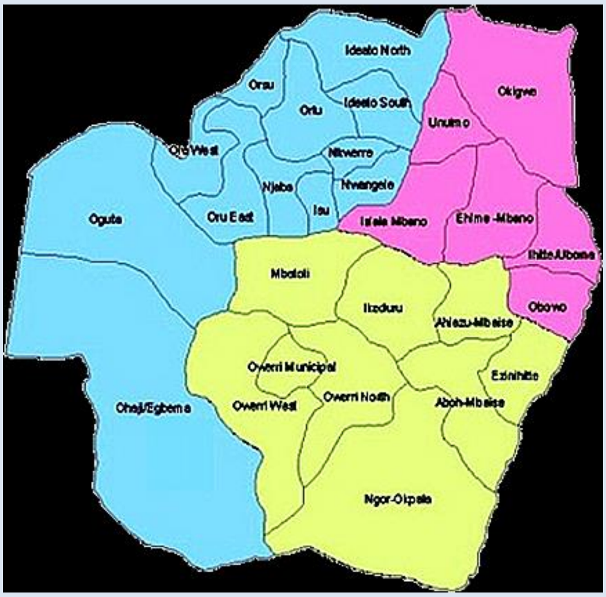

Fig. 1: Map of Imo State, Southeastern Nigeria.
Source: Owerri Capital Development Authority

The study used secondary and primary data. Secondary data included mean monthly rainfall volume, number of rainy days and monthly air temperatures for a period of 41 years [1972-2012] from the Agro Meteorological Station of the National Root Crops Research Institute, Umudike, in the southeast Nigeria. For primary data, a structured questionnaire and semi-structured interview was used to elicit information on perceptions of climate change impacts on classroom ecology (the teaching and learning room) and school physical plant (school building, location and environmental safety), and adaptation measures.

Respondents were male and female science students and teachers in public co-educational secondary and tertiary institutions in Imo State. These were two public secondary schools in each education zone and the four tertiary institutions in the state. Sixty science students (thirty males and thirty females) from the six secondary schools and forty students (twenty males and twenty females) from faculties/schools of environmental sciences in the four tertiary institutions were randomly selected for the survey. Also, six (three female and three male teachers) from each school were purposely selected and interviewed. They have spent about twenty years and above in schools in the area of the study. They were assumed to have experienced some form of climate variations and impacts on schools over the years. Statistical tools employed are trend analysis and descriptive statistics.

RESULTS AND DISCUSSION

Demographic Characteristics of Respondents

Result suggests that the sex composition of the respondents vary. The male population is slightly higher than the female population, as males were 53%, while females were 47% [fig. 2].

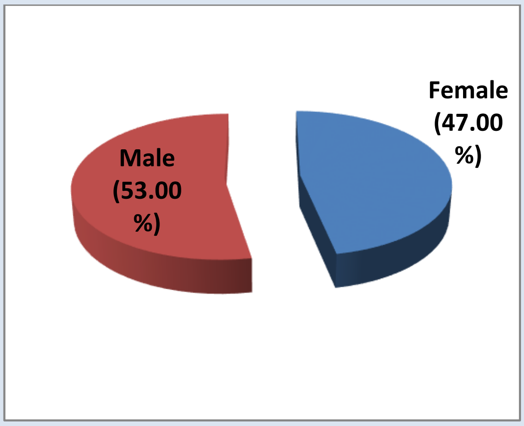

Fig. 2: Distribution of respondents by gender

With respect to the age distribution the teachers and students, 70.21% female respondents are within the 15 – 20 age range while 71.7% of male respondents fall within the age range of 15-20. This shows that majority of the respondents are students who are in the later part of secondary education and early part of higher education. Most importantly, this consists of those who are assumed to be aware of climate change as well as have the capacity to perceive the impacts.

Table 1: Frequency distribution of respondents according to age (In parentheses are percent scores)

	Male	**Female**
Age (Years)	Frequency	Frequency
15 – 20	33 (70.21)	38 (71.70)
21 – 25	9 (19.15)	7(13.21)
26 – 30 above	5 (10.64)	8 (15.09)
Total	47 (100.00)	53 (100.00)

Trend analysis and perception of precipitation volume and temperature

Rainfall data over forty years [1972 to 2011] was obtained from the national Root Crops Research institute (NRCRI), Umudike in Southeast Nigeria, and subjected to analysis. The trend as shown in Fig. 3 indicates increasing tendency for fluctuation in rainfall volume which however has a general tendency to be increasing. A trend analysis shows a positive coefficient 1.4622.

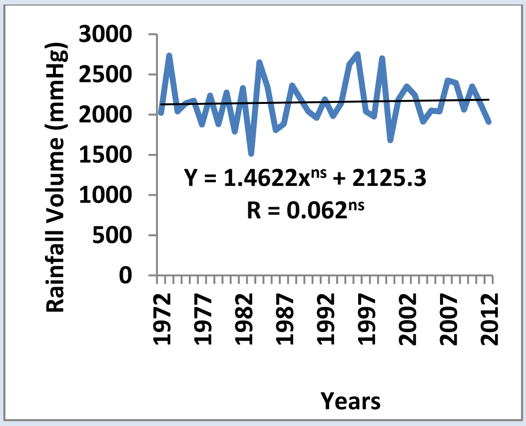

Fig. 3: Trend result of rainfall volume from 1972 - 2012

Nb: ns is insignificant

The issue of changing rainfall volume was presented to teachers and students for their perception. The results indicate that both males and female students and teachers perceived changes in rainfall volume [(Table 2].

Table 2: Frequency distribution of respondents according to perception of change in rainfall volume

	Gender	
Perception on Rainfall Volume	**Female**	**Male**
Decreased	8 (17.02)	4 (7.55)
Unchanged	0 (0.00)	5 (9.43)
Increased	39 (82.98)	44 (83.02)
Total	**47 (100.00)**	**53 (100.00)**
Perception on Rainy days	**Female**	**Male**
Decreased	37 (78.72)	42 (79.25)
Unchanged	2 (4.26)	6 (11.32)
Increased	8 (17.02)	5 (9.43)
Total	**47 (100.00)**	**53 (100.00)**
Perception on Temperature Intensity	**Female**	**Male**
Decreased	10 (21.28)	8 (15.09)
Unchanged	3 (6.38)	4 (7.55)
Increased	34 (72.34)	41 (77.36)
Total	**47 (100.00)**	**53 (100.00)**

Nb: figures in parenthesis are percentages

All female students and teachers perceived long-term changes in volume of rainfall while 90.57% of the male students perceived long-term changes in volume of rainfall. Most of them [82.98% for female students and 83.02% for male students] perceive rainfall volume in Imo State to be increasing. Only 17.02 percent of female students and 7.55% of male students noticed the contrary, a decrease in rainfall volume. The result shows that both males and females have noticed some form of change in the volume of rainfall. This is in line with the findings of [17] in Imo state, and [19] in the Niger Delta area of Nigeria. Both observed increase in rainfall which causes flash floods and flood disasters. More male students and teachers perceive changes in climate than females. This could be that males are more likely to be observant with regard to their environment and are eager to know what is happening around them than females.

Trend analysis and perception of precipitation days and temperature

For the perception on rainy days, most of the students (78.72% for females and 79.25% for males) noticed that this is decreasing [Table 1]. This is however not in agreement with records at the meteorological station, which shows the opposite. The statistical record of rainfall volume data from the Agro-metereological station, National Root Crop Research Institute Umudike between 1972 and 2012 shows a decreasing trend, with a negative coefficient of 0.4479 [Fig. 4]. That human memory recall is in agreement with the trend with records obtained from meteorological station is a methodological lesson, that climate event is very important to people and reliance on memory recall could to a very high extent be correct.

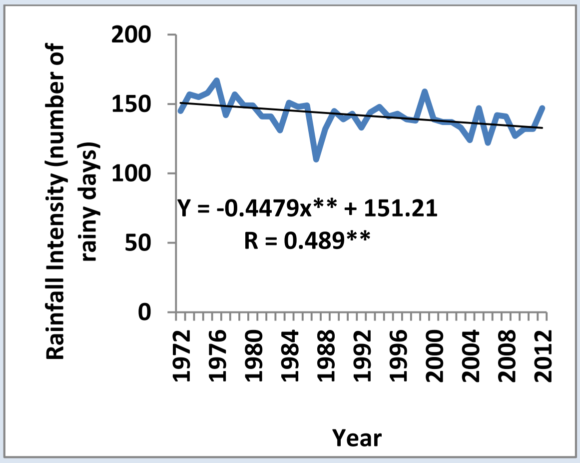

Fig. 3: Trend result of rainfall intensity from 1972 - 2012

Nb: ** Significant at 1% level of probability

Taken together the lessons from Figures 2 and 3 are that the volume rainfall is increasing while the number of rainy days is decreasing. These suggest increased intensity of rainfall. We can therefore expect increased occurrence of flood in the area because increasing volume of rainfall in decreasing number of rainy days will lead to hazards like flood and erosion. Thus, students' perceptions appear to be in accordance with the statistical record in the region. Changes in rainfall will have a strong impact in key sectors including the education sector. Teaching and learning in the classroom and the school buildings, location and safety will be at stake. These were observed in the schools visited with clear manifestation of erosion [fig. 4 and 5]. In the example in this figure, the school walls are falling

Fig. 4: School wall pulled down

Fig.5: Consequence of erosion and flooding

Further consequences of rainfall intensity which are reported to be increasingly stormy is the collapse of school buildings, including roofs blown off [Fig. 6].

Fig. 6: A school building with roof blown away by wind storm

Data on temperature from 1972-2012 shows an increasing trend. The trend coefficient is 0.0289 and is statistically significant [fig.7]. The coefficient of correlation of temperature and time is 0.768 and is positive statistically significant implying that temperature has significant positive relationship with time. Therefore, time is a major determinant for temperature changes. This means that warming is real and significant in Imo State. The students and teachers also correctly perceived the direction of temperature change in Imo which is on the increase. This is supported by [17] who observed that the evidence of variations in the climate of Imo state is seen on steady increase in surface temperature. [16] in his study on other evidences of climate variations across Nigeria observed that a steady rise in global surface air temperature trends and variable storm intensities are becoming regular feature of the climatic system.

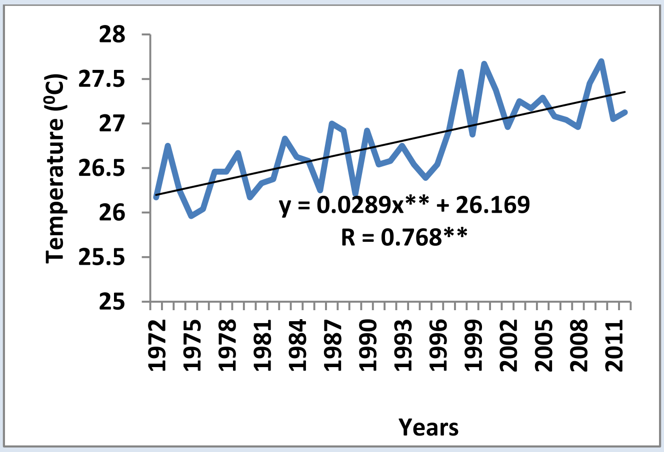

Figure 4: Trend result of temperature from 1972 - 2012

**** Significant at 1% level of probability**

Gender and climate change: Perception of hazard and impact

With regard to perception of the occurence of climate related hazards [Table 3], results show that more than half of both males and female respondents noticed increased hazards due to temperature (sun and heat), flooding, heavy rainfall, strong wind storms and erosion. Their observation is supported by meteorological records and the trend analysis. This indicates evidence of climate change variations in Imo state which causes extreme weather events, such as intense rainfall, which leads to soil erosion, among others. Also their perceptions correspond to the actual changes reflected in the study by [17] who identified flooding, heavy rainfall as hazards associated with increase in rainfall intensity and volume. There is however no difference in gender perception which could be attributed to both male and female students and teachers being of science inclination, and are thus uniformly familiar with environmental issues.

On impacts on classroom ecology (the teaching and learning room) as well as school physical plant (school buildings and environment), male students expressed that increased temperature results to excessive heat in the classroom resulting to sweating, and heat stress and subsequently discomfort. Females complained of weakness of the body, reduced mental capacity as shown in lack of readiness to learn as a result of heat stress and exhausion during the peak of dry season. Both male and female students perceived inability to understand and comprehend concepts when teaching is going on. Teachers (both male and female) expressed that teaching and class management is becoming difficult with increased temperature. The situation will get worse due to the large number of students in a classroom which is peculiar to public schools in Imo state. This finding is supported by [7] who observed that the state of the classroom predicts the position of education success or failure. Also, positive classroom ecology can keep students in school and improve accomodative management policies, while negative aspects of school can make students uncomfortable.

Table 3: Perception of changes in climate related hazards and impacts of climate change by gender

Observed changes in climate	**Perceived Impacts on classroom and school physical plant (outside the classroom)**	
	Males	**Females**
Increased Temperature (sun and heat)	Excessive heat in the classroom resulting to sweating, and heat stress and subsequently discomfort.	Weakness of the body, reduced mental capacity as shown in lack of readiness to learn.
	Inability to understand and comprehend concepts taught in class.Teaching and class management becomes difficult.	
Flooding	Collapse of school buildings, pulling down of trees	Washes away school farms and crops. Drowns school children thereby cause harm or death
Heavy rainfall	Non attendance to school resulting to poor performance and incidence of drop out.	
Strong wind storms	Removal roof of school buildings, pulling down of trees thereby exposing the classroom and school physical plant for further damage.	Increased incidence of cadio-respiratory diseases such as athsma and influenza.

Erosion	Washes away top soils of the school compound, roads leading to schools. Uncondusive school premises and distortion of the safety of the environment. Distorts extracurriculla activities such as sports and agricultural activities.

With regard to flooding, male respondents noted that it results to collapse of school buildings and pulling down of trees while females perceived washing away of school farms and crops, and injury to students during heavy rainfall. Non attendance to school resulting to poor performance and incidence of drop out as perceived by male and female respondents are sometimes as a result of heavy rainfall. However, some public school buildings in Imo state are already dilapidated and are likely to be affected by erosion due to heavy rainfall. As observed by [12], features of school safety should involve good building plans, with protective measures for risk management.

Perceived impacts of strong wind is removal of roofs of school buildings, and pulling down of trees thereby exposing the classroom and posing the school compound for further damage. This finding is supported by [9] who expressed the need for a safe school environment. They observed that the school environment free from risk and hazard improve students enrollment, and encourage extracurricula activities such as sports and agicultural activities. Trees and plants provide shades, play grounds and sometimes learning environment for student. Female respondents perceived increased incidence of cadio-respiratory diseases such as athsma and influenza. By implication, females can be considered to be probably more health concious than males.

Washing away of the top soils of the school pemises and roads leading to schools, safety environment is threatened, and distortion of extracurriculla activities such as sports and agricultural activities are observed to be impacts associated with erosion by large number of male and female respondents.

However, despite these perceptions, it is important to note that there will be impacts that are not climate change – related, showing that climate change impacts should not be considered in isolation. There are also broad determinants of vulnerability which need to be identified in further studies and adressed. This will increasse the capacity of educational institutions to adapt to impacts of climate change.

Adaptation Measures

Adaptation measures with regard to increased temperature mentioned by most of the male and female students and teachers include change in classroom design, reduction of number of students in the classroom and increased number of class streams [Table 4]. Also they expressed that change in learning periods to early hours of the day and evenings, and adopting discovery and inquiry methods of learning by teachers are essential. The reason could be that these methods will give students opportunity to search for information and transform it into meaningful knowledge as well as help reduce the number of hours spent in the classroom. Training and providing qualified teachers in environmental studies to expose children to climate changes and related issues.

With regard to flooding, heavy rainfall and strong wind, male respondents perceived that preservation of trees and planting of grasses in the school compound would help adapt to extreme weather events as a result of climate [fig 5]. Female are of the opinion that solid school structures should be built as well as educating the children on appropriate lifestyle and behaviours. This would help them grow up and be inspired to become lifelong climate advocates. Proper drainage and refuse disposal should be encouraged. By implication, public health will be improved.

Findings suggest that coping strategies adopted in some of the schools visited include use of sandbags to check gully erosion [fig. 6]. Others are ointment on the skin to protect the skin during much heat stress or wave, ventilation of the classrooms by reconstructing the classroom structures. As observed by [10] good classroom structures that are strong and safe with proper ventilation is strongly related to academic performance of students. The number of students in classrooms have been reduced to thirty-five students per teacher which is recommended by [6]. To adapt to consequences of flooding, heavy rainfall and strong wind, few of the schools visited preserved the trees in school compound, adopted sand bagging and grass planting as coping measures.

Table 4: Perceived adaptation measures and coping strategies in schools

<table>
<tr><th rowspan="2">Observed changes in climate</th><th colspan="2">Perceived adaptation strategies</th><th rowspan="2">Coping strategies or Adaptation measures in schools</th></tr>
<tr><td>Male</td><td>Female</td></tr>
<tr><td>Increased Temperature (sun and heat</td><td colspan="2">Change in classroom design, reduce number of students in the classroom and increase number of class streams

Change in learning periods to early hours of the day and evenings. Use discovery and inquiry methods of learning.

Training and providing qualified teachers in environmental studies to expose children to climate changes and related issues.</td><td>Use of ointment on the skin.

Ventilated classrooms

Reduction of number of students in the classroom.</td></tr>
<tr><td>Flooding, heavy rainfall, strong wind storm</td><td>Preservation of trees and planting of grasses in the school compound.</td><td>Solid school structures should be built. Education on appropriate lifestyle and behaviours. Proper drainage and refuse disposal.</td><td>Preservation of trees in school compound.

Sand bagging

Grass planting</td></tr>
</table>

Fig. 5: Preservation of trees as a coping strategy in the school compound

Fig. 6: Sand bagging as a coping measure in school compound

CONCLUSION

The study has shown that rainfall volume is increasing while number of rainy days is decreasing. This suggests increased rainfall intensity, as well as rain associated with extreme events. These lead to roofs in school buildings blown away, falling school walls, flooding, erosion, and general school environment degradation. Temperature is also rising making teaching and learning difficult. It is also shown that the challenges of climate change, hazards associated with climate change, impacts, and adaption measures are all manifest in education institutions. Teachers and students suffer these and are therefore very perceptive of these. The associated hazards of climate change also adversely affect the school environment as well as teaching and learning.

With respect to differences in perceptions of the impact of climate change in education institutions differ by gender, it has been shown that this is not majorly the case. Being mostly science and environment students both sexes tend to be well informed of climate change related events, hazards, impacts and adaptation. Both male and female respondents indicated that there have been variations in the climate of Imo state. This corresponds to the meteorological records.

Perceived climate change related hazards include increased temperature, flooding, heavy rainfall, strong wind and erosion. Perceptions on impacts on school cilimate with regard to classroom structure, teaching and learning activities, and school physical plants and environment vary by gender. Males tend to be more observant and sensitive to environmental issues than females. They also expressed more concerned about impacts on school physical plants while females are more concerned about impacts on health. Perceptions on adaptation strategies also vary by gender. Adaptation and coping strategies identified in schools include use of ointment by the females to prevent sun burn, preservation of trees, planting of grasses and sand bagging.

REFERENCES

1. Agwu, J. (2009). Gender and Climate change in Nigeria: A study of communities in North – Central and South Eastern Nigeria. Heinrich Boll Stifung.
2. Anolu, V. (2013). Imo and Challenges of Environmental Degradation. Daily Independent. July, 17th, 2013.
3. Akpodiogaga, P & O. Odjugo (2010). General Overview of Climate Change in Nigeria. *Journal of Human Ecology.* 29 (1): 47-55. Kamla-Raj.
4. Babatunde, J; A.T., Salami and M., Tadross (2011). Developing Climate Change Scenarios, Biophysical Impacts and Adaptation Strategies in Nigeria. A final Report submitted to NEST as part of the building Nigeria Response to Climate Change (BNRCC) Project.
5. Charland, W. (2011). Arts Integration as School Culture Changes: A Cultural Ecosystem Approach to Faculty Development. *International Journal of Education and the Arts.* 12(8). Retrieved from http://www.ijea.org.
6. Federal Republic of Nigeria (2004). National Policy on Education. (4th. ed). Abuja: Nigeria.
7. Galton, M. (2010). Going with the flow or back to normal? The impact of creative practioners in schools and classroom. Research Papers in Education. 25 (4): 355-395.
8. Intergovernmental Panel on Climate (IPCC), (2001). Third Assessment Report (TAR).
9. Intergovernmental Panel on Climate (IPCC) (2007). Climate Change. The fourth Assessment Report (AR4). Synthesis Report for Policymakers. Available at http: // www.ipcc.ch/pdf/assessment-report/ar4/
10. Inuwa, A.M, & Yusuf, B.N.M (2012). Teachers Challenges in Nigerian Public Secondary Schools Climate: Implications on Students Dropout. *Science Journal of Sociology and Anthropology*. Available at http://www.sipub.org.
11. Klient Tank A.M.O, G.P Konnen, F.M. Selten. (2005). Signals of Anthropogenic Influence on European Warning as seen in the trend patterns of daily temperature variance. *International Journal of Climatology. 25 (1-16).*
12. Lingard, B, Hayer, D and Mills. M (2003). Teachers and Productive Pedagogies Contextualizing Conceptualizing, Utilizing Pedagogy*. Culture and Society*. 11(3). 399-424.
13. MDG Report (2010). Assessing Progress in Africa toward the Millenium Development Goals. Available at 2010MDG. Reports. Africa.pdf
14. Nigerian Environmental Study/Action Team (NEST) 2003. *Climate Change in Nigeria. A Communication Guide for Reporters and Educators.* Ibadan: NEST. 5-16.
15. National Population Commission (2006).
16. Obioh, I.B (2010). Evidence of Climate Change and why it is of concern to Nigeria. Canada-Nigeria Change capacity Development Project. NEST-GCSI Awareness Raising workshops. Ibadan Center for Energy Research and Development, Obafami Awolowo University, Ile-Ife. Nigeria.
17. Okorie, F.C, Okeke, I, Nnaji, A, Chibo, C and Pat-Mbano, E (2012). Evidence of Climate Variability in Imo State of Southeastern Nigeria. *Journal of Earth Science and Engineering. 2 (544-553).*

18. Onyeneke, R.U; F.A, Iruo and I.M, Ogoko (2012). Micro – level Analysis of Determinants of Farmers' Adaptation Measures to Climate Change in the Niger Delta Region of Nigeria: Lessons from Bayelsa State. Nigeria Journal of Agicultural Economics 3(1): 9-18.
19. Sayne, A. (2011). Climate Change Adaptation and Conflict in Nigeria. *Special Report.* United States Institute of Peace. Washington DC.

Experiencing climate change and variability in Ghana: A socio-cognitive perspective

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ABSTRACT

Global climate change has resulted in observed increases in annual temperature and extreme rainfall events in some locations in Ghana, presenting serious threats to the environment and social development. Therefore, the response of the rural poor to real and perceived climatic variability may enhance or limit their livelihood options and influence the magnitude of vulnerability to climate stressors. Using participatory social research methods, this paper evaluates the experiences of climate change and variability from a socio-cognitive perspective, establishes the realities of such changes and presents their perceptions as influence by gender in some households in the North *Kwahu* district of Ghana. Results showed that the local impacts of climate variability as experienced in the communities relate to extreme events such as floods and droughts. These extreme climatic events may influence households differently depending on the wealth, age,

education and gender roles and relations within the households, as evinced by the differences in perception and impact on their livelihoods.
The paper suggests some guidance for the accomplishment of risk communication and information efforts. It however did not assess the consequences of their perceptions for behavioral intentions or actual behavior.

Keywords: Participatory methods; Climate variability and change; household life cycle; gender; Ghana

INTRODUCTION

Climate change is a global phenomenon that involves alterations in weather variables over a long period. Scientists have attributed climate change effects to the increased load of Carbon dioxide (CO_2) in the atmosphere, due to emissions from fossil fuels and biomass burning and from the mineralization of soil carbon (IPCC, 2007). Associated with climate change is climate variability involving increased global temperature and enhanced variation in weather variables at shorter time scales at local levels. This includes shifts in the seasonal weather patterns, the frequency and intensity of storms, floods and droughts, which have variable impacts in different parts of the world.

In Ghana, the observed increasing annual temperature and extreme rainfall events (drought and floods) in many locations attributed to global climate change (Adiku and Stone, 1995), may present serious threats to the environment and social development. At the social level, communities with the lowest living standards would be the most vulnerable and adversely influenced by the climate change effects (IPCC, 2007).

These vulnerable groups are the least resilient to offset the impact of an experience or anticipated stressors, e.g. land degradation, extreme weather, low health and socioeconomic status (Kasperson and Kasperson, 2001, Turner *et al.,* 2003). Given that, these groups are mainly the rural poor; a developing country like Ghana, with a typical agrarian economy and with over 55% of the population engaged in the rural economy are vulnerable (EPA, 2000) and at risk to climate change stressors. The agricultural-based livelihood systems, which include small scale rain-fed farming systems, pastoralist system, inland and coastal fishing, and forest-based systems, are already vulnerable to climate change due to the risk of crop failure, loss of livestock and fish stocks, increasing water scarcity and destruction of productive assets. They also face an indirect impact due to the anticipated long-term changes in temperature and rainfall, associated with global climate change. Climate change impact of any form on agricultural production and processing will make rural livelihoods vulnerable.

Many programs that seek to improve the livelihoods of the rural poor have often fallen short of their goals, with respect to poverty reduction, livelihood resilience, and equitable development among different gender. The lack of any links between project goals and small-scale farmers' priorities and the fact that much of the climate change studies lie in the domain of biophysical scientists without the requisite social communication skills hinder facilitation of effective communication with the vulnerable populations. In addition, the scientific climate language as couched in probability terms recognises the weaknesses in predictability that is often difficult to communicate to the non-scientific community (Hewitson *et al.,* 2007). Further, some rural culture and beliefs suggest that issues of climate variability and change are in the domain of the supernatural (Adiku *et al.,* 2007). For effective dialogue on climate change and its impact on society, there is the need to establish a common ground for discussing their experiences.

Climate does not relate only to the varying state of the earth's atmosphere but also describes the state of the climate system (IPCC, 2001). There is however, some evidence that the climate of the West African continent as controlled by complex maritime and terrestrial interactions which produce a variety of climates across the region from the southern coastal West African humid tropics to the hyper-arid Sahel to Sahara, resulting in uncertainties in predictions of the Regional Climate Models (RCM) (Christensen *et al.,* 2007). The situation is more complicated for some climate variables, especially rainfall which, exhibits spatial and temporal variability (Hulme *et al.,* 2005).

Advances have been made in the understanding of the complex mechanism responsible for the rainfall variability in West Africa (Warren *et al.,* 2006; Christensen *et al.,* 2007), with some scholars suggesting the possibility of global circulation such as El Niño-Southern Oscillation (ENSO) (Boko *et al.,* 2007). In Ghana, the sea surface temperature (SST) of the Atlantic (Opoku-Ankomah and Cordery, 1994) and the ENSO (Adiku and Stone, 1995; Adiku *et al.,* 2007) influence rainfall patterns. Data from the Environmental Protection Agency of Ghana (EPA, 2000) also suggest a steady rise in temperature over the past 30 years, and evidence of increased drought frequencies in Ghana. Climate-related disasters frequently happen in Ghana; events, such as heavy rainfall and drought, contribute to land degradation and displace large populations. According to the Emergency Disaster Database (EM-DAT, 2007), a major drought in 1983 affected 12.5 million people, and a severe flood affected 2 million people in 1991 followed by further floods in 1995 (affecting 700,000), 1999 (325,000), 2001 (144,000) and 2007 (333,000). In addition to the seasonal variability in rainfall, wide fluctuations in distribution, amount of rainfall and number of rainy days recorded over years and decades, in some instances lead to drought. The major droughts in Ghana caused serious hydrological imbalances that negatively affected land resources, particularly soil quality and fresh water supplies (EPA, 2000). Each drought cycle exacerbates the vulnerability of the affected area to desertification.

This notwithstanding, most evidence of climate change is indirect and inferred from changes in indicators that reflect climate and in recent past detected by changes in settlement and agricultural patterns. The climate is therefore changing and has done so throughout history; exerting a day-to-day impact on the economic development of Africa, particularly for the agricultural and the water resources sectors at regional, national, local and household scales (Boko *et al.,* 2007). Climate change impact may be short term resulting from more frequent and intense extreme weather events or long term by changing temperature and precipitation patterns (FAO, 2007).

Several General and Regional Climate Models have shown that future changes in climate may negatively affect several parts of Sub-Saharan Africa, Ghana inclusive (EPA, 2000, Fischer *et al.,* 2002). Despite these uncertainties in predictions from the models, projections indicate a general reduction in annual rainfall by 4% combined with a decadal warming rate of 0.29°C in the tropical forest of West Africa (Malhi and Wright, 2004). Human populations under relatively limiting conditions develop coping strategies to overcome changes in the ecosystem. However, an increase in the frequency and intensity of stressors such as floods and droughts may limit the developed coping strategies with a consequent inability of the system to deal with such increased stressors.

This scenario enhances vulnerability and poses a grave danger to potentially dangerous human-ecological systems ranging from forestry, fisheries and water resources, to human settlements and health (Smit *et al.,* 2000; Meehl *et al.,* 2007).

In order to enhance the potential effectiveness of measures taken to reduce vulnerability to current climatic and future hazards, several scholars have stressed the need to pay closer attention to external climate conditions within the social, political, and economic context in vulnerability assessments (Kelly and Adger, 2000; O'Brien *et al.,* 2004; Füssel, 2007). The approach emphasizes the importance of scale in vulnerability assessment that disaggregates households and community levels from regional or national level of analysis. Therefore, suggesting the assessment of vulnerability and / or adaptation from the household or micro-level rather than from a macro - structuralist perspective that has dominated the fields of climate change, disaster mitigation, and resource management for some time now. In addition, Dow *et al*. (2007) suggested a framework that includes both the climate and the societal processes involved in vulnerability, as well as changes in social circumstances, such as economic shocks, HIV/AIDS and other epidemics, and conflict to monitor evolving patterns of vulnerability.

The Climate change events undoubtedly, will affect both the development of the human and physical environment, by influencing food security, freshwater supply, rural and urban settlements and their infrastructure. Distribution of such impacts would not be uniform within a community as those with the least resources have the least capacity to adapt and therefore are the most vulnerable (Archer, 2003; Denton, 2002). The risks associated with anthropogenic climate change therefore provide a new range of issues and concerns related to how the human populace reacts and deals with such environmental risk.

Anthropogenic climate change according to the IPCC (2001) affects human systems at spatial and temporal scales, from the increased likelihood of extreme events at the local or regional level to the gradual temperature increase at the global scale. Ghana's exposure and sensitivity to climate change is high, considering its economic dependence on agriculture and natural resources like the forest and the reoccurring periods of drought and wild fires and flooding in the sub-region (Boko *et al*., 2007). Solving the problem of household vulnerability and adaptation system would require a full understanding of how they experience and perceive climate change and variability as a stressor. Knowledge gaps still exist as to how climate interacts with society and, how household members perceive climate change impact: Hence the need to evaluate the experiences of climate change and variability from a socio-cognitive perspective.

This paper reports a case study carried out to explore the experiences of households to climate variability and change in the context of their livelihoods in three communities in the North *Kwahu* district of Ghana.

Specifically, this paper questions how the populace experiences and understands environmental risk. It explores and evaluates the realities and understanding of climate variability in the populations, juxtaposing secondary meteorological data on evidence from participatory activities such as climate mental models and historical matrix that draw on experiences. In addition, it examines how gender evaluated as wealth status, education, sex and age of household heads influence their perception of climate change and variability.

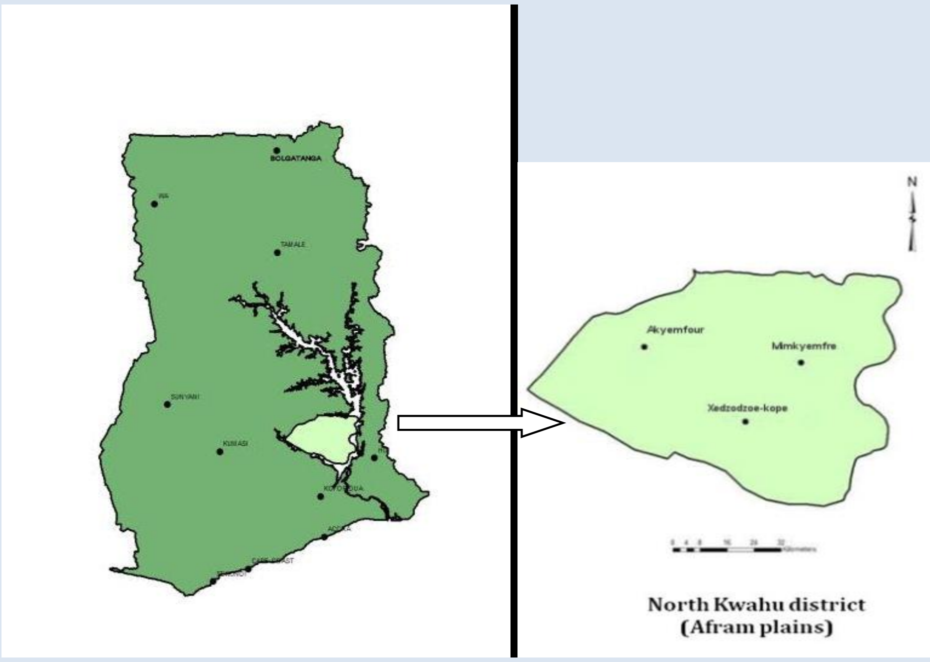
This paper after the introduction presents in four sections; first, a brief description of the study area, the second describes the methodology used in data collection, the third presents findings and discussions and the fourth concludes with implications and suggestions for policy.

THE CURRENT STUDY LOCATION

The study conducted in three communities, *Akyemfour*, *Xedzodzoekope* and *Mem-Chemfre*, in the North *Kwahu* District of the Eastern Region of Ghana, is between latitudes $6^{o}\ 40^{I}$ N and $7^{0}\ 10^{\prime 1}$ N and longitudes $0^{O}\ 40^{I}$ W and $0^{o}\ 10^{I}$ W (Map 1). It is located within the Volta River basin, an important geographical zone that stretches over 400,000 km^2 of West Africa's topography (Barry *et al.,* 2005).

This District, formerly referred to as Afram Plains District, is among Ghana's potential breadbaskets, producing cocoa, grains, tubers, vegetables, and rice. Current productivity levels for major crops are 11 t/ ha for cassava, 13 t/ha for yam, 1.6 t/ha for maize and 0.8 t/ha for cashew, all of which are very low compared to Ghana's average yields (PPMED, 2005), though the climate and soil fertility conditions are favourable to support increased production.

With improved technologies and improved extension service delivery, there is a potential to increase the productivity levels to 20 t/ha for cassava, 28 t/ha for yam, 5 t/ha for maize and 1.8 t/ha for cashew (PPMED, 2005). Increased population growth as a result of in-migration and the subsequent need for land to crop, charcoal production, and wood harvesting have accelerated deforestation, carbon release, and loss of soil fertility and productivity in the area. The District has a tremendous potential to contribute significantly to the improvement of the well-being of its inhabitants. The communities selected in this study cover different farming systems and ethnic groups. And currently experience transformation in land use/ cover, decline in forest cover, climate variability over the last three decades and long-term climate change impacts.



Map 1: Map of Ghana showing the Kwahu North district and the three study communities
Source: Climate Change Learning and Observatory Network, 2007

The district has three perennial rivers for both domestic and agricultural purposes. These rivers are the *Afram* River that drains the district in the west, Volta River in the east, and the *Obosom* River in the north. The district is also a peninsula cut off on three sides by the Volta Lake and on the fourth by lack of a connecting road network to the rest of Ghana. Transport to and from the District is mainly by ferry. This lack of physical access constrains the marketability of agricultural products from the district and poses a disincentive to increased agricultural production, income levels and subsequently the vulnerability level of the inhabitants of the district.

Agricultural land in the district is under communal ownership and land allocation to individuals or households is on a usufructuary basis by lineage or clan-based land-owning groups who control or manage agricultural land. Soils in the district developed over Voltaian clay shale occur in both forest and savannah vegetation zones; and are mostly the *Ejura* series, classified as Haplic Luvisols under the FAO system of classification. In the absence of bush fires, they accumulate considerable reserves of organic matter in the top layers. With minor exceptions, the soils of the district are fertile and suited to a wide variety of crops. The quality of soils is unlikely to be a constraint to the agricultural development of the District. The district experiences a tropical climate with seasonal variation in rainfall and temperature. Rainfall pattern is bimodal with the major rainy season starting in April and usually ending by mid July, recording about 75% of the total annual rainfall. The minor rainy season occurs in September and October, followed by a five-month dry season from November to March or April. During the dry season, many tributaries of *Afram* and *Obosom* rivers as well as some boreholes dry up. Variations exist in the total monthly and annual rainfall amounts, and onset of the rainy season. In some years, even the peak rainfall months (May-June) fail to record appreciable rainfall. In general, however, variations in the annual rainfall are higher than in the monthly rainfall. Generally, the mean annual temperature is 27.7^{0}C, with February and March being the hottest months (36.8^{0}C and 36.6^{0}C respectively) whereas December and January (19.9^{0}C and 20.1^{0}C respectively) are the coldest. These characteristics of the location make it a highly vulnerable district with a potential of being susceptible to climate variability and change.

METHODOLOGICAL APPROACH

This study designed as a case study used mixed research methods and employed episodic mode of interviewing, synthesizing all semi-structured and narrative interviews (Silverman, 2001). Most of the methods, tools/activities and questions for collecting data developed under the Climate Change, Collective Learning, and Observatory Network in Ghana (CCLONG) project; are based on principles of community involvement, such that communities are seen as best able to describe circumstances and stresses that are important to them. This participatory research technique took a variety of forms, with focus on narratives, semi-structured interviews and focus group discussions. The study used both primary and secondary data. The secondary data provided background information that was useful in defining the climatic and socio-demographic characteristics of the study area. Meteorological data used in the climate analysis were from the Ghana Meteorological Agency.

Primary data were sourced using informal and formal modes of communication in the form of interviews and focus group discussions. A maximum participation of 10 elders who have lived in the community for over 30 years formed the sample for assessment. Individuals at the household level were the unit of observation aggregating at the household level as a unit of analysis for the household interviews. After gaining entry into the communities through community leaders and chiefs, data collection on their experiences and understanding was achieved using the following activities and/or tools:

Mental models

This activity uses a tool that presents a psychological representation of problems in the form of a group conceptual map of ideas to elicit the cause and effect of climate change perceived by the study communities (Zaksek and Arvai, 2004; Tschakert, 2007). For this activity, a focus group of elders and opinion leaders (men and women inclusive) of the study community construct a collective understanding of the issue at stake by discussing the causes, factors, and processes that bring about changes in the experienced climate. A minimum of 10 participants discussed the causes of climate change, listed or drew them on blank cards and then posted them on a large sheet. Arrows were used to link factors, processes, and causes. The negative and positive consequences of climate change, for humans and the environment as presented reflects their understanding of the issue at stake. Questions that guide this activity are presented in appendix 1.

Historical matrix

This activity employed a focus group discussion to elicit the communities' historical memories of climate hazards for the past 30 to 40 years. The historical extreme events were mapped on a timeline, showing periods of normal rainfall peaks and distribution, and extreme events when most of their assets and/or human lives were lost. These historical memories aided community members to recount experiences and solutions to problems in the past.

Household survey

Socio-demographic characteristics, climate variability and change impact on the livelihoods of members were assessed at household level using semi-structured questionnaires that capture their experiences and cognition. To sample households for household interviews, all households within the community were first classified into three wealth categories; low, intermediate and high resource endowed households. This was because poverty, as a key determinant of livelihood vulnerability and adaptive capacity, varied within the study community. The opinion leaders of each community prepared a list of assets or resources for classifying the households within the communities.

The prepared lists of households were categorized into three wealth categories: high, intermediate and low resourced households. Households with high resource endowments have more than 10 acres of yam, over 5 acres of cassava and maize, several sheep and goats, over 20 cattle, more than one out board motor, more than 3 canoes and over 10 fishing nets. Low resourced households normally crop less than 2 acres of yam, cassava and maize, have few sheep and goats (1-5) and few fishing nets. Intermediary resourced households fall between the two extreme wealth categories. The wealth categories were validated using household asset information from the household survey, by comparing assets of sampled household. Four households randomly drawn from each category, representing about 10 percent of the total households in each community, resulted in the selection of 12 households per community and thirty-six households in total for all three communities.

Households assessed their impact scores to climate stressors, using the likert scale (1-5) and scoring with pebbles, to enable quantitative comparison between household types and members. Questions that guide this activity are presented in appendix 2.

Climate data analysis

For the purpose of this study, the description and analysis of weather and climate were limited to rainfall and temperature, since these variable are key indicators of meteorological elements that brings about economic, environmental and social effects (WMO, 1992). Rainfall and temperature data from the nearest meteorological station data, *Kete Krachi* (Longitude 0^0 6`W; Latitude $7^0$ 48`N) approximately 80 kilometres from the capital of North *Kwahu* district (*Donkorkrom*) was used. The approach by the Ghana Meteorological Agency (GMA) for climate change analysis was used. The GMA in developing climate change scenarios for Ghana has zoned the country into sections (EPA, 2000:57). The Kwahu North District falls under the same section C2 with *Kete* Krachi. For rainfall, the 30-year average from 1961 to 1990 (1350.1mm) was used as a base mean annual rainfall and the deviations of annual rainfall from this mean value were determined for the same period. Trend analysis revealed the long-term patterns of rainfall, the minimum and maximum temperature. Climate projections to year 2020 were made based on trend analysis with climate data forecast from the Ghana Meteorological Agency climate change scenario developed, using excel computer software.

Primary data analysis

Qualitative data obtained through community focus group discussions and household discussions were analysed using contextual analysis. The quantitative data from the field survey conducted through 2007 - 2009 were cleaned and coded. The Microsoft Excel programme facilitated the organization and classification of data for analysis. The study presented results as frequency tables, cross tabulation and bivariate analysis using the Statistical Package for Social Sciences (SPSS v16.1). Almost all data disaggregated by household wealth rank, sex (male and female), education, and age of household head or respondent presented gender in a multi dimensional facet. The age groupings were 15 to 34 and 35 to 89. Age groupings reflect whether respondents have personally experienced extreme climate events. The age groupings, 35-89 years captured long term and / or frequent experiences in such extreme climatic events.

EXPERIENCING CLIMATE VARIABILITY

In exploring the experiences and responses of the population to climate variability, the study places the research in the context of socio-cognitive factors. The socio-demographic characteristic of the sampled households, which includes the wealth status, education, sex and age of household head, provided the basis for understanding the gendered differences in behaviours and perception of climate variability and change.

In addition, establishing the evidence of climate variability within the communities would present a clearer understanding of how climate variability influences livelihoods.

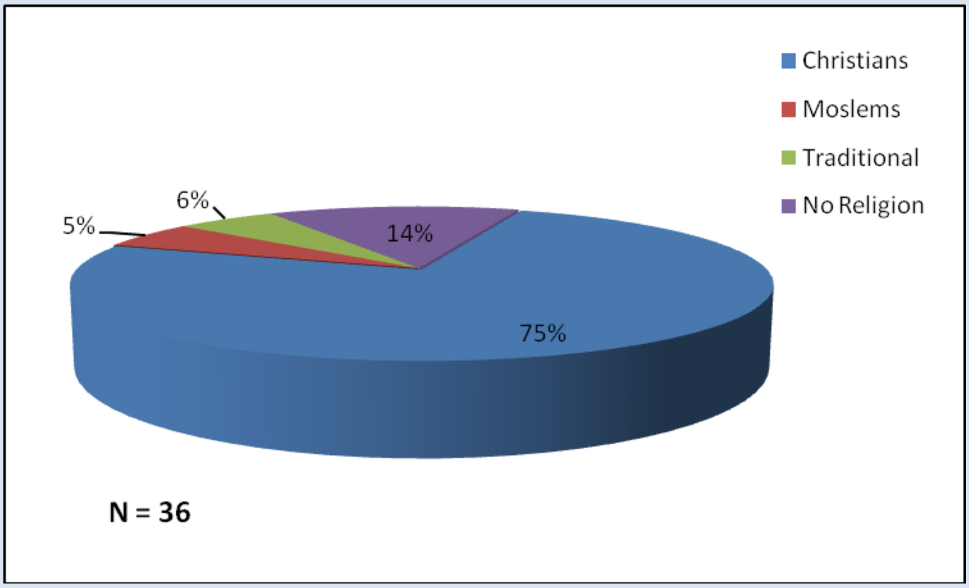
This section evaluates the basis for understanding the differences in behaviour and perception of climate variability and change within the households and establishes the presence of climate variability and change within the community.

Basis for gendered differences

The sampled households (N=36) analysed captured 75% male-headed households and 25% female-headed household. Household type distribution was as follows: Nuclear (44%), Extended (28%), Polygnous (11%), Joint family (11%) and Matrifocal (6%). Most of the female-headed households were “de jure” female households where they were the breadwinners and legally possessed the resources of the house. The female household heads were widowed, abandoned, or divorced. The sampling captured one “de facto” female-headed household.

Age of household head of the sample ranged from 22 to 87 years with the mode at 35 years and the median at 48 years, capturing young and old generation households within the community.

The average household size of male-headed households was 7.5 and that of the households with female heads was 6.7. These values were higher than rural household size (4) in Ghana as reported in the Ghana Demographic and Health surveys, 2008.
Religion, according to Bowie, (1999) is a systemic path of life of the communities, it expresses living pattern of individuals, personality traits, values, practices, attitudes and perception, which vary among individuals within the sampled households. Figure 1 shows the percent distribution of the various religious sects among the sampled household heads.



Source: Field survey, 2007

Figure 1: Percent distribution of religion of sampled household head

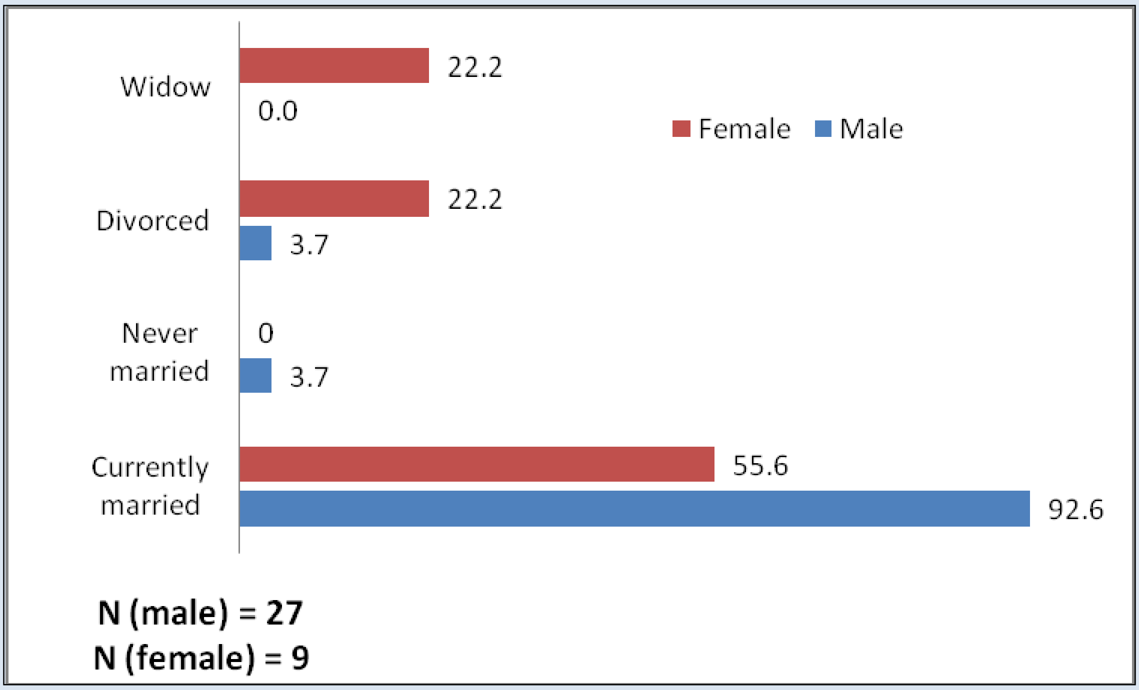
About 86.1 percent (31) of the household heads could affirm their faith (Christian, Moslems and Traditional religion) in a supernatural deity while the remaining 13.9 percent (5) have no faith in any religion. A high percentage of household heads were Christians (75%). The data however revealed differences in religious sects among individual household members.

A higher percentage of male (77.8%) and female (66.7%) household heads were Christians; no female household head was a Moslem. These characteristics influenced their belief and perceptions about the causes and consequences of climate change, and the environmental risk impact. Generally, climate as regulated by the supernatural have "*good*" or "*bad*" seasons reflecting the "*blessing*" or "*wrath*" of the supernatural, respectively. No physical basis for climate variability could be proposed or discerned from the group discussions.

Marital status of sampled household heads showed that only one head (2.8%) had never married, 83.3 percent (30) were currently married, 8.3 percent (3) were divorced and 5.6 percent (2) were widowed. Seventy three percent (22) of the currently married households were in a monogamous arrangement and 27 percent (8) in a Polygynous union.

Polygyny, which is the practise of having more than one wife, is common in Ghana (GDHS, 2008) and this has implication for gender power relations within households. Married women in this type of married relationship are marginalized in decision making, because their roles are seen as easily replaceable and this undermines their relative bargaining positions in relation to their spouses in major household decisions (Ezeh and Adadjanian, 2000).

About twenty percent of the currently married male-headed households and sixty percent of the female household heads were in a polygynous relation. In addition, monogamous relationship among the sampled households revealed a distribution of 80 percent and 40 percent male and female heads respectively at a chi-square value of 9.19, these differences were significant at a probability of 0.01. It is therefore likely for currently married female-headed households to have co-wives. The distribution of marital status by sex of household head is as presented in figure 2. The sample captured more men (62.5%) than women (55.6%) as currently married and a greater percent of women as divorced (22.2%) and widowed (22.2%).

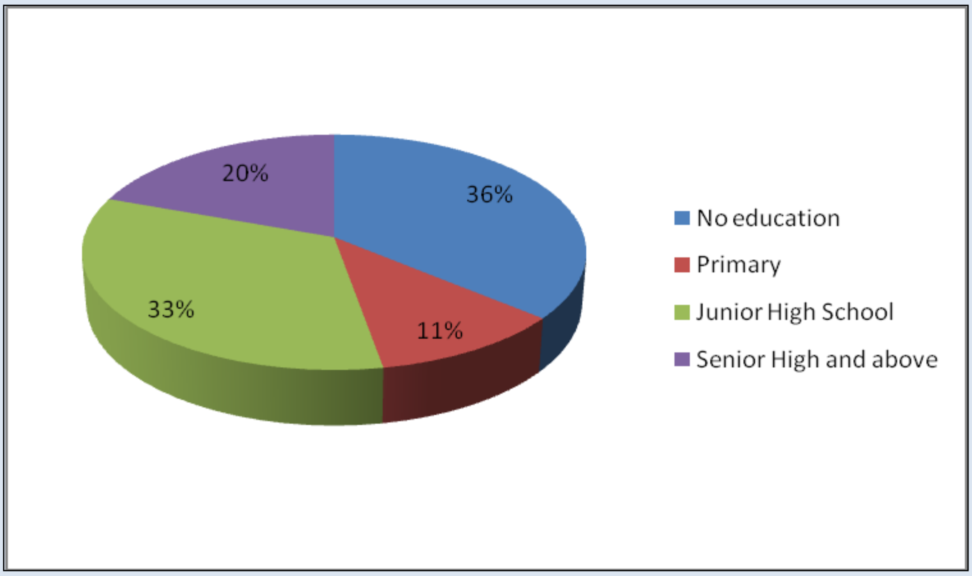


Source: Field survey, 2007

Figure 2: Percent distribution of marital status of household heads by sex

These differences in marital status of household heads by sex were significant at a probability less than 0.05 (χ^2value of 10.22), indicating a relationship between the sex of household heads and marital status. Females as head of sampled households are therefore most likely to be divorced or widowed.

A considerable number of persons in the study sample have some level of formal education (Figure 3). Educational level of household heads is a good indicator to assess quality of human capital because it plays a vital role in determining a person's capacity to gain insights from planned activities.

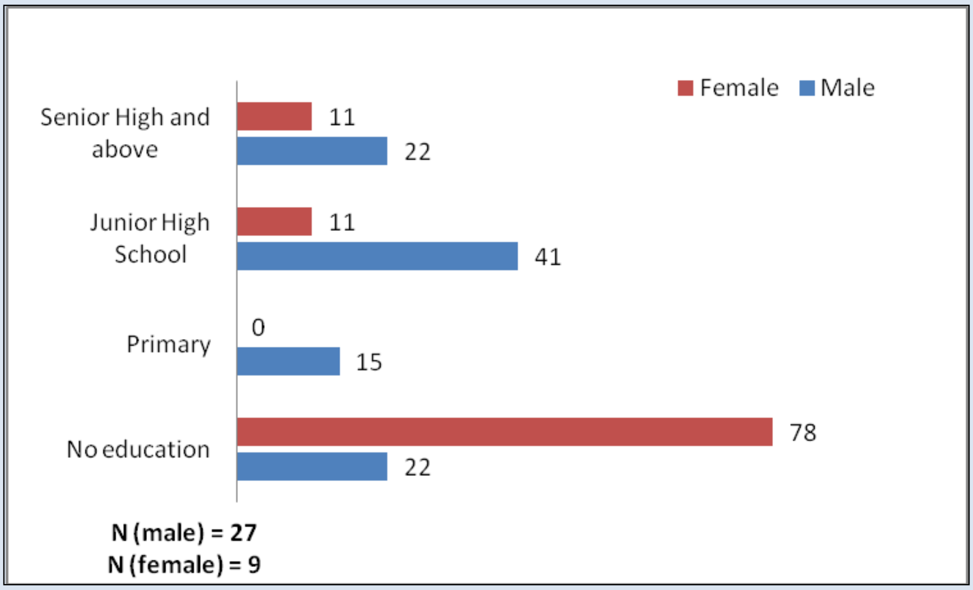


Source: Field survey, 2007

Figure 3: Percent distribution of educational level of household heads

Over sixty percent of the sampled household heads had a minimum of primary or above educational level, only 36 percent have had no formal education. Disaggregating this data by sex also revealed significant (χ^2 value of 9.31) differences between the educational level of male and female household heads at a probability of 0.02. The study revealed that 77.8 percent (21) of the male household heads have had some form of formal education, while the same percentage of female (7 out of 9) household heads have had no formal education (Figure 4).

These findings confirm the general observation that rural Ghanaian women are less educated (Ghana Demographic and Health Surveys, 1998). In addition, Ghanaian girls in most rural households had, until the recently introduced Free Compulsory Universal Basic Education in 1996, no access to formal education.



Source: Field survey, 2007

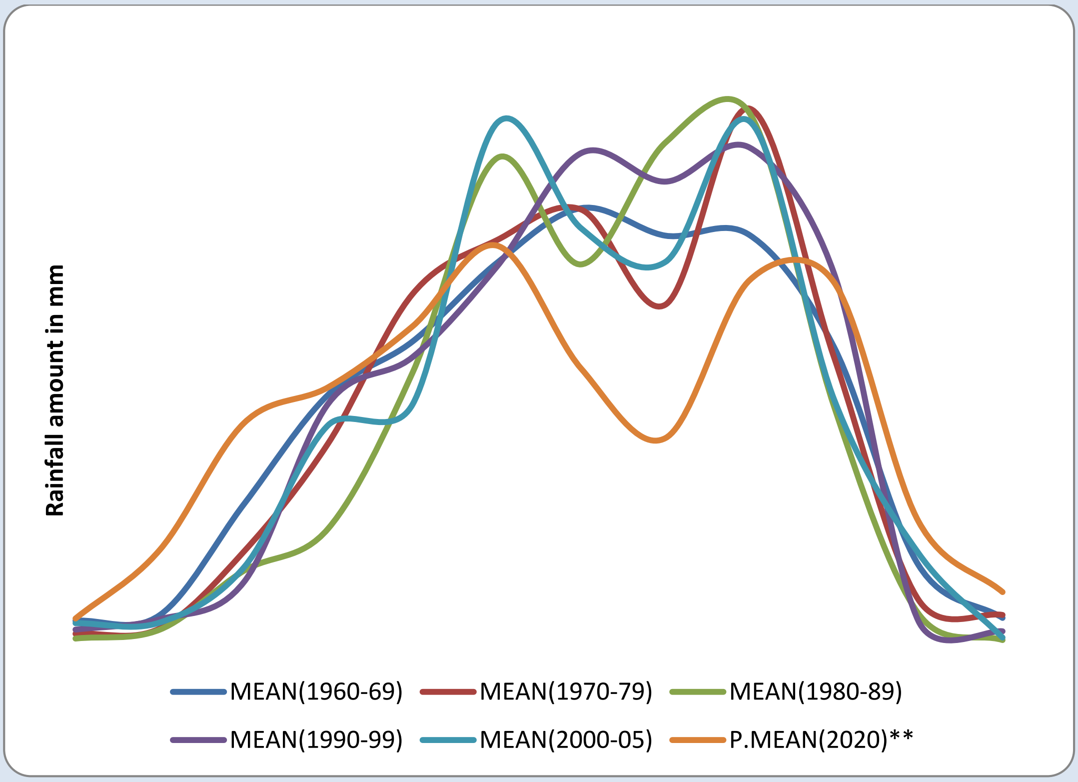
Figure 4: Percent distribution of educational level of household heads by sex

Wealth ranking categorized as either low, intermediate and high resource endowment within the households sampled presented an indicator for evaluating gender differences. Since this indicator represent poverty levels, percent distribution within the sample may influence perception. Segregating these data by sex, age and educational status of household heads revealed interesting distribution and corresponding cognition. Percent distribution of sex of household heads within the wealth ranks were above 50% for women in the low and intermediary resource endowed households and 76.9% were men in the high resourced category – more male heads fall within the high resourced households. Household heads older than 35 years dominated the sampled population. However, a greater percentage of young adults less than 35 years head households with low resource endowment (36.4%) than high resource households (7.7%). Educational levels which is key factor or asset in empowerment was relatively high, with over 50% have had some level of education in all categories of wealth ranking. Forty five percent have no education in the low resource category as against 30.8 percent in the high resource endowed households.

Evidence of climate variability

In examining the experiences of the study area to climate variability, evidence of its occurrence and understanding of its impact is imperative. The study compared ten-year mean monthly rainfall patterns (Figure 5) and responses from the historical matrix to establish its presence in the communities. With the 1960s as the base years and indicated rainfall occurrence throughout the year, all other years showed two distinct seasons with sharp decline in amount in August. Normal peaks in June and September were extremely high after the 1960s. Future rainfall pattern in 2020 (EPA, 2000:57) is expected to follow similar pattern (Figure 5), but will be high in the first 3 months, peaks in June, drop sharply in August and then would increase in amounts after the second peak in September. Such increases could potentially cause flash floods in the face of local geological conditions and poor soil conditions that prevent soil infiltration as suggested by Downing et al. (2000) and Hellmuth et al. (2007). This could be the reason for the recent frequent floods experienced during September in the study area, although rains have always been the same or lower when compared with conditions in the 1960s.

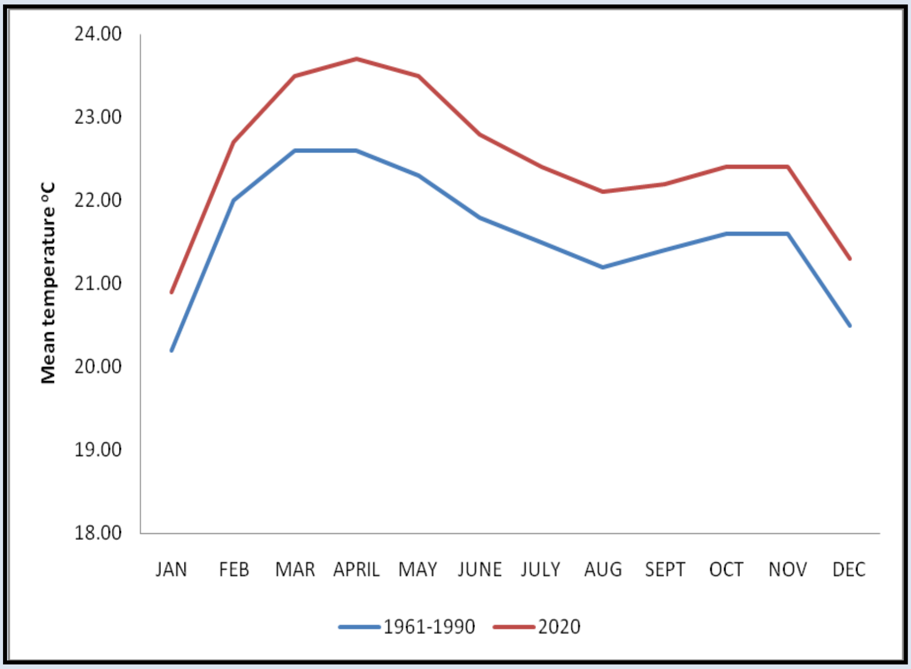
Through the design of the historic matrix, men and women in the study communities discussed observed shifts in rainfall peaks and extreme rain events. The following responses such as *"high rains used to be in June/July now it is in September"; "dry seasons are now more pronounced"; "early rains are unreliable but rains in September and October are heavier"*, described events as experienced since their arrival in the community.



Source: Kete Krachi climate data from Ghana Meteorological Agency;
P. Mean (2020) ** - projected mean for 2020

Figure 5: Smoothed monthly rainfalls (mm) for the site during various year groups using 1960-1969 as base year

The long-term climate records and the analysis presented support these local observations. It was also observed that higher rainfall fluctuations were more evident for the last recent decades than the earlier periods. The combination of lower projected future rainfall (Figure 5) and increased rainfall fluctuations would imply that farmers' traditional and indigenous wisdom alone could no longer be reliable to predict the effects of climate variability. The monthly rainfall distribution is characterised by two distinct rainy seasons as depicted in figure 5 and observed by community members. Monthly mean minimum and maximum temperatures for specified periods evaluated in relation to baseline period of 1961-1990 are presented in figures 6 and 7, respectively.

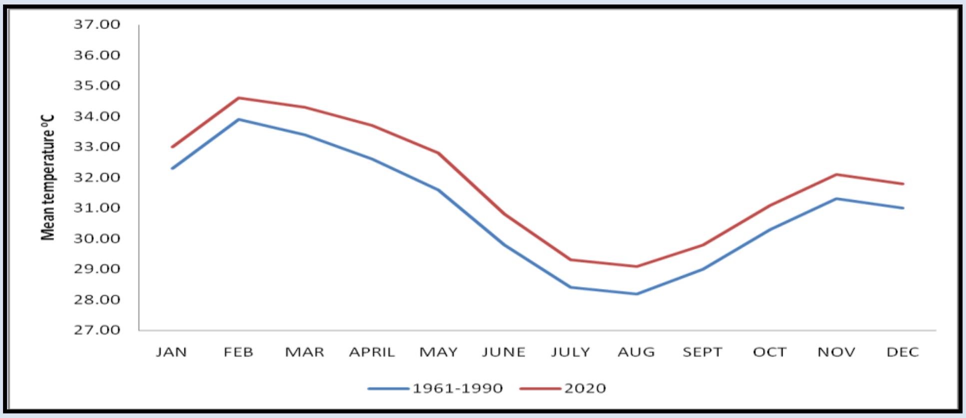


Source: *Kete Krachi* climate data from the Ghana Meteorological Agency

Figure 6: Graphical presentation of monthly mean minimum temperature

They show similar trends and/or patterns with increased average intensity of 0.8^{o} for both minimum and maximum temperatures. Community members described the increased intensity or changes in minimum and maximum temperatures in a focus group discussion (Historical Matrix) as "*Too much sunshine*"; *"The sun is too hot during February, which use to be the hottest month now the heat is too much during that month".* Projected variation for 2020 as presented in Figure 6 and 7 will be higher than temperatures recorded for 1961 – 1990.

Minimum and maximum temperatures between March and June are expected to be more than 1 degree. This corroborates the findings of most physical scientist who believe the long-term effect of climate change will be the effect of global warming and the short-term effect, which need immediate attention, are the variability in climate condition in the various localities (IPCC, 2001).



Source: *Kete Krachi* climate data from the Ghana Meteorological Agency

Figure 7: Graphical presentation of mean monthly maximum temperature

Responses such as *"short cropping season"; "now only one farming instead of 2 seasons"; "animals grow lean"; "soils become hot and hard"; "rivers and streams dry up"; "fishes die"; and "bush animals die*" are all indications of low agricultural productivity as a result of increased temperature couple with low rainfall amounts within the year.

These would eventually lead to low income, hunger, lack of drinking water, poor health and possibly death as perceived by the people as consequences of climate change during the mental modelling.

Understanding climate change and variability

Given the evidence of climate variability in the research communities, the study explored further the perception of these phenomena by the rural people using the mental model. They expressed their understanding of climate variability and change by psychologically modelling climate change. The population severely described how they perceived climate variability and change depending on tribe of the populace. Due to lack of exact vernacular definitions, several descriptions and local terminology were presented. For example, the *Akans* used phrases such as "*Ewiem nsakraye"* and "*Afe afe mu nsakraye*" to express climate change. This phrase could literally translate as "*atmospheric changes*" and *"yearly changes or year to year changes"* respectively. The Ewes referred to climate change as "*Xexeame fe totro*" and "*Xeyiyi fe tortro*" which literally implied "changing times". The several phrases in the local dialect used in describing climate change does not really reflect climate change but the yearly weather variability experienced as a result of global warming and suggest a gap in knowledge.

This notwithstanding, the model clearly reflected the changes in atmospheric and land conditions, which are short-term effect of climate change. The causes of change in the climatic patterns such as poor seasons and below normal rainfall were attributed to human sins, infractions and the reaction of the supernatural. This response was obvious because of the high percentage of the respondents who believe in a supernatural deity.

Typical viewpoint expressed include, "*God's will or doing"; "Wrath of deities towards the spread of Christianity" and "Disrespect for sacred groves or forbidden activities".*

The sampled population perceived causes of climate variability as inadequate rainfall, irregular rainfall, floods, hot sunshine, "light clouds", windy weather, and human activity such as the construction of the Akosombo hydroelectric dam and forest and vegetation cover loss. The model presented the positive and negative effect of climate variability on the environment and the society. The negative impacts were mostly drier, wetter and more unpredictable weather conditions for agricultural activities, which could cause low agricultural productivity. Positively, people in the community envisioned a good fish harvest, regenerated forest and soil fertility and adequate water for domestic use under wetter climate conditions. Responses such as *"short cropping season"; "now only one farming instead of 2 seasons"; "animals grow lean"; "soils become hot and hard"; "rivers and streams dry up"; "fishes die"; and "bush animals die*" are all indications of low agricultural productivity as a result of increased temperature coupled with low rainfall amounts within the year. These would eventually lead to low income, hunger, lack of portable drinking water, poor health and possibly death as perceived by the people.

Frequent reoccurrence of extreme climate events like droughts and floods were perceived as the consequence of climate variability and change. Key are the 1983/84 prolonged drought and the 1991 heavy rains and floods identified during the historical matrix as the most memorable and devastating extreme events.

These events presented the basis for discussion in the household survey. Further analysis of the responses indicated that 85.7% of the total respondents believed the climate event could reoccur, with its reoccurrence affecting all community farms and livelihoods.

Respondents (14.3%) who doubted the recurrence of extreme weather grounded their reasoning as follows: "*I heard but did not experience it"; "will not happen again"; "I cannot tell why"; "I was young and the way it is described makes me believe it will not happen again".* There was a consensus by all respondents that climate variability would affect farm activities, livelihoods, households and the community.

The wealth status or resource endowment level of households did not significantly influence the likelihood of event reoccurrence however; significant differences exist between responses of young (15-34 years) and older (35+ years) household heads. Over 50% of household heads older than 35 years believe the possibility of event reoccurrence with about 41% very sure it would reoccur again. Household heads between the age of 15 to 34 years presents their cognition of event reoccurrence on a nominal scale of not likely (25%), possibly (25%) and very likely (50%). Percent distribution within educational status of household heads was significant at a probability less than 0.05 and a chi-square value of 6.25. A greater percentage of household heads with no education (69%) believe this event is very likely to reoccur compared with 27 percent of educated household heads. On the contrary, 63 percent of the educated household heads as against 31 percent household heads with no education doubt the possibility of its reoccurrence.

The perceived severity of climate impact as an indicator of experience differed among the household members (Table 1). Severity impact evaluated as scores by respondents were higher for female than male but the differences were not significant. Generally, climate change severely affected households' heads. Among members of the household, the children and spouses were the least impacted; with spouses of male respondents (2.2) perceived to be severely affected than spouses of female respondents (2.0).

Table 1: Climate variability impact scores of household members as influenced by sex of respondent

Sex of respondent	Household members – severity score (1-5)*		
	Head	**Spouse**	**Children**
Female	3.0	2.0	2.4
Male	2.95	2.2	2.1
Mean	3.0	2.1	2.2

(1-5)* - severity score increase from 1, almost negligible to 5, very severe and could kill
Source: Data from field survey, 2007;

Education status of household heads also influence the severity impact scores of household members; educated household heads have higher impact scores for heads and their spouses when compared with scores of those without education (Table 2). Most probably because the non- educated household heads were scoring from experience and believe that the event will reoccur.

Table 2: Climate variability impact scores as influenced by educational status

Educational status of household head	Severity score of household members (1-5)*		
	Head	**Spouse**	**Children**
No education	2.6	1.6	2.3
Educated	3.2	2.4	2.42
Mean	2.97	2.1	2.23
F Cal (P<0.05)**	3.87**	4.94**	0.08ns

(1-5)* - severity score increase from 1, almost negligible to 5, very severe and could kill Source: Data from field survey, 2007;

Table 3: Climate variability impact scores as influenced by resources level of households

Household Resource level	Severity score of household members (1-5)*		
	Head	**Spouse**	**Children**
Low	3.27	2.0	2.8
Intermediary	3.0	2.7	2.7
High	2.7	1.7	1.3
Mean	2.97	2.11	2.23
F Cal (P=0.05)**; (P=0.001)***	1.41ns	3.2**	8.63***

(1-5)* - severity score increase from 1, almost negligible to 5, very severe and could kill
Source: Data from field survey, 2007

Household members with high resource endowment were the least impacted by climate change and variability; the highest were the low resource households. Spouses in the intermediary resource households were the most impacted by climate variability, the least is in the high resource group (Table 3). Households with low resources or less wealth perceived their children as highly impacted by climate change. These suggest an inverse relation between access to livelihood resources and vulnerability to climate change and variability; an increase in assets to resources will reduce vulnerability to climate change and variability impact.

Disaggregating the responses by age (Table 4) the young adults (15-34 years) recorded higher severity scores than the older groups (35+ years), apparently reflecting the non-experience of the younger group to climate situations in previous decades. Young adult males (age 15-34 years) reasoned that their spouses were severely affected (Table 5) by climate variability than spouses of older male household heads and expressed this perspective as follows: *"women spouses engaged in additional odd jobs to supplement housekeeping"; "women travel longer distances to fetch water"; "wives are responsible for their homes.* However, male household heads older than 35 years (2.96) believed they would be the most affected in the event of extreme climate variability than their spouses (2.04) and children (2). Reasons that explained these differences include the following; *"I provide food for the children", "Man has to struggle for food for the family", "Household head is the provider of food so has more impact than the other members"* and *"Responsible for the upkeep of the family".*

Table 4: Climate variability impact scores as influenced by age of household heads

Age groups(years)	Severity score of household members (1-5)*		
	Head	Spouse	Children
15 – 34	3.0	2.37	3.0
35 – 89	2.96	2.04	2.0
Mean	2.97	2.11	2.23
F Cal (P<0.05)**	0.11 ns	0.60 ns	4.63**

(1-5)* - severity score increase from 1, almost negligible to 5, very severe and could kill
Source: Data from field survey, 2007

Table 5: Climate variability impact scores on household members as influenced by age and sex of respondent

Sex of respondent	Age groupings (Years)	Severity scores of household members (1-5)*		
		Head	Spouse	Children
Male	15-34	3.0	2.5	3.8
	35+	2.9	2.1	1.7
Female	15-34	3.0	2.3	2.3
	35 +	3.0	1.9	2.4
F Cal (P<0.05)**		0.11 ns	0.6 ns	4.63**

(1-5)* - severity score increase from 1, almost negligible to 5, very severe and could kill
ns – Not significant **Source: Data from field survey, 2007**

Male and female respondents as head of households see themselves more severely affected by climate extremes events than their children and spouses (Table 5). These responses expressed dominance in patriarchal kinship where the male head of household or males in households take full and sole responsibility of the upkeep of all family members.

CONCLUSION AND POLICY IMPLICATION

The causes and consequences of climate variability as depicted by the communities' model clearly reflected the changes in atmospheric and land conditions, which are short-term effect of climate change. The lower projected future rainfall and increased rainfall fluctuation, which resulted in frequent floods and prolonged droughts in the communities, may be associated with global climate change; and established the fact that the research communities are experiencing climate variability.

With over 70% of the household sampled being religious and only 5% with no religion, it was not surprising that the poor seasons and below normal rainfall were attributed to human sins, infractions and the response of the supernatural or God.

The study identified a gap in the understanding of the causes and consequences of such changes, which is the basis of adaptation decision making. While they readily accepted the human / anthropogenic cause of climate change, the effect of the emission of greenhouse gases from industrial regions as the main cause of such change was absent.
Deforestation, charcoal production and indiscriminate bush burning, which rendered the ecosystem very sensitive to climate change were identified, as causes of climate change instead of consequences or impact of climate change. A strategic need of interest identified was to improve the common understanding or perception of climate variability and change. This is supported by the fact that while we expect the educated household heads to better understand climate change and variability and its impact on livelihoods; the study establish that a greater percentage of heads with no education but with experience believe the event would reoccur. Experience is therefore a better teacher than formal education. This symbolic form of empowerment for transforming power relation establishes a rationale for action as suggested by Larson (2002).
Therefore, with 85.7 percent of the sampled households believing that extreme climatic events could happen again, improving their local understanding of climate variability and change will increase their adaptive capacity as suggested by O'Connor et al., 1999.

However, since more men (66.7%) than women (33.3%) were sure of its reoccurrence, women representation in such educational networking should be encouraged to ensure equity. Age of household head also influence perception of climate risk, with increase in age recording high impact scores. The inclusion of all age and gender particularly those disadvantaged in capacity building is therefore necessary for a better understanding of climate risk. This is because education as a key indicator for human capital endowment (O'Connor et al., 1999) increased the perception and climate impact scores of households. Eighty percent of educated household heads believe the event would reoccur again as against 60% uneducated household heads.

Age of household head, a household life cycle variable, which gives insight into ethno-cultural context and communal history, greatly influenced severity impact on household members. As the reason for disbelief indicates a non-experience of such harsh climate hazards, it is assumed that the risk experienced in a lifetime of an individual would influence impact severity score. The severity score for climate change impact by household heads aged 15 to 34 years (3.0) was higher in comparison to their spouses (2.4) and the same as their children (3). Older household with heads aged over 35 years (3) believed extreme climate events would affect them more than their spouses (2) and children (2). The differences related to age of household head, according to McSweeney (2006), complicate issues at the micro levels and therefore, it is often suggested issues related to the environment particularly climate variability and change, which has a rippling effect on livelihoods at the local level, are evaluated in relation to age of household headship.

This study also shows that women within the sample are heterogeneous in relation to their response to severity impact of climate variability. Women as household heads perceived they are the worst affected by climate hazards than women as spouses in married households did; confirming the heterogeneity observed among rural women. Men as heads of household on the other hand believed they are the most impacted.

Children in young households headed by females (15-34 years) are less impacted (2.3) than those from young male headed households (3.8). While these scores may be subjective, they give an indication of differences in impact of climate hazards among household members, especially in children where statistical differences were significant. This confirms the observation by Mitchell et al., (2007) that climate change affects everyone but it is not gender neutral, reinforcing disparity between men and women vulnerability to climate variability.

Households have experienced and responded to extreme climatic events like floods and drought for several years, by developing a number of ways to survive in such environments and drawing on resources available. These extreme climatic events may influence households differently depending on the wealth, age, health and gender roles and relations within the households, as evinced by the differences in perception and impact scores presented.

Finally, as generally assumed our results show that knowledge increase people's perception and subsequently willingness to take steps that address those environmental problems. Risk perceptions and knowledge, however, share the stage with general environmental beliefs and demographic characteristics. Although related, this paper did not establish the relationship between risk perceptions, knowledge, and general environmental beliefs as independent predictors of behavioral intentions. Our findings suggest some guidance for—as well as limits to what can be accomplished by—risk communication and information efforts. Thus presenting how people conceptualize risks related to climate change, but rarely looks at the consequences of these perceptions for behavioral intentions or actual behavior.

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REFERENCES

Archer E.R.M. (2003) Identifying undeserved end-user groups in the provision of climate information. *B. Am. Meteorological Society,* 84, 1525-1532.

Adiku S.G.K. and R.C. Stone (1995) Using the southern Oscillation index for improving rainfall prediction and agriculture water management in Ghana. Agriculture Water Management, 29, 85-100.

Adiku S.G.K., F.D. Mawunya, J.W. Jones, and M. Yangyouru (2007) Can ENSO help in agricultural decision-making in Ghana? **In:** M.V.K. Sivakumar and J. Hansen (Eds.), *Climate Prediction and Agriculture* (Chapter 20, 205-212). Berlin: Springer Berlin Heidelberg.

Barry, B, E. Obuobie, M. Andreini, W. Andah and M. Pluquet (2005)
The Volta River Basin. Comprehensive Assessment of Water Management in Agriculture. Comparative Study on River Basin Development and Management. International Water Management Institute, December 2005, http://www.iwmi.cgiar.org/Assessment/files_new/research_projects/River_Basin_Development_and_Management/VoltaRiverBasin_Boubacar.pdf. Accessed on July 2007

Boko M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo, and P. Yanda (2007) Africa. **In:** M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 433- 467). Cambridge: Cambridge University Press.

Bowie F. (1999) The Anthropology of Religion: An Introduction. Oxford-Blackwell. Pages 19, 21.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K.Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton (2007) Regional Climate Projections. **In:** *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Denton F. (2002) Climate change vulnerability, impacts and adaptation: Why does gender matter? *Gender and Development.* Vol. 10 #2, pp.10-20.

Diaw K. and E. Schmidt-Kallert (1990) Effects of Volta Lake Resettlement in Ghana – A Reappraisal after 25 years. Hamburg: Institüt fur Afrika-Kunde.

Dow K., R.E. O'Connor, B. Yarnal, G.J. Carbone, C.L. Jocoy (2007) Why worry? Community water system managers' perceptions of climate vulnerability. Global Environmental Change. 17. 228-237.

Downing T.E., Y. Sokona, and J.B. Smith (2000) Action on adaptation to climate change. Presentation to the UNFCCC workshop on Article 4.8 and 4.9 of the convention: Adverse effect of climate change 9-11 March 2000, Bonn, Germany, Oxford Environmental Change Institute, University of Oxford

EM-DAT (2007) The OFDA/CRED International Disaster Database. Universite´ Catholique de Louvain, Brussels. http://www.em-dat.net. Accessed on 17/07/2007

EPA (2000) Environmental Protection Agency. Ghana's Initial National Communication under the United Nations Framework Convention on climate change. Ministry of Environment Science and Technology, Accra. December 2000. 171pp.

Ezeh A.C. and V. Agadjanian (2000) Polygyny, Gender relations and Reproduction in Ghana. The Journal of Comparative Family Studies. 31 (4): 427 – 441.

Food and Agriculture Organization of UN (FAO), (2007) Climate Change - The issue. http://www.fao.org/clim/issues_en.htm. Accessed on 1/08/2008\

Fischer G., M. Shah and H. van Velthuizen (2002) Climate change and agricultural vulnerability. International institute for applied systems analysis, Laxenberg, 152 pp.

Füssel, H-M. (2007) A generally applicable conceptual framework for climate change research. *Global Environmental Change* 17, 155-167.

Hellmuth, M.E., A. Moorhead, M.C. Thomson and J. Williams (Eds.), (2007) Climate Risk Management in Africa: Learning from Practice. International Research Institute for Climate and Society (IRI), Columbia University, New York, USA.

Hulme M., R. Doherty, T. Ngara and M. New (2005) Global warming and African climate change. Climate Change and Africa, P.S. Low ed., Cambridge University press, Cambridge, 29-40.

IPCC (2001) Climate variability In: McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken, K.S. White (Eds.), Impacts, Adaptation, and Vulnerability. Cambridge University Press, Cambridge.

IPCC (2007) Intergovernmental Panel on Climate Change, Climate change 2007: The Physical Science Basis – Working group 1, Fourth assessment report of the IPCC. Cambridge University Press, Cambridge-UK

Kasperson, J.X., and R.E. Kasperson (2001) Climate Change, Vulnerability and Social Justice. Stockholm Environment Institute, Stockholm.

Kelly, P.M., and W.N. Adger (2000) Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change* 47, 325–352.

Larson, M.J. (2002) Transforming power relationship: Building capacity for ecological security. *Gender and development*. Vol. 10 No. 2, 92-103.

Malhi Y. and J. Wright (2004) Spatial patterns and recent trends in the climate of tropical rainforest regions: Philosophical transactions of the Royal Society of London Series A, 359 (1443): 311

McSweeney K. (2006) How are household lifecycle-land/resource use relationships mediated by ethno-cultural difference? Panel Contribution to the Population-Environment Research Network's Cyber seminar on Household Micro-demographics, Livelihoods, and the Environment, April 2006 http://www.populationenvironmentresearch.org/papers/McSweeney_statement.pdf. Accessed on 21/09/2009

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory (2007) Global Climate Projections. **In:** S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds.), *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 747-845. Cambridge: Cambridge University Press.

Mitchell T., T. Tanner and K. Lussier (2007) *We know what we need*! *South Asian women speak out on climate change adaptation*, Action Aid International, London and the Institute of Development Studies (IDS)

O'Brien K. L., R.M. Leichenko, R. Kelkar, U. Venema, H. Aandahl, G. Tompkins, H. Javed, A. Bhadwal, S. Barg, L. Nygaard and J. West (2004) Mapping vulnerability to multiple stressors: climate change and Globalization in India. *Global Environmental Change* 14, 303–313.

O'Connor R.E., R.J. Bord and A. Fisher (1999) Risk perceptions, general environmental beliefs and willingness to address Climate Change. Risk analysis Vol. 19 no. 3 page 461-471

Opoku-Ankomah Y. and I. Cordery (1994) Atlantic Sea surface temperatures and rainfall variability in Ghana. *Am. Meteorological Society Journal of climate* 7 (4), 551-558.

PPMED (2005) Planning, Policy, Monitoring and Evaluation Department. Ministry of Food and Agriculture: Facts and Figures. 2005

Quinn C.H., M. Huby, H. Kiwasila and J.C. Lovett (2003) Local perceptions of risk to livelihood in semi-arid Tanzania. *Journal of Environmental management.* 68, 111-119.

Silverman D. (2001) Interpreting qualitative data: Methods for analysing talk, text and interaction. 2nd Edition, London, Sage Publication. 428 pp.

Smit B, I. Burton, R.J.T. Klein and J. Wandel (2000) An anatomy of adaptation to climate change and variability. *Climatic Change* 45:223–251

Smith K., C.B. Barrett and P.W. Box (2000) Participatory Risk Mapping for Targeting Research and Assistance: With an example from East African Pastoralist. *World Development*, Vol. 28, No. 11, Pages 1945-1959.

Tschakert P. (2007) Views from the vulnerable: understanding climatic and other stressors in the Sahel. *Global Environmental Change*, 17(3-4), 381-396.

Turner B., R. Kasperson, P. Matson, J. McCarthy, R. Corell, L. Christensen, N. Eckley, J. Kasperson, A. Luers, M. Martello, C. Polsky, A. Pulsipher and A. Schiller (2003) A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Science, USA Early Edition

Warren R., N. Arnell, R. Nicholls, P. Levy and J. Price (2006) Understanding the regional impacts of climate change. Research report prepared the stern review on the economics of climate change. Tyndall centre for climate change research, working paper 90, University of East Anglia, Norwich, 223p.

WMO (1992) World Meteorological Organisation, 1992 International Meteorological Vocabulary 2nd Edition Geneva. Publication number 182, ISBN 9263021821

Zaksek, M., Arvai, J.L. (2004) Toward improved communication about wild land fire: mental models research to identify information needs for natural resource management. *Risk Analysis* 24 (6), 1503–1514.

Appendix 1 Mental Model

The following questions guide the activity.

1. What causes climate changes as discussed in the historical matrix? Factors? Processes?
2. Are people responsible for these processes
3. What are the negative consequences / impact of these climate changes for people and then the environment?
4. Are there any benefits from climate change?
5. If yes are there benefits for people? For environment?
6. What can people do to prevent or reduce negative consequences?
7. What can people do to enhance positive consequences?
8. Who do you see as the most effective in helping you respond to these changes? NGO? LOCAL OR NATIONAL GOVERNMENT? CHURCH?

Appendix 2 Semi-structured interviews at household levels

Community: Sex: Age:

Household ID #: Date:

Introduction: Discussions on climate change mental models and historical matrix reviewed and participant is allowed to clearly envision the memorable climate event.

1. Do you believe such an event can happen during the next 10-15 years? If yes, Why? If no, Why not?
2. How likely do you think such an event will happen again? (a)Very likely (b) possibly (c) Not likely. Explain Why?
3. Do you think you will be affected by such an event?
4. How likely do you think other members of this household will be affected by such an event? (a)Very likely (b) Possibly (c) Not likely[If response is not likely skip Q5]
5. Is it going to affect other members of the household differently? Explain why?
6. Could such an event affect your farming activities? Yes / No Explain?
7. Could such an event affect your Livelihood and well-being? Yes / No Explain?
8. How severely do you think you or other members of your household can be affected? Indicate severity with pebbles: 5=very severe, could kill; 1= almost negligible. Explain why?

Counselling Strategies for Mainstreaming Gender into the Climate Change Policies of Anambra North Senatorial Zone Of Anambra State of Nigeria

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ABSTRACT

This study investigated the counselling strategies for mainstreaming gender into the climate change policies of Anambra North Senatorial Zone of Anambra State of Nigeria. Three hundred and fifty respondents were randomly selected from the seven local government areas that make up Anambra North Senatorial Zone. These respondents provided the data for the survey. A structured questionnaire was used for data collection. Three research questions and one hypothesis guided the study. Mean, standard deviation and t-test statistic were used to analyze the data. The findings of the study showed that women and girls in the study area were more vulnerable to the negative effects of climate change than their male counterparts. The negative effects of climate change identified in the study were: destruction of homesteads by flood, destruction of farmlands/crops, disruption of farming activities/means of livelihood, reduced income/zero income, among others. Counselling strategies for mainstreaming gender into the climate change policies of the study area should be intensified in Anambra State.

Key words: Gender, Gender mainstreaming, Climate Change

INTRODUCTION

Gender mainstreaming is a globally accepted strategy for promoting gender equality (Ivowi 2012). According to the United Nations (1997), Gender mainstreaming is also seen as a public policy concept of assessing the different implications for women and men of any planned policy action, including legislation, policies or programmes, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experience an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is again to achieve gender equality. The United Nations (of which Nigeria is a member) is formally committed to gender mainstreaming within all United Nations policies and programmes. In all societal, in all parts of the world, gender equality is not yet realized. Men and women have different roles responsibilities and decision-making powers. The issue of Gender Mainstreaming has, however, suffered indifference, unresponsiveness and lip services over the past decades especially in Sub-Saharan Africa. Nigeria is no exception. Gender Mainstreaming in the Nigerian context would mean taking practical measures through policy formulation and implementation to bring women at par with men in all areas of life: Political, economic, education etc. Gender Mainstreaming is a measure adopted by the United Nations Development Programme (UNDP) to strengthen its impact on the situation of women and on gender equality. The terminology, "Gender Mainstreaming" introduced by Money (1955), came into widespread use with the adoption of the platform for Action during United Nations Fourth World Conference on Women, held in Beijing (China) in 1995.

Hornby (2010) defines gender as the fact of being male or female. Gender is the collective social differences between males and females, as determined by culture. A gender analysis recognizes that men and women play different roles in their families, communities and societies. They also have different kinds of access to information, resources and networks. It assesses the impact that an activity may have on men and women, and on gender relations. This analysis can help to ensure that men and women are not disadvantaged by an activity, enhance its sustainability and effectiveness, and identify priority areas for action to promote equality between women and men. Gender refers to the differences in socially constructed roles and opportunities associated with being a man or a woman and the interactions and social relations between men and women. Gender therefore determines what is expected, permitted and valued in a woman's or a man's behaviour in a specific context (Giddens, 2006). Likewise when a community is faced with a disaster or external shocks like floods or drought, the manner in which men react to the situation is different from the way women will face a similar situation. This is due to the culturally constructed gender roles that may put one gender in a more vulnerable situation compared to the other. Women for instance will face more challenges caring for children and the elderly in provision of food and care than men in such situations (Ellis, 2000).

Climate change is a lasting variation in the global climate in response to natural and/or human factors. Climate changes affect weather patterns, increasing the frequency and intensity of floods, droughts, and extreme weather events (Mirza, 2003). These types of conditions also result in natural disasters. While climate change is not solely destructive, the negative impacts of global warming on health and agriculture are greater than the benefits for the majority of the world and increase as global temperatures rise. These climate changes will cause the most harm for the most vulnerable populations or those who lack the ability to cope with and adapt to climate change because of a lack of access to essential resources. Marginalized groups like women, children, the elderly, and the impoverished have less access to and control over resources and therefore are more negatively impacted by climate change.

Statement of the Problem

Climate change continues to be of great concern both nationally and internationally, especially with regards to resource allocation and utilization for adaptation and mitigation. It is also clear that climate change is accelerating, taking almost catastrophic dimensions and the impacts are felt greater across the world than in the past thirty years. The impacts of climate change in the form of hurricanes, floods, and droughts affect the entire communities and presumably therefore, affect the lives of both women and men in a number of ways. Concern is emerging such that the negotiations on climate change do not fully involve the affected groups yet each of these groups is impacted by climate change in different ways.

In Anambra North Senatorial Zone of Anambra State of Nigeria, out of the seven local government areas constituting this zone, five local government areas form the riverine areas of the entire State. These five local government areas are also called the disadvantaged areas of the State. It is not worthy that this researcher hails from one of these disadvantaged areas. A natural fact is that the poor and impoverished are dependent on the environment and its natural resources for subsistence and income. Therefore, ninety-nine percent of the indigenes of these local government areas are farmers and fishermen. The most recent natural disaster in these local government areas in 2012 was flooding. Homesteads and farmlands were massively destroyed and the inhabitants had to flee. All their property was destroyed by the flood and the State Government had to quarter them in Camps to safeguard their lives. It was very evident from observations, interviews and common experience that women, girls, children and the elderly bore the brunt of this disaster. This study has therefore set out to investigate counselling strategies for mainstreaming gender into climate change policies of this Senatorial Zone that is most prone to natural disasters, in order to ensure that particular gender does not suffer more in such a situation.

Purpose of the Study

The main purpose of this study is to investigate counselling strategies for mainstreaming gender into the climate change policies of Anambra North Senatorial Zone of Anambra State of Nigeria. Specifically, the study:

1. ascertained the negative impacts of climate change in the study areas;
2. consequences of these negative impacts on both men and women, children and the elderly;
3. solutions to the negative impacts of climate change.

Research Questions

1. What are the negative impacts of climate change in the study area?
2. What are the consequences of these negative impacts?
3. What are the possible solutions to the negative impacts of climate change in the study area?

Hypothesis:
There is no significant difference in the mean scores of the male and female respondents on the solutions to the negative impacts of climate change in the study area.

METHOD

Design of the study: The study employed a descriptive survey research design to investigate the counselling strategies for mainstreaming gender into the climate change policies of Anambra North Senatorial Zone of Anambra State of Nigeria.

Area of the Study: The study was carried out in Anambra North Senatorial Zone of Anambra State of Nigeria. Anambra state is one of the thirty-six States of Nigeria. Anambra North Senatorial Zone is one of the three Senatorial Zones of Anambra state and is made up of the following seven local government areas: Onitsha North, Onitsha South, Ogbaru, Anambra East, Anambra State West, Ayamelum and Oyi local government areas. The inhabitants of Onitsha North and Onitsha South local government areas are mainly traders who make the entire Onitsha the commercial capital of Anambra State. The rest of the local governments in Anambra North Senatorial Zone are inhabited by the indigenous people who are mainly farmers and fishermen.

Population of the Study: The study population was made up of all the male and female inhabitants of Anambra North Senatorial Zone.

Sample and Sampling Technique
A sample of fifty respondents was randomly drawn from each of the seven local government areas, giving a total sample of three hundred and fifty respondents used for the study.

Instrument for Data Collection: A structured questionnaire was the instrument designed by the researcher to elicit data for the study. The instrument was divided into two parts. Part A requested for personal data from the respondent while Part B dealt with negative impacts of climate change and their consequences in the study area as well as possible solutions. Part B contained 30 items. The instrument was developed on a 4-point Likert scale of Strongly Agree (SA) (4) Agree (A) (3) Disagree (D), (2) and Strongly Disagree (SD) (1).

Validation of the Instrument: Three Senior Officials of the Ministry of Environment validated the instrument. Their suggestions were used to improve the production of the final copy of the questionnaire. A reliability co-efficient of 0.90 was obtained to confirm the reliability of the instrument using the Cronbach Alpha reliability method. Six research assistants helped to administer and retrieve the questionnaires in the six local government areas while the researcher worked in her own local government area – Anambra East local government area.

Method of data Analysis: Three hundred and fifty (350) copies of the questionnaire were retrieved and analyzed. Mean and standard deviation were used to answer the research questions. Any questionnaire item with mean score below 2.50 was regarded as disagree and not accepted while mean scores of 2.50 were accepted as a positive response. The t-test was used to test the hypothesis.

RESULTS

The findings of this study are presented in this section. The intention is to provide an overall picture of the responses as the negative impacts of climate change, the consequences and the possible solution to the negative impacts of climate change as given by the male and female respondents.

Research Question One:

What are the negative impacts of climate change in Anambra North Senatorial Zone?

Table 1: Mean responses on the negative impacts of climate change.

S/N	Item	Male		Female	
	Negative impacts of climate change	$\bar{X}$	SD	$\bar{X}$	SD
1	Destruction of homesteads by flood	3.77	0.26	3.89	0.27
2	Destruction of farmlands/crops	3.85	0.27	3.91	0.27
3	Loss of livestock	3.86	0.27	3.97	0.28
4	Disruption of farming activities/means of livelihood.	3.92	0.27	3.96	0.28
5	Reduced income/zero income	3.71	0.25	3.83	0.26
6	Inability to cope with health problems.	3.74	0.25	3.79	0.26
7	Susceptibility to climatically-induced health risks like diseases.	3.54	0.23	3.94	0.28
8	Increased male unemployment/crime rate.	3.45	0.22	3.97	0.28
9	Increased mental and physical abuse by male relatives.	2.58	0.17	3.94	0.28
10	Compulsion to abandon one's home caused stress and depression.	3.38	0.22	3.65	0.24
	Consequences of the negative impacts				
11	Magnified care-giving for children, the elderly for women.	2.85	0.18	3.88	0.27
12	Increased workloads like fetching water or wood for women.	2.85	0.18	3.84	0.26
13	Food shortage/Reduction in agricultural productivity.	3.89	0.27	3.97	0.28
14	Decline in livelihood opportunities causing considerable stress.	3.34	0.21	3.86	0.27
15	Overcrowding, lack of privacy and the collapse of regular routines in make-shift rehabilitation camps.	3.85	0.27	3.96	0.28
16	Family dislocation and displacement leading to anger, frustration and violence.	3.79	0.26	3.97	0.28

17	Increased emotional insecurity and consequent increase in infections of sexually transmitted diseases and HIV because of exposure to new sexual partners.	2.54	0.17	3.94	0.28
18	Lack of safe water leading to water borne diseases.	3.54	0.23	3.97	0.28
19	Poor nutrition and high mortalities especially among expecting and nursing mothers.	3.77	0.26	3.91	0.27
20	Insecurity of life and property in rehabilitation centres as evidenced in loss to thieves/robbers, rape and sexual harassment of girls and women.	2.06	0.18	3.86	0.27
	Possible solutions to the negative impacts				
21	Campaign for gender equality so that the hardships brought about by climate change will not hit women disproportionately hard and exacerbate the already existing inequality between the sexes.	2.45	0.17	3.91	0.27
22	Provision of equal capacity and opportunity to prepare everybody for the impacts of climate change.	3.44	0.22	3.80	0.26
23	Inclusion of women in decision making on climate change issues.	1.98	0.19	3.77	0.26
24	Representation of the needs of the female folk on decision making bodies at all levels in order to develop policies and programmes which recognize that men and women have different adaptive capacities.	2.38	0.17	3.69	0.25
25	Adherence to gender mainstreaming to increase the efficiency of responses to climate change.	2.77	0.17	3.17	0.20
26	Legislation at local Government area level must be undertaken to ensure that climate change policies must involve both sexes.	3.23	0.20	3.20	0.20
27	Adequate preparation to cushion disaster effects ahead of time to avoid "fire bridge" approach by government.	3.28	0.21	3.40	0.22
28	Grants and loans by government to enable farmers start off on a freshnote after a disaster.	3.43	0.22	3.71	0.25
29	Ensuring that the committees in charge of rehabilitation camps are manned by responsible and responsive men and women to avoid embezzlement and misappropriate of relief materials.	3.74	0.23	3.34	0.25
30	Fund raising and donations from philanthropists and non-governmental organizations to ensure adequate supply of essential requirements at Rehabilitation Camps.	3.17	0.20	3.77	0.26

Table 1 shows the mean responses and standard deviations of the male and female respondents on the causes, consequences and possible solutions of the negative impacts of climate change. The respondents agree on items 1 – 10 which deal with the negative impacts of climate change. The mean scores of these items, as can be seen are 2.50 and above showing agreement. On the consequences of the negative impacts of climate change, the male and female respondents also agree on items 11 – 20 which are on the consequences of the negative impacts. However, the male respondents did not agree with item 20 which is on the insecurity of life and property in the rehabilitation centres as evidenced in loss to thieves/robbers, rape and sexual harassment of girls and women. The female respondents agree to this item. This means that the female respondents agreed that there was insecurity of life and property. They also agreed that property was lost to thieves and robbers and some of the girls and women in the rehabilitation centres were raped and sexually harassed. On the possible solutions to the negative impacts, responded to in items 21 – 30, the male respondents failed to agree to items 21, 23, and 24 whose mean scores were 2.45, 1.98 and 2.38 respectively while the female respondents agreed to all the items.

Null hypothesis:

There is no significant difference in the mean scores of the male and female respondents on the solutions to the negative impacts of climate change in the study area.

Table 2.

t-test analysis on the mean scores of male and female respondents on the possible solutions to the negative impacts of climate change.

Variables N X $\overline{\text{SD}}$

Variables	N	$\overline{X}$	SD	df	t-cal.	t-test	Decision
Male	175	2.96	0.20	348	27.95	1.96	Significant
Female	175	3.62	0.24				Ho rejected

Tables 2 shows the t-test analysis on the mean scores of male and female respondents on the possible solutions to the negative impacts of climate change. The calculated t (t-cal.) is 27.95 while the critical t (t-crit.) is 1.96. Therefore since the calculated t (27.95) is greater than the critical t (t-crit) (1.96), the null hypothesis of no significant difference is rejected and the alternative hypothesis is accepted. Hence there is a significant difference between the mean scores of the male and female respondents on the possible solutions to the negative impacts of climate change.

DISCUSSION

Items 1 – 10 of the instrument answered research question one on the negative impacts of climate change. The male and female respondents all agreed on the items. Hence such negative impacts as destruction of homesteads by flood, destruction of farmlands/crops, loss of livestock, etc were agreed upon as the negative impacts of climate change. This finding is in line with the assertion of Ongoro and Ogara (2012) when they stated that the impacts of climate change in the form of hurricanes, floods, and droughts affect the entire communities and presumably therefore, affect the lives of both women and men in a number of ways. Goldsworthy (2010) argues further that women's everyday household work and care for their families will be made more difficult due to climatic changes.

Items 11 – 20 answered research question two on the consequences of the negative impacts of climate change. Such consequences as magnified care-giving for children and the elderly for women, increased workloads like fetching water or wood for women, food shortage/reduction in agricultural productivity etc were agreed upon. Climate change, according to Ongoro (2011), who agrees with the findings of this study, usually leads to decline in food security and livelihood opportunities and this causes considerable stress, for men and boys given the socially ascribed expectation especially in the African society where men are supposed to provide a livelihood for the household. Bartlett (2008), also agrees with the consequences when he posited that overcrowding, lack of privacy and the collapse of regular routines and livelihood patterns can contribute to stress leading to anger, frustration and violence, with children (especially girls) and women who are the most vulnerable bearing the brunt.

Research question three is answered by items 21 – 30 which dealt with possible solutions to the negative impacts of climate change. Hence such possible solutions as campaign for gender equality, provision of equal capacity and opportunity, inclusion of women in decision making, representation of the needs of the female folk etc are agreed upon by the respondents. It will be noted however, that because of the entrenched gender bias against the women folk, the male respondents refused to agree on items 21, 23 and 24. These items are campaign for gender equality inclusion of women in decision making on climate change issues and representation of the needs of the female folk on decision making at all levels. The disagreement of the male respondents does not come as a surprise on these items. March (1999) argues that capacities, vulnerabilities, and needs are differentiated by gender. As Terry (2009) indicates, unless greater attention is given to gender dimensions, policies aimed at mitigation and adaptation will exacerbate the hardships of already disadvantaged women especially in developing countries who depend on natural resources for survival. In fact, the importance of gender in the development of climate change laws, policies and adaptation planning needs to be emphasized, since climate change has pervasive and far-reaching social, economic, political and environmental consequences. The challenge cannot therefore be not without the collective power and knowledge of women and men.

Table 2 shows the t-test analysis of the null hypothesis. Since the calculated t of 27.95 is greater than the critical t of 1.96, the null hypothesis of no significant difference is rejected and the alternative hypothesis accepted. This means that there is a significant difference between the mean scores of the male and female respondents on the possible solutions to the negative impacts of climate change. This difference is to be expected given the fact that women are particularly vulnerable to climate change because they are more prone to the adverse impacts from climate change. Their limited adaptive capacities arise from prevailing social inequalities and ascribed social and economic roles that manifest itself in differences in property rights, access to information, lack of employment and unequal access to resources. Coupled with this is the fact that the traditional African society would usually relegate women to the background and insist that the women’s role must not exceed child rearing and household chores. This tends to deny women access to decision-making even in areas they would bear the brunt. It is because women bear a disproportionate burden of climate change consequences that climate change is a gender issue.

Counselling Strategies

The counsellor has a role to play in mainstreaming gender into the climate change policies of Anambra North Senatorial Zone of Anambra State of Nigeria. The ability of the counsellor to perform the specific roles will go a long way to help curb the menace of the negative impacts of climate change.

So far it is presumed that there are practising counsellors at the primary, secondary and tertiary levels of our educational system. It is at these levels that the youths are taught and counselled on the meaning of climate change, the impacts and the consequences. It is also at these levels that it should be made clear that gender differences must be taken into account to understand the impact of climate change.

The next counselling strategy is at the policy-making level of the local governments. This level is the chairman of the local government and his counsellors. The chairman is usually an indigene of the local government area and the counsellors, who are also indigenes, represent the various wards and towns making up the local government area. During the sitting of the local government parliament so to speak, the counsellor solicits to be given audience to address the parliament on climate change, issues and challenges. The findings of this study come in handy at this stage. The counsellor should itemize the impacts of climate change into six important areas viz:

- Sustenance and livelihood;
- Food crisis and hunger;
- Psychological trauma and stress;
- Dire matrimonial consequences;
- Loss of dignity
- Health –Related Impacts.

The counsellor should take time to address these issues one after the other as well as dwell on the effects on men and women.

The next level is the state level the more experienced counselors, especially those who have access to the government of the day should seek to address the state house of Assembly on climate change issues and challenges. The members of the state house of Assembly are drawn from the twenty one local government areas of the state, including the disaster-prone areas. They are expected to take what they gather from the lecture on climate change back to their various constituencies. The counselor's address at this stage must centre on the following points. That the honourable members of the house should:

- Recognize that women are more vulnerable in climate change driven scenarios.
- Understand and address gender- specific natural resource use pattern;
- identify women's particular skills and capacities that lend themselves to mitigation and adaptation;

- Increase women's participation in decision – making at all levels in climate change mitigation and adaptation.

The counselor's role at this stage is made easy because the speaker of the state house of Assembly is a female. She will not only compel the honourable members to grant audience to the counselor, she will also help to emphasize the key points of the speech.

Finally some of the state commissioners are women. The counselor gets at them to help drive home the points raised and ensure that occasionally women in communities are addressed to enlighten them on the issues at stake.

CONCLUSION

This study has dealt with mainstreaming gender into the climate change policies of Anambra North Senatorial zone of Anambra State of Nigeria. The negative impacts, consequences and possible solutions have been investigated. To date, the debate on climate change has been very narrow, focusing on economic effects, efficiency and technological problems. However, to be effective, policies and measures that aim to address climate change need to be based on a holistic understanding of human perception, values and behavioural choices (Hemmati and Rohr, 2009). Finally, this study has outlined counseling, strategies that would help in mainstreaming gender into the climate change policies. Based on the findings of this study, it is hoped that taking the different daily realities of women and men into account can produce a qualitative improvement in climate change policy and measures.

REFERENCES

Bartlett, S. (2008). *Climate Change and Urban Children: Impacts and implications for Adaptation in low and middle income countries*. International institute for Environment and Development (11ED). Human Settlements Discussion Paper Climate Change 2, UK 11ED.www.iied.org.

Ellis, F.(2000). *Rural Livelihood Diversity in Developing Countries*. London: oxford University Press.

Giddens, A. (2006). *Essentials of Sociology*. New York: Norton and Company Inc.

Goldsworthy, H. (2010). Women, global environmental change and human security in mathew R.A, Bamett J, McDonald B, O' Brien kleds *Global Environmental Change and Human Security*. Cambridge MA: MIT press, pp 215 – 235.

Hornby, A.S. (2010). *Advanced Learners' Dictionary.* Oxford: Oxford University press.

Ivowi, U.M.O. (2012). Issues in Gender Mainstreaming in the Nigerian Educational system*:* Policies, Practices challenges and Possibilities. *International Journal of Forum for African women educationalist Nigeria*.1(1).

March, C. (1999). *A Guide to gender Analysis framework.* Oxford: Oxfam GB.

Mirza, M.M.Q. (2003). Climate change and extreme weather events: can developing countries adapt? *Climate Policy.* 3 (3) 233-248.

Ongoro, E.B. and Ogara, W. (2012). Impact of Climate Change and gender roles in community adaptation: A case study of pastoralists in Samburu East District, Kenya. *International Journal of Biodiversity and Conservation* 4(2) 78-89.

Terry, G. (2009). No Climate justice without Gender justice: An overview of the issues. *Gender and Development.* 17(1) 5-18.

United Nations (1997). UN Report of the Economic and Social council for 1997.

A Review of Carbon Sequestration in Soils as a Tool for Mitigating Climate Change in Africa

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ABSTRACT

The climate change phenomenon has increasingly, become a major concern globally, in recent years. Evidence has shown that the damage caused in a particular part of the globe can have far reaching effects on distant and even unrelated areas. The vulnerability of the African Continent particularly, to the impacts of these changes has been affirmed, with recent environmental trends suggesting that it is experiencing dangerous extremes in terms of rising temperatures and weather conditions. Unsustainable management of natural resources in Africa has been identified as a major contributory factor to the climate change effects. Arable soils are the largest reservoirs of organic carbon storing an estimated range of carbon that is more than twice of that in living vegetation or the atmosphere. Global warming will accelerate decomposition of soil organic matter and without concerted efforts, such carbon stocks could suffer overall decline leading to increased atmospheric Carbon Dioxide. There is therefore the need to consider and adopt pragmatic approaches to counteract these negative effects in the face of rising global temperatures. There is a general agreement that although soils are a part of the climate change problem, they can also be an integral part of the solution due to their potential to help in reversing the trend through the sequestration of carbon. Adoption of Sustainable Land Management practices that will increase carbon sequestration in soils will contribute to mitigation of climate change by increasing the "resilience" of the land in the African continent. The paper reviews the impact of carbon sequestration technique as a tool for mitigating climate change in Africa.

Keywords: Climate Change; Soil Organic Carbon; Sustainable Land Management; Carbon Sequestration

INTRODUCTION

Climate change is one of the biggest challenges facing our globalized world today. It has been defined by the United Nations Framework Convention on Climate Change (UNFCCC) as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Its impacts which are not only on the environment, but also on economic and social development vary among regions, with the African region being disproportionately affected. While Africa has contributed the least to climate change, it will yet likely experience the most severe impacts (Toulmin et al.,2005; Black, 2006). Particularly, Countries in Sub-Saharan Africa (SSA) are vulnerable to climate change impacts because of their limited capacity to adapt. Africa is one of the world's most important reservoirs of terrestrial carbon, which includes soil, forests and agricultural carbon stocks, accounting for at least 20 per cent of the world's forest carbon. For example, Central African forests alone are estimated to store between 25-30billion tonnes of carbon. Evidence also shows that mature humid forests in Africa also can provide a critical buffer against global and regional climate change(13).

Agricultural soils are among the planet's largest reservoirs of carbon – roughly twice the amount that is stored in all terrestrial plants with the potential for expanded carbon sequestration (Akpalu and Ekbom, 2010). Decreasing carbon stocks in the biosphere, including agricultural soils, have historically been a net source of CO2 emissions to the atmosphere (Marland et al, 2007). Globally, it has been estimated that 78 Pg of carbon have been lost due to agricultural practices, with 26 Pg attributed to erosion and 52 Pg attributed to mineralization (Lal (2004a). Agriculture also contributes a significant share (14 percent) of greenhouse gas (GHG) emissions, more if related land-use change (particularly deforestation) is included (WRI 2010). Currently, agriculture and other forms of land use contribute 32% to the world's Green House Gas (GHG) emissions (IPCC, 2007a,b). Moreover, each ton of carbon lost from soil is said to add, approximately 3.7 tons of CO2 to the atmosphere. Conversely, every ton increase in soil organic carbon represents 3.7 tons of CO2 sequestered from the atmosphere. Moreover, between 70-80% of the rural population in Africa are dependent on agriculture, livestock and forests for their livelihoods. About 70% of the economic (i.e. cost-effective) potential for reducing emissions from agriculture in developing countries (17) Global carbon markets could harness this potential. However, current rules of the clean development mechanism (CDM) and other regulated markets have essentially locked out African farmers (9). A glance at global mitigation potentials shows that changes in agriculture and land use, including deforestation in tropical areas, currently account for one-third of global greenhouse gas emissions (see Figure 1). Increasingly, therefore, agriculture is being recognized as part of the problem in international climate negotiations. While developed countries' emissions result mostly from industry, energy consumption and transport, FAO figures reveal that 74% of all agricultural emissions originate in developing countries, and 70% of the agricultural mitigation potential can be realized in these same countries.

The United Nations Framework Convention on Climate Change (UNFCCC) defines carbon sequestration as the process of removing C from the atmosphere and depositing it in a reservoir. It entails the transfer of atmospheric CO2, and its secure storage in long-lived pools (UNFCCC 2007). It has been estimated that 50-66% of historic losses could be sequestered over the next 50 years of adoption of best management practices on all agricultural land (Lal2004a). Globally, this equates to 30 to 60 Pg C at a rate of 0.9± 0.3 Pg C yr-1 over 25 to 50 years. This sequestration rate is equivalent to approximately 10% of current total GHG emissions due to fossil fuel burning and land-use change (IPCC 2007) or 25 to 33% of the annual increase in atmospheric CO2 levels. Using a more detailed inventory approach, Smith *et al*. (2008) estimated that the global technical mitigation potential, considering all greenhouse gases, from agriculture by 2030 is 5.5 to 6.0 Pg CO2-eq yr-1 (or ~ 1.5 Pg C yr-1). It is extremely important to keep in mind that these types of estimates assume adoption of best management practices across every acre of land under production.

With the adoption of the Kyoto accords, at least by some countries, sequestered carbon (C) has become a tradable commodity. This provides a double incentive to increase soil organic carbon in the C-depleted and degraded soils of Africa – return C to improve soil quality and assist in removing CO2 from the atmosphere to assist in mitigating climate change. The challenge, however, remains to determine which agricultural systems can actually sequester C and the best methods to quantify the C sequestration potential of the practice. Quantification of the impacts of land use on carbon stocks in sub-Saharan Africa is challenging because of the spatial heterogeneity of soil, climate, management conditions, and due to the lack of data on soil carbon pools of most common agroecosystems. Realizing the full potential for mitigation in Africa will require considerable new investments towards the adoption land use practices that sequester high carbon. At the same time, the economic potential for mitigation through agriculture in the African region is estimated at 17 percent of the total global mitigation potential for the sector. Moreover, the economic potential of agricultural GHG mitigation is highest in East Africa, at 41 percent of total potential (Smith et al. 2008).

Sustainable land management can play a significant role in climate change mitigation through reducing emissions of greenhouse gases and sequestering carbon in vegetation, litter, and soils. In addition to their effects on land use change, SLM practices can also have important mitigation effects in situ, on the agricultural lands themselves (TERRAFRICA, 2009). The UNFCCC (2008) estimates that for Africa, 924 mega tons of additional CO2 could be stored with the adoption of improved agricultural practices. Much of this (89%) is predicted to come from soil carbon, because although the amount of additional carbon that can be sequestered in soils is less than the potential above ground (e.g. through trees), for a given size of land, the total volume of soil is high. The world needs carbon (C) sequestration techniques that provide social, environmental, and economic benefits while reducing atmospheric CO2 concentration. In addition, because carbon stored in agricultural soils can be easily quantified using well-accepted scientific practices, it can provide benefits to farmers through rental payments and to society by avoiding the cost of implementing expensive new technologies. Despite the vast potential of C sequestration in soil and vegetation (terrestrial ecosystems), the option has not been strategically considered by policy makers (Lal R). It is a win-win option because of numerous co-benefits, especially the beneficial impact on soil quality.

This study reviews evidence on the practice, outcomes, and potentials and challenges and limitations of Soil Carbon Sequestration through the adoption of sustainable natural resource (Land) management practice in Africa as a tool for mitigating Climate Change in ecosystem services, and supporting climate change adaptation and mitigation at local to global scales.

Soil Carbon Sequestration in Africa

Soils are an important component of the global carbon cycle and serve as a large reservoir of terrestrial carbon. Human activities have decreased the amount of carbon held in affected soils. Prior to the human-induced CO_2 emissions, the natural processes that make up the global "carbon cycle" maintained a near balance between the uptake of CO_2 and its release back to the atmosphere. However, existing CO_2 uptake mechanisms (sometimes called CO_2 or carbon "sinks") are insufficient to offset the accelerating pace of emissions related to human activities. In spite of attempts at emissions reduction for over three decades, the total atmospheric carbon burden has increased by approximately 42 parts per million (ppm) to our current level of 393 ppm *(NOAA, 2013)*, and the rate of increase is accelerating *(International Energy Agency, 2012).* Controlling atmospheric CO_2 will thus require deliberate mitigation with an approach that combines reducing emissions and increasing storage.

Management of agricultural systems to sequester C has been accepted as a partial solution to climate change (Morgan et al. 2010). The sequestration of carbon in agricultural soil is not a linear, but rather it is a dynamic development process which needs a long time and accurately adopted practices for the fieldsite where it is applied on ( ). Changes in agricultural practices-notably changes in crop varieties, application of fertilizer and manure, rotation and tillage practices-influence how much and at what rate carbon is stored in, or released from, soils. Quantification of the impacts of land use on carbon stocks in sub-Saharan Africa is challenging because of the spatial heterogeneity of soil, climate, management conditions, and due to the lack of data on soil carbon pools of most common agroecosystems.

Regardless of the need to adapt/mitigate ACC, enhancing SOC pool in agricultural soils is essential to feeding world's population of 7 billion in 2011 and 9.3 billion by 2050.Hansen et al. (2007) estimated that terrestrial sequestration has a capacity to create a draw down of atmospheric CO2 by 50 ppm over 100 to 150 years which is a conservative estimate as the actual potential may be double than this (Lal). In addition to SOC, there also exists the potential of SIC sequestration (Lal 2001, Sahrawat 2003), which should not be ignored because of the large areas involved. Even the draw down of 50 ppm, being a natural and cost-effective fix with numerous ancillary benefits, is not small. Rather than a drawback, the dynamic nature of SOC pool is an advantage for agronomic ecosystems. More importantly, the SOC sequestration buys us time until alternatives to fossil fuel take effect. Proven soil/land management options st. Promoting a widespread adoption of these options over several decades until 2050 creates a bridge to the future. The types of practices that can build soil carbon almost always represent win-win outcomes because improved soil carbon has been proven to contribute positively to plant growth and agricultural productivity (Swift and Shepherd 2007).

Increasing SOC improves soil quality, boosting agricultural productivity while reducing atmospheric CO2 concentrations.

It is important to note the application of different methods of measuring Carbon fluxes into and out of the soil. Beside of the unique set up of an example with all particularities from the biotic and a-biotic environment (e.g. localisation) it is crucial to distinguish and classify in and between soil orders and zones of climate and parent material of the derived data.

Potential and Impact of Soil Carbon Sequestration on Climate Change Mitigation in Africa

Soil Carbon sequestration has been proven as a feasible strategy with near-term (by 2100-2150) potential of sequestering 50-100 Pg C, with a significant drawdown of atmospheric CO2 concentration (Hansen et al. 2008). McKinsey et. al. (2009) has documented that SOC sequestration in terrestrial ecosystems is the most cost-effective option, especially when compared with geological sequestration in rock strata and saline aquifers. The technical GHG mitigation potential of agriculture has been calculated at 5.5 to 6 gigatonnes of CO2 per year by the year 2030(14) about 90% of this potential could be achieved through soil carbon (C) sequestration. Estimates of soil organic carbon (SOC) in parts of Africa especially Sub-Saharan Africa however remain unclear for several reasons: different methods for estimating soil carbon have been used, 2) reports from different studies consider different depths e.g. 0-10 cm, 0-20 cm and even 0-200 cm, and differences in sampling techniques and soil analytical procedures, and 4) different time of sampling. Also unlike in the developed Countries with a huge economic strength, there is a dearth of actual data from field experiments and reviews have been based basically on the output from large scale models.

Agricultural Best Management Practices for Climate Change Mitigation

The need for a management shift on Africa's agricultural land has been identified as a necessary measure for climate change mitigation. In general, any shift in management that increases inputs and/or reduces losses should build SOC stocks especially in soils that have lost significant quantities of SOC relative to pre-clearing conditions. Management shifts have been broadly classified into 7 categories: 1) management for increased yields; 2) tillage and stubble management; 3) crop rotation; 4) pasture and grazing management; 5) retirement of agricultural land; 6) offsite organic matter additions; and 7) alternative farming systems.

Changes in agricultural practices-notably changes in crop varieties, application of fertilizer and manure, rotation and tillage practices-influence how much and at what rate carbon is stored in, or released from soils. Management practices that have been proven to improve soil carbon stocks while reducing depletion fall into the main categories of land use management for all agricultural land use types have the same principles:

- minimum tillage
- crop rotation and therefore as much as possible input of diverse residuals

- closed nutrient cycle through balance of fertilization and
- protection against physical erosion and chemical leaching of important soil particles through integrated water management.

Some of these practices which are not new are discussed below:

Reduced Tillage and No-tillage Management

The principle idea of tillage application in farming system is to mix the upper soil layers for the main purpose that nutrients come faster into contact with metabolisation so that no natural horizons develop which then would prolong the decay times until organic matter is mineralized (FOLLET, 2001). No tillage“ is considered to be the soil friendliest way of cultivation, because not more than 25% of the field width is disturbed by machinery which is only used for the sawing of seeds which at least 15-30% of the original cover remains undisturbed. „Conventional-tillage“is when 15% and less of the initial plants and weeds can be still found in the field. Usually the termconventional tillage is combined with decreasing SOM and destabilisation of particulate SOC and disappearance of the light fraction (LAL and KIMBLE, 1997). On the other hand the term conservation tillage (CT) is referred to as increasing soil quality, with a few exceptions, because LAL (1997) explained that ploughing enabled the formation of organic clay-minerals in an experiment on a soil from West-Africa (compare CHARREAU and NICOU 1971 with LAL, 1997). Also the decline in tillage intensity especially on coarse textured soil may have very small influence on the stabilisation of SOM (LAL, 1997). So it is considered that the environmental conditions are responsible for the effects which result from tillage induced changes.

Fertilization and Nutrient Management

The aim of a sustainable land management is to preserve and improve the production factor of soil. This can be done for example through effective mechanisms of carbon sequestration (LAL and KIMBLE, 1997): the two strategies to enhance the fixation of the (non-)labile C pool is either to increase micro-aggregation or the incorporation of SOC (e.g. manure) into the subsoil layers. Especially for N fixation the cropping system may be adopted productively by intercropping (combining cereals and legumes for instance), crop rotation management (iteration every couple of years) or other symbiotic measures to improve plant growth and soil quality like the application of legumes and crops which have different root depths (PEIGNÈ et al, 2007). As the depletion of C sources goes fast, the restoration takesmuch longer scales of time; although the speed can be a little bit increased by the use of farm yard manure (FYM) plus chemical fertilisers, which in the combination shows the highest effects towards carbon sequestration.

Cover Crops

Cover crops are also an effective strategy to protect the soil surface against all kinds of destructive forces. Furthermore, the soil moisture is stabilised and the nutrients are retained against mineralisation processes. LAL et al (1978) also reported that already after two years the SOC increased when grasses and leguminous cover crops were planted in a disturbed Alfisol of Western Nigeria (comp. LAL et al, 1997 with LAL et al, 1978).

Agroforestry

The prospect of using tropical forest projects to sequester significant amounts of atmospheric carbon asone mitigation approach to climate change has received considerable attention. Establishing agroforestry on land that currently has low tree cover has been identified as one of the most promising strategies to raise carbon stocks on currently productive land without compromising food and fiber production (Albrecht and Kandji 2003; Kuersten and Burschel 1993; Montagnini and Nair 2004). Agroforestry is the deliberate integration of trees or other woody perennials into field crop or livestock systems, in order to exploit synergies and complementarities between different structural elements of the system. Agroforestry has been shown in many instances to lead to more diverse, more productive and more sustainable agricultural production than less integrated approaches (e.g. Cannell et al. 1996; Nair 2007; Sinclair 1999; Van Noordwijk and Lusiana 1998).

Agroforestry systems in humid tropical regions can store substantial amounts of carbon, but little attention has been paid to potential carbon stocks in drier areas. Only Smith et al. (2008) provide an estimate for agroforestry in warm dry areas (at −0.73–1.39 Mg C ha−1 a−1, with a mean of 0.33 Mg C ha−1 a−1), but these numbers were produced by assuming that agroforestry sequestered the same amount of carbon as agriculture with tillage and residue management. They considered only soil carbon and did not take into account above and belowground carbon sequestered in the trees. These numbers are thus unlikely to reflect the true potential of dryland agroforestry systems.

Crop Rotation and Residue Management

It may be a desirable option to maintain or improve farmers' soil fertility and crop yields (by replenishing essential nutrients like soil carbon), and increase land resilience against drought and other hazards. Providing soil cover by leaving crop residue on the farm has also other private benefits such as preventing/reducing on-farm soil loss and maintaining soil moisture. However, in Africa, leaving crop residue on a plot has alternative beneficial uses, such as fodder to livestock or fuel. In addition, crop residues reintegrated into the soil sequesters carbon (offsets CO2 emissions), which generates positive externalities to society but are not typically internalized by the farmer. As it is known from conservation tillage, incorporation of residual parts of harvested plants are

multi-purpose amendments for the soil nutrient cycle that help to improve the stability and quality at the same time. Therefore specific crops are planted to attain the best mix of underground plant residuals (e.g. N from leguminous) and aboveground litter (e.g. rye grass and Persian clover) for a natural soil amelioration. FOLLET (2001) assumes that from 100 kg crop residues 50% can be managed to be used effectively for carbon sequestration with a final result of 5-10kg that is found in SOC. If all crop residues would be used for carbon sequestration continually for 20 years then LAL foresees a potential of 5 Pg to be stored in the soil (LAL and KIMBLE,1997) and that would increase the global carbon stock in agrosoils by 0.001%.

In a quantitative assessment of the effect of different soil management practices on soil organic carbon sequestration in South-Eastern Nigeria (Anikwe, 2010) the highest SOC content was found in natural undisturbed forest, whereas lowest S0C was observed in conventionally-tilled, continuously-cropped plot. Lowest SOC levels were found. Results show slight differences in pH values for the different soils studied. However, sites which were continuously- and conventionally-tilled plots, were among the plots with the lowest soil pH. Results of the study show that there were differences in total quantity of carbon sequestered in the different land utilization types in the study area. These differences were confirmed by the high coefficient of variation (55%) between the SOC content of the different land use types.

Economics of Soil Carbon Sequestration in Africa

Determination of potential annual soil carbon storage is important for investors and project participants who want to see an immediate return on their effort. Existing policies are based on an assumption that at least one ton per hectare per year can be sequestered on a steady, long-term basis which has been contradicted by even a cursory analysis of the scientific literature. Lal, 2004, observed that rates of SOC [Soil Organic Carbon] sequestration in agricultural and restored ecosystems depend on soil texture, profile characteristics, and climate, and range from 0 to 150 kg carbon per hectare per year in dry and warm regions, and 100 to 1000 kg carbon per hectare per year in humid and cool climates.". He indicated that the "one ton assumption" applies only in humid, cool climates—even then, as the highest estimation. Given that most current soil carbon sequestration projects are taking place in warmer, drier climates of developing countries, the estimation is grossly optimistic. Another factor to be considered is that of diminishing returns of soil carbon projects naturally over time, when the soils eventually become saturated and cannot absorb any more carbon. Table 1 presents examples of establishment and maintenance costs of land-based.

Table 1: Examples of establishment and maintenance costs of land-based agricultural mitigation options

Technology options	Practices	Case study	Establishment cost US$/ha	Average maintenance costs US$/ha /year
Agro-forestry	Various agro-forestry practices	Grevillea agroforestry system, **Kenya** Shelterbelts, **Togo** Different agro forestry systems in Sumatra, Indonesia Intensive agro forestry system (high input, grass barriers, contour ridging), Colombia	160 376 1,159 1285	90 162 80 145
Soil and water conservation	Conservation agriculture (CA)	Small-scale conservation tillage, **Kenya** Minimum tillage and direct planting, **Ghana** Medium-scale no-till technology for wheat and barley farming, Morocco	0 220 600	93 212 400
	Improved agronomic practices	Natural vegetative strips, The Philippines Grassed Fanya juu terraces, **Kenya** Konso bench terrace, **Ethiopia**	84 380 2060	36 30 540
	Integrated nutrient management	Compost production and application, Burkina Faso Tassa planting pits, **Niger** Runoff and floodwater farming, **Ethiopia**	12 160 383	30 33 814
Improved pasture and grazing management	Improved pasture management	Grassland restoration and conservation, Qinghai province, China	65	12
	Improved grazing management	Rotational grazing, South Africa Grazing land improvement, **Ethiopia**	105 1052	27 126

(1)Project estimates
Sources: Wacat 2007, Liniger et al, 2011, FAO 2009, Cacho et al 2003

Limitations of Soil Carbon Sequestration in Africa

The sequestration of carbon in agricultural soil is not a linear, but rather it is a dynamic development process which needs a long time and accurately adopted practices for the field site where it is applied on. The occurrence of carbon stocks and fluxes depend strongly on biotic and abiotic environmental conditions and parameters of the ecological system in a specific region. The feasibility of how far natural carbon sequestration can contribute to mitigate global carbon emissions. Adaptation not only is needed to increase the resilience of poor farmers to the threat of climate change, but it also offers co-benefits in terms of agricultural mitigation and productivity. That is, many of the same practices that increase resilience to climate change also increase agricultural productivity and profitability and reduce GHG emissions from agriculture. However, there may also be tradeoffs between increasing farm productivity and profitability, adaptation to climate change, and mitigation of GHGs. To maximize the synergies and reduce the tradeoffs implicit in various land management practices affecting crop and livestock production, a more holistic view of food security, agricultural adaptation, mitigation, and development is required. Mitigation, adaptation, and rural development strategies should be developed together, recognizing that in some cases hard decisions will need to be made among competing goals. Policymakers should aim to promote adaptation strategies for agriculture that have the greatest co-benefits in terms of agricultural productivity, climate change mitigation, and sustainable development.

There is little research to date on the synergies and tradeoffs between agricultural adaptation, mitigation, and productivity impacts. FAO (2009) differentiates between activities with high versus low mitigation potential and those with high versus low food security prospects. A summary of synergies and tradeoffs between productivity, climate change adaptation and green house gas mitigation potential is presented in Table below.

Table 1: A summary of synergies and tradeoffs between productivity, climate change adaptation and green house gas mitigation potential

Management practice	Productivity impacts	Climate adaptation benefits	Greenhouse gas mitigation potential
Cropland management			
Improved crop varieties or types (early-maturing, drought resistant, etc.)	Increased crop yield and reduced yield variability	Increased resilience against climate change, particularly increases in climate variability (prolonged periods of drought, seasonal shifts in rainfall, and the like)	Improved varieties can increase soil carbon storage
Changing planting dates	Reduced likelihood of crop failure	Maintained production under changing rainfall patterns, such as changes in the timing of rains or erratic rainfall patterns	
Improved crop/fallow rotation/rotation with legumes	Increased soil fertility and yields over the medium to long term due to nitrogen fixing in soils; short-term losses due to reduced cropping intensity	Improved soil fertility and water holding capacity increases resilience to climate change	High mitigation potential, particularly crop rotation with legumes
Use of cover crops	Increased yields due to erosion control and reduced nutrient leaching; potential tradeoff due to less grazing area in mixed crop–livestock systems	Improved soil fertility and water holding capacity increases resilience to climate change	High mitigation potential through increased soil carbon sequestration
Appropriate use of fertilizer and manure	Higher yields due to appropriate use of fertilizer/manure	Improved productivity increases resilience to climate change; potential greater yield variability with frequent droughts	High mitigation potential, particularly where fertilizer has been underutilized, such as in SSA
Incorporation of crop residues	Higher yields due to improved soil fertility and water retention in soils; tradeoff with use as animal feed	Improved soil fertility and water-holding capacity increases resilience to climate change	High mitigation potential through increased soil carbon sequestration
Reduced or zero tillage	Increased yields over the long term due to greater water-holding capacity of soils; limited impacts in the short term; tradeoff in terms of weed management and potential waterlogging	Improved soil fertility and water-holding capacity increases resilience to climate change	High mitigation potential through reduced soil carbon losses
Agroforestry	Greater yields on adjacent cropland due to improved rainwater management and reduced erosion	Increased resilience to climate change due to improved soil conditions and water management; benefits in terms of livelihood diversification	High mitigation potential through increased soil carbon sequestration

Management practice	Productivity impacts	Climate adaptation benefits	Greenhouse gas mitigation potential
Soil and water management			
Irrigation and water harvesting	Higher yields, greater intensity of land use	Reduced production variability and greater climate resilience when systems are well designed and maintained	Low to high depending on whether irrigation is energy intensive or not
Bunds	Higher yields due to increased soil moisture; potentially lower yields during periods of high rainfall	Reduced yield variability in dry areas; potential increase in production loss due to heavy rains if bunds are constructed to retain moisture	Positive mitigation benefits minus s carbon losses due to construction c bunds
Terraces	Higher yields due to increased soil moisture and reduced erosion; potential to displace some cropland	Reduced yield variability under climate change due to better soil quality and rainwater management	Positive mitigation benefits minus s carbon losses due to construction c terraces
Mulching or trash lines	Increased yields due to greater water retention in soils	Reduced yield variability under drier conditions due to greater moisture retention	Positive mitigation benefits
Grass strips	Increased yields due to reduced runoff and soil erosion	Reduced variability due to reduced soil and water erosion	Positive mitigation benefits
Ridge and furrow	Increased yields due to greater soil moisture	Reduced yield variability in dry areas; possible increase in production loss due to heavy rains	Positive mitigation benefits minus initial losses due to construction of ridges and furrows
Diversion ditches	Increased yields due to drainage of agricultural lands in areas where flooding is problematic	Reduced yield variability under heavy rainfall conditions due to improved water management	Positive mitigation benefits through improved productivity and hence increased soil carbon
Management of livestock or grazing land			
Diversify, change, or supplement livestock feeds	Higher livestock yields due to improved diets	Increased climate resilience due to diversified sources of feed	High mitigation potential because improved feeding practices can reduce methane emissions
Destocking	Potential increases per unit of livestock; total production may decline in the short term	Lower variability over the long term, particularly when forage availability is a key factor in livestock output	High mitigation potential because reduced livestock numbers lead to reduced methane emissions
Rotational grazing	Higher yields due to greater forage availability and quality; potential short-term tradeoff in terms of numbers of livestock supported	Increased forage availability over the long term, providing greater climate resilience	Positive mitigation potential due to increased carbon accrual on optimally grazed lands
Improved breeds and species	Increased productivity per animal for the resources available	Increased resilience of improved species or breeds to withstand increasing climate extremes	Varies, depending on the breeds or species being traded

Challenges of the adoption of Soil Sequestration in Africa

The challenges of Carbon sequestration in Nigeria are manifold. There is the issue of difficulty and uncertainty of carbon measurement. Carbon credits, as a commodity bought and sold in a financial market, gain their monetary value from the underlying asset: the amount of carbon that is either not released into the atmosphere to begin with (avoided emissions), or is later taken out of the atmosphere (sequestered emissions). This valuation is easier with avoided emissions because the amount of carbon avoided is easily quantifiable. With soil carbon sequestration however, measurement is costly over large areas and landscape-scale estimation methods are extremely imprecise. Carbon can easily react with oxygen and re-enter the atmosphere at any time; different soil types in different climates will store varying amounts; particularly rainy or dry seasons will change the rate of carbon storage. An accurate accounting of soil carbon for the purposes of creating a standard commodity requires direct measurement, which most soil carbon projects and methodologies seek to avoid. There is also the issue of *non-permanence*. For a credit to have value for an investor, it must have value over the time the investor owns the commodity. Therefore, because carbon captured in soil/trees is only temporary, it is worth much less than permanent emission reductions; the non-permanence also undermines the environmental integrity of the practices. Furthermore, questions still remain as to exactly how much carbon soils can store on a yearly basis—important for investors and project participants who want to see an immediate return on their effort. Many policy analyses assume that at least one ton per hectare per year can be sequestered on a steady, long-term basis; however, this figure is contradicted by even a cursory analysis of the scientific literature. In a 2004 review, soil carbon sequestration expert Professor Rattan Lal of Ohio State University concluded that “observed rates of SOC [soil organic carbon] sequestration in agricultural and restored ecosystems depend on soil texture, profile characteristics, and climate, and range from 0 to 150 kg carbon per hectare per year in dry and warm regions, and 100 to 1000 kg carbon per hectare per year in humid and cool climates.” Finally, soil carbon projects naturally have diminishing returns over time: Soils eventually become saturated and cannot absorb any more carbon. Accurately measuring carbon stock changes may be costly, in particular in agricultural systems and he carbonrbon benefit at the farm level for smallholders may not justify the transaction costs related to carbon measurement and accounting.

Barriers to carbon transactions in the agricultural sector in developing countries include: low GHG mitigation and removal potential at the farm level, and the need for aggregation at the landscape level; the expense, complexity and uncertainty of establishing new market infrastructure; the fear that carbon markets would expose countries and farmers to excessive delays, lack of liquidity, transaction costs and downside risks or detract from policies that promote more efficient agricultural practices; limited focus on productivity and smallholder benefits by current carbon standards; lack of protocols for MRV and high costs of establishing baseline emissions; and high initial risks and low initial returns, given early project costs and slow accumulation of carbon over years or decades.

POLICY OPTIONS/FUTURE DIRECTIONS

A striking feature of many of the sustainable land management practices that are likely to generate synergies between food security and mitigation and investments is that they are generally not new techniques, and their adoption rates have generally been low,

particularly in food insecure and vulnerable regions in sub-Saharan Africa and Southeast Asia. There are a number of potential explanations for this failure to adopt (and indeed, for continuing practices that lead to further degradation), including the presence of opportunity costs as discussed in the previous section. There is a substantial literature documenting research on barriers to adopting sustainable land management techniques and the findings can be grouped into the following major categories: i. delayed return on investments; ii. collective action failure; and
iii. lack of tenure security.

African ministers should develop a common position and collectively endorse reduced net emissions from AFOLU as a major element of their climate change strategies. Climate change negotiators should agree on a work plan for reducing emissions from Agriculture, Forestry and Other Land Uses (AFOLU) under a post-2012 climate change agreement. Acceptance of biocarbon credits from emission reductions and carbon stock increases from AFOLU from developing countries International greenhouse gas offset markets. Research funding and Institutional capacity building should be supported by developed Countries to support biocarbon activities. Adoption of multi-sectoral approaches for reduced emissions from AFOLU should be undertaken. Gas
arcane topic of soil carbon sequestration has become an item of significant political debate around the edges of the U.N. Framework Convention on Climate Change (UNFCCC). This brief provides an introduction to:

CONCLUSION

Sustainable land management can play a significant role in climate change mitigation through reducing emissions of greenhouse gases and sequestering carbon in vegetation, litter, and soils. In addition to their effects on land use change, SLM practices can also have important mitigation effects in situ, on the agricultural lands themselves (TERRAFRICA, 2009). However, African countries are unlikely to engage in soil carbon sequestration unless there are clear local economic and societal benefits. Therefore, it is essential to estimate all potential costs and benefits related to the various management options. Large-scale adoptions of ecologically sound land use practices are likely to be the most cost effective and environmentally friendly option to increase soil carbon sequestration in Africa [ ]. In addition, a correct measurement and verification of carbon sequestration potential of soils in Africa would enable it to participate in the Clean Development Mechanism (CDM), proposed in Article 12 of the Kyoto Protocol to the United Nations Framework Convention on Climate Change. This will allow developing countries to sell or trade project-based carbon credits, such as Carbon Emission Reduction (CER) credits, to or with industrial countries, if adopted. CER credits could provide an incentive for participation in climate change mitigation and cover the costs that African participants will encounter when engaging in carbon sequestration [ ].

The UNFCCC (2008) estimates that for Africa, 924 mega tons of additional CO2 could be stored with the adoption of improved agricultural practices. Much of this (89%) is predicted to come from soil carbon, because although the amount of additional carbon that can be sequestered in soils is less than the potential above ground (e.g. through trees), for a given size of land, the total volume of soil is high. Technically and economically feasible strategies are needed to mitigate the consequences of increased atmospheric CO_2. This can only be achieved through scientific information. Significant reductions in the atmospheric CO2 concentrations can only be achieved with substantial additional costs and major changes in living standards. Adoption of CO2 reduction strategies are widely debated, not well received, and not agreed upon by all nations. Increasing SOC improves soil quality, boosting agricultural productivity while reducing atmospheric CO2 concentrations. In addition, because carbon stored in agricultural soils can be easily quantified using well-accepted scientific practices, it can provide benefits to farmers through rental payments and to society by avoiding the cost of implementing expensive new technologies. Despite the vast potential of C sequestration in soil and vegetation (terrestrial ecosystems), the option has not been strategically considered by policy makers (Lal R). Their concerns include the following (Post et al. 2009): finite and temporary /transient nature; difficulties in measurement, monitoring and verification; leakages elsewhere; and diversion from the real issue of finding alternatives to fossil fuels. Yet among several wedges proposed (Pacala and Socolow 2004), an important is SOC sequestration through conservation tillage as a significant option. Despite the concerns, the potential of soil/terrestrial sequestration is strategically too important to be ignored. It is a win-win option because of numerous co-benefits, especially the beneficial impact on soil quality. Regardless of the need to adapt/mitigate ACC, enhancing SOC pool in agricultural soils is essential to feeding world's population of 7 billion in 2011 and 9.3 billion by 2050. Hansen et al. (2007) estimated that terrestrial sequestration has a capacity to create a draw down of atmospheric CO2 by 50 ppm over 100 to 150 years which is a conservative estimate as the actual potential may be double than this (Lal). Promoting a widespread adoption of these options over several decades until 2050 creates a bridge to the future.

THEME 6: CLIMATE CHANGE AND HEALTH DELIVERY

A Survey of Helminth Parasites of Wild Birds in the University of Benin, Benin-City, Nigeria

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ABSTRACT

A study on the prevalence of helminth parasites of some wild birds' species within the University of Benin, Benin City, Nigeria revealed parasites prevalence of 23.07% in the fifty-two birds examined. The birds examined in this study were Turdus pelios, Passer griseus, Cinnyris coccingatrus, Ploceus cuculatus, Apus affinis and with parasites prevalence of 0%, 9.0%, 16.67%, 29.03%, and 50.00%, respectively. The helminth parasites recovered included five species of nematodes: Ascaridia galli, Heterakis gallinarum, Subulura brumpti, Capillaria caudinflata and Dispharynx nasuta and two species of cestodes: Choanotaenia infundibulum and Raillietina tetragona. Nematodes were more abundant and had a total prevalence of (19.23%) while the prevalence of cestodes was 3.85%. All the parasites were recovered from the gastro-intestinal tract. Wild birds have been reported as potential source of infection and re-infection to man and his domestic animals. Therefore, migration of wild birds as a result of climate change may lead to change in hosts and parasites prevalence from one geographical region to another.

Keywords: Raillietina tetragona, Heterakis gallinarum, Turdus pelios, Passer griseus, Nigeria.

INTRODUCTION

Ornithological studies have majorly focused on biology, taxonomy and, ecology of wild birds. The importance of understanding the distribution of wild animals' parasites has been indicated by many researchers, [1,2,3] Ornithological literature has many citations of losses among birds, many of these are attributable to abnormal weather conditions and diseases due to parasites, [4,5]. Birds are commonly afflicted by helminth parasites which may result in the loss of production [6]. Higher temperatures and rainfall both side effects of climate change, could be bad for birds but great for parasites which thrive in warmer and wetter conditions [5]

Wild birds may act as reservoir hosts for domestic birds' parasites [3] therefore; Parasitism in these birds has implications for their ecology, evolution, and conservation, [7]. A better knowledge of both the birds and their parasites will increase our understanding of their life history. Furthermore, the relationship between parasites might provide important clues to relationship between various groups of birds. There is a lot of literature on parasites of domestic birds, however not much is known of helminthes of wild birds in Nigeria. Birds acquire these parasites through their food and feeding habits [8], or by the blood sucking activities of haematophagous arthropods [9]

Most of these birds have close contact with domestic fowls and other animals and these wild birds could be reservoirs for a number of parasitic infections. However, parasites loads that number in hundred and thousands of individuals many occur in what appear to be otherwise healthy birds. The presence of parasites in wild birds may affect their population, biodiversity and cause instability in ecosystem [10]

The aim of this study was to determine the prevalence of gastrointestinal helminthes parasites of wild birds in the University of Benin, Benin City, Nigeria.

MATERIALS AND METHODS

The field work was carried out in the University of Benin, Ugbowo Campus, Benin – City, Nigeria between December, 2009 and May, 2010. Benin lies between Latitudes $61^{0}7$ and $6^{0}26$'N and Longitude $5^{0}35$' and $5^{0}41$E.

The birds were randomly collected from various locations on campus and taken to the Parasitological laboratory for investigations. Birds collected, in some cases kept temporarily in cages prior to parasitological examination.

The area covered in this survey lies in the rainforest zone characterized by an annual rainfall of 1850-2445mm and temperature range between 30-36^{0}C; a vast majority of the study area could best be described as open grassland with scattered trees. Materials used to capture birds in the course of this study included Catapult, cast gums, walk – in trap, and cages.

Identification of Wild Birds:

Identification of the birds was done using the book "*Birds of Africa, South of the Sahara*" (Lan Synclair and Peter Ryan, 11). Birds examined were assigned serial numbers and parasites recovered were appropriately recorded to correspond to the serial numbers of their hosts. The sexes of the birds were determined by observing the genital organs after dissection.

Endoparasites Investigation

The postmortem examination was done according to Msoffe, (12) after suffocation, the abdominal and thoracic cavity were opened followed by systemic autopsy examination which include, the oesophagus to the gizzard, small intestine, the caeca, and the ilecaeco-colic junction to the cloaca. Each section was opened longitudiually and the contents carefully washed through with normal saline solution. The parasites were isolated from the gut content, washed and fixed in 10% formal saline for further processing and identification (13). Cestodes were cleared in lactophenol and stained with Acetocarmine overnight. Following staining, the specimens were washed in distilled water to remove excess stain and dehydrated by passing it through increasing grades of alcohol; 50%, 70%, 90%, and 100% then cleared in xylene and mounted on microscopic slides with Canada balsam. Nematodes were examined unstained.

Identification of Gastrointestinal Parasites

All parasites were identified using the helminthological keys by Soulsby, (13).

RESULTS

Results obtained are presented in Tables I – III

Fifty two birds, in the Orders, Passeriformes and Apodiformes; belonging to 5 genera *were* carefully examined for helminthes parasites among which 12 were infected.

The species of birds encountered in the survey include: *Ploceus cuculatus (*Weaver bird), *Apus affinis (*Little swift*), Passer griseus (*grey-headed sparrow*), Cinnyris coccinigastrus* (splendid sunbird) *and Turdus pelios* (African thrush). Bird species belonging to the order Passeriformes were *Passer griseus, Ploceus cuculatus* and *Turdus pelios;* had parasites prevalence of 22.73% while members of the order Apodiformes (*Cinnyris coccinigastrus* and *Apus affinis had* parasites prevalence of 25.0%. However the passerine birds had more parasite species.

The parasites encountered include: *Ascaridia gali, Heterakis gallinarum, Capillaria Caudinflata, Dispharynx nasuta, Subulura brumpti, Choanotaenia infundibulum and Raillietina tetragona* (Table 1).

The highest parasite prevalence was recorded in *A. affinis* (50%) while *T. Pelios,* had no parasites, *P. cuculatus* had the highest number of parasites (80%). Some of the parasites showed host specificity except *A. galli* which occurred in most birds had a percentage of 36.46. A total of 20 helminth parasites with a mean intensity of 1.7 were recovered from the 12 infected birds giving a total prevalence of 23.07%. (Table II)

All the cestodes recovered where from male birds while the female birds had a higher percentage of nematodes. Adults had higher parasite prevalence than juvenile birds (Table III). Most of the parasites were recovered from the small intestine, a few from the proventriculus and ceaca.

Capillaria cuadinflata, C. infundibulum and *S. brumpti had* 1.92%, *H. gallinarum* (5.78%), *R. tetragona* and *D. nasuta* (3.85%) *parasite* prevalence respectively.

TABLE I: Parasite Prevalence Found in the Order Passeriformes and Apodiformes of the Bird Hosts

Order of bird hosts	Species of birds	Parasite fauna encountered	Total number of birds examined	Number of birds found infected	Prevalence recorded in the bird orders (%)
Passeriformes	*Passer griseus, Ploceus cuculatus and Turdus pelios*	*Ascaridia gali, Heterakis gallinarium, Subulura brumpti,Raillientina tetragona, Capillaria caudinflata and Choanotaenia infundibulum*	44	10	22.73
Apodiformes	*Cinnyris coccinigastrus Apus affinis*	*Dispharynx nasuta Ascaridia galli*	8	2	25

TABLE II: Distribution of Parasites in the Various Bird Hosts

Bird Hosts	Helminth Parasites Encountered	No of hosts Examined	No of Infected Hosts	Intensity	Mean Intensity	Prevalence (%)
Passer griseus	*Choanotaenia Infundibulum(1)*	11	1	1	1	9.09%
Turdus pelios	-	2	-	-	-	-
Ploceus cuculatus	*Ascaridia galli(7), Heterakis gallinarium(4), Subulura brumpti(1) Raillientina tetragona(2), Capillaria caudinflata(2)*	31	9	16	1.8	29.03%
Apus affinis	*Ascaridia gali(1)*	2	1	1	1	50.00%
Cinnyris coccingastrus	*Dispharynx nasuta (2)*	6	1	2	2	16.67%
Total	*A. gali(8), H. gallinarium(4), S. brumpti(1) Raillientina tetragona(2), C. caudinflata(2) Choanotaenia infundibulum(1)*	52	12	20	1.7	23.07%

TABLE III: Comparison of the Parasite Prevalence between the Adult and Juvenile Birds and Between Male and Female Birds

Sexes of bird Hosts	Numbers of birds Examined	Number of Infected birds	Prevalence (%)
Males	21	6	28.57
Females	31	6	19.35
Adults	40	10	25.0
Juveniles	12	2	16.67

DISCUSSION

Wild birds act as reserviours of many parasites, because of their free ranging nature. Literature on studies of parasites of birds is ever increasing however, in Nigeria studies on helminths parasites of free-ranging wild birds is underreported, and parasites of domestic birds have been more investigated. In this study, a total helminth parasite prevalence of 23.07% was observed in the 52 birds studied. The parasites encountered have a cosmopolitan distribution except for *Subulura brumpti. [12, 3, 14, 16]*. *Ploceous cuculatus* was the most parasitized bird in this study with a mixed infection of 5 helminths (Table 2), this may be related to their food and feeding habits. *Rallietina tetraqona* was also been reported. Goulart 2005 observed that ground level of endoparasites because of their constant reinfection. Adult birds were more infected when compared to Juveniles (25.0% and 16.67% parasite prevalence rates respectively). Radfar et al [3] observed that adult pigeons had higher number of worms than nestlings. It was deduced that the adults have had a longer exposure to intermediate hosts of the parasites than nestlings. However in some reports the converse is the case as older birds acquire a certain degree of immunity against parasites [17].

Male birds exhibited a higher level of infection compared to females in this study. Female birds spend more times in the nest than male birds because of caring for the young while males are more active feeders as observed for Quelea birds [1]

Most of the helminth parasites encountered in this study were of major clinical importance in poultry.

In conclusion, wild birds are afflicted by many parasites that cause diseases which occasionally lead to illness and death. Increase in temperatures and rainfall-both side effects of climate change may increase parasites burdens in birds. This survey revealed 7species of helminths in 5species of wild birds on University of Benin, Ugbowo Campus, *P cuculatus* one of the most abundant wild birds exhibited a mixed array of parasites.

REFRENCES

1. Yusufu S.D, Biu A.A and Buba G, (2004). Quelea Birds (Quelea quelea): A correlation study between their feeding habit and Gastro-intestinal parasitism in Borno State, Nigeria Int. Journal of Agriculture and Biology 268-269.
2. Cunha A.L.B, Mendonca R.A, Olivera L., Baratella-Erencio, Olwerra-Filho R.M, Simoes R.S, Simoes M.J, Evencio-Neto J. 2005. Acta Vet 77-387-392.
3. Radfar M.H, Fathi S, Aol E.N, Dehaghi M.M and Seghinsara N.R (2011) A survey of parasites of Domestic pigeons *Columba lvia* domestica) in South Khorasan, Iran Veterinary Research 4(1) 18 – 23.
4. Biu A.A, Yusufu S.D, and Suleiman B.A (1999). The Prevalence of intestinal helminthiasis among local breed of chickens *Gallus gallus domesticus* in Maiduguri, North eastern Nigeria J. Life and Environ. Sci. 1; 28-32
5. Wildlife Conservation Society (2010), Potential Climate change Side effects. More parasites on South-American birds.
6. Couto D (1997), correlacoes ecological envre ectoparasites eaves de florestas de Minas Geraw. In: LEITELL, SAITO at (Eds): Contribuicao ad conhencimento ecologico do corrado. Departmento de Ecologia, Universidade de Brazilia. Pp 210 – 218.
7. Freitas M.E.L, Olivera JB, Cavalcanti MDB, Leite AS, Magalhaes, Oliveira RA, Evencio-Sobrino A (2002): Gastro intestinal parasites of captive wild birds in Pernambuco State, Brazil Parasitol Latinoam 57:50-54.
8. Valkinas G. Ravinder N. Sehgal M, Tatjana A.L, Smith T.B (2005) Further observations on the blood parasites of Birds in Uganda J. of Wildlife Diseases 41 (3), 580.
9. Combes, F.G (1996) The evolutionary transition to coloniality promotes lighter bird parasitism J.S Evol. Boil. 15:32-41.

   Helminth (1973) parasites of the Brown headed cowbird, *Molothmo ater ater*, from Ohio. The Ohio Journal of Science 73 (6), 376 – 380.
10. Synclair L. and Ryan P. (2003) Birds of Africa, South of the Sahara. 566pp.
11. Msoffe, P.L.M, A Muhanwa.P, Chiwanga G.H and Kaskuku A.A, (2010). A study of ecto and endo parasites of domestic pigeons in Morogoro Municipality, Tanzania Afr. J. Agric. Res, 5:264-269.
12. Soulsby, E.J.L (1982). Helminths, Anthropods and Protozoa of Domesticated Animals. 7th Edn. Bailhere Tindal, London.
13. Borghare A.T, Badge V.P, Jawrar A.D, Katre D.D, Junde P.D, Maske D.K and Bhangale G.N (2009). Incidence of Gastrointestinal parasitism of Captive Wild Pigeon at Nagpur Veterinary world vol. 2 No. 9 343.
14. Cooper C.L, Troutman E.L and Crites J.L

    Helminth (1973) parasites of the Brown headed cowbird, Molothmo ater ater, from Ohio. The Journal of Science 73 (6), 376-380.
15. Goulart C.E.S (2005): Occiorencia de endoparasities emaves solvestress em differentes recintros no vale verde pargue Ecologico. In: Anais da 5a conferencia sul-Americana de Medicina Veterinaria, Rio de Janerio, Brazil.
16. Edosomwan E.U, Olumese E.R and Igetei J.E (2011) A Study of ecto and endo parasites of domestic birds in Etsako municipality, Edo North Nigeria. NISEB Journal Vol. 11 (3) 209-216
17. Merila J.M; Bjorklund and Bennet G.F. (1995) Geographic and Individual Variation in haematozoan infections in the green finch *Carduelis chloris*, Can. J. Zool. 73:1798-1804

Allergic Conjunctivitis and Impact of Climate Change

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ABSTRACT
Climate change which has resulted from degradation of the environment has indirect implications for allergic conjunctivitis. People with Allergic Conjunctivitis cannot work efficiently due to the discomfort arising from the ailment. The condition therefore affects input and consequently, output. Allergic Conjunctivitis occurs when dust, smoke particles or pollen grains get into the eye, causing inflammation (hence, redness) of the affected eye and usually spreads from one eye to the second. This condition is characterised by itching, irritation, watering of eyes, light sensitivity and general discomfort in the eye. The disease is common and prevalence is higher in dry dusty environments. Climate change has led to increase in temperatures, thereby making regions which normally have high temperatures to become even hotter, a situation which predisposes people to Allergic Conjunctivitis. In addition, it has also affected the occurrence of disease-causing microorganisms across the globe. For instance, some fast mutating viruses have been identified recently to be linked with chronic conjunctivitis in certain parts of the world. This paper, therefore, analyses the effect of climate change on prevalence and severity of Allergic Conjunctivitis.

INTRODUCTION

The Eye and Air Pollution

The eye is vulnerable to the effects of air pollution. Manifestations of air pollution can range from minimal or no symptoms to chronic discomfort and eye irritation. Two common ocular effects of air pollution include Dry Eye Syndrome and Conjunctivitis (Stahl and Barney, 2004).

Dry Eyes

This is also known as Keratoconjunctivitis sicca (kcs) or Dysfunctional Tear Syndrome (Khaw et al., 2004). It is a common eye problem caused by lack of tear production. Tears normally keep the eyes moistened and lubricated. However, there would be stinging, burning, dryness and redness if enough tears are not produced to keep the eyes wet and comfortable.

Normally, tear production decreases as there is an increase in age as a result of decreased tear production enhanced by hormonal changes. Dry eyes could also occur as a result of exposure to environmental factors such as sun, wind, pollutants such as smoke, dust, e.t.c.

The condition could be treated with artificial tears (lubricant eye drops used to treat the dryness and irritation associated with deficient tear production). Patients are also advised to stay away from harsh environmental conditions and air pollution. Complications like corneal ulcers, infection and conjunctivitis may result if left untreated.

Conjunctivitis

Conjunctivitis is the inflammation of the conjunctiva (Figures 1 and 2). The conjunctiva is the thin skin or layer that covers the white part of the eyes (Singh and Bielory, 2007. Conjunctivitis has various causes hence various types caused as a result of irritation or allergies (Schmid and Schmid , 2000). Conjunctivitis (commonly known as *Apollo* in Nigeria) could be transferred from person to person if it is of viral or bacterial origin.

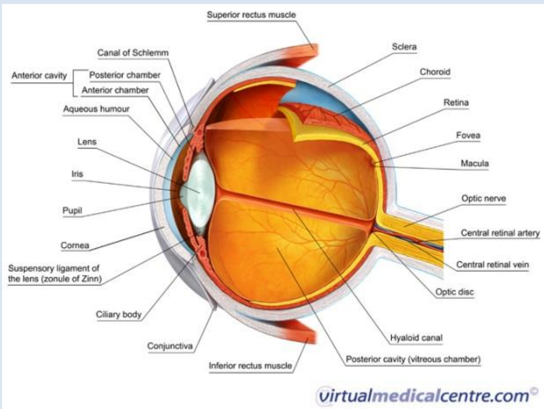

Figure 1: Parts of the human eye.

Figure 2: Human eye showing symptoms of conjunctivitis

.Types of Conjunctivitis

- Bacterial conjunctivitis

-Viral conjunctivitis

- Gonococcal and chlamydial conjunctivitis

- Neonatal conjunctivitis

- Allergic conjunctivitis

- Giant papillary conjunctivitis

ALLERGIC CONJUNCTIVITIS

This is the inflammation of the conjunctiva that occurs when the immune system over-reacts to a foreign body hence causing inflammation of the eye. The eye is sore as well as inflamed. These symptoms occur because the over reacting immune system makes the body release histamine and active substances by conjunctival mast cells and these cause dilation of blood vessels which irritate the nerve endings and cause increased tear secretion (Singh and Bielory, 2007; Beilory and Friedlaender, 2008). Allergic conjunctivitis is **non-infective** i.e. cannot be passed from one person to the other.

Causes of Allergic Conjunctivitis

Air pollution due to:

- Smoke (e.g. from automobiles, industries, cooking stoves, burning wood and coal for cooking).

-Pollen from trees and grasses

- Perfumes

- Dustmites

- Cosmetics

- Pesticides (e.g. aerosol sprays and insect powder)

Seasonal Allergic Conjunctivitis

Seasonal conjunctivitis could also occur as a result of allergies. This type of conjunctivitis is when symptoms occur at the same time each year. Most cases are due to pollen grains entering the eye and this usually occurs in the hay fever season (Leibowitz, 2003).

EPIDEMIOLOGY OF ALLERGIC CONJUNCTIVITIS

Allergic conjunctivitis occurs more frequently among those with allergic conditions e.g. hay fever. According to Abelson and Schaefer (1993) allergic conjunctivitis is a frequent condition and it is estimated to affect about 20% of the world's population on an annual basis and the incidence of this condition is known to be increasing due to the preponderance of eye irritants in the environment.

Symptoms of Allergic Conjunctivitis

- Pink/red eyes
- Photophobia (mild sensitivity to light)
- Burning/gritty sensation
- Conjunctival oedema
- Swollen lids
- Itchy eyes
- Tearing with a watery discharge

How Allergic Conjunctivitis Comes About

Allergic conjunctivitis involves early phase and late phase reactions. Recent studies on mouse models of allergic conjunctivitis show the immune regulation of both the early phase reaction and late phase reaction of allergic conjunctivitis (Niederkorn, 2008). The early phase reaction is IgE antibody-dependent, whereas the late phase reaction is IgE-independent and is mediated by inflammatory cells, especially eosinophils. Evidence suggests that IFN-gamma is crucial for optimum expression of allergic conjunctivitis (Niederkorn, 2008). Common findings in acute allergic conjunctivitis include evidence of mast cell activation and eosinophil attraction and activation (Stahl and Barney, 2004).

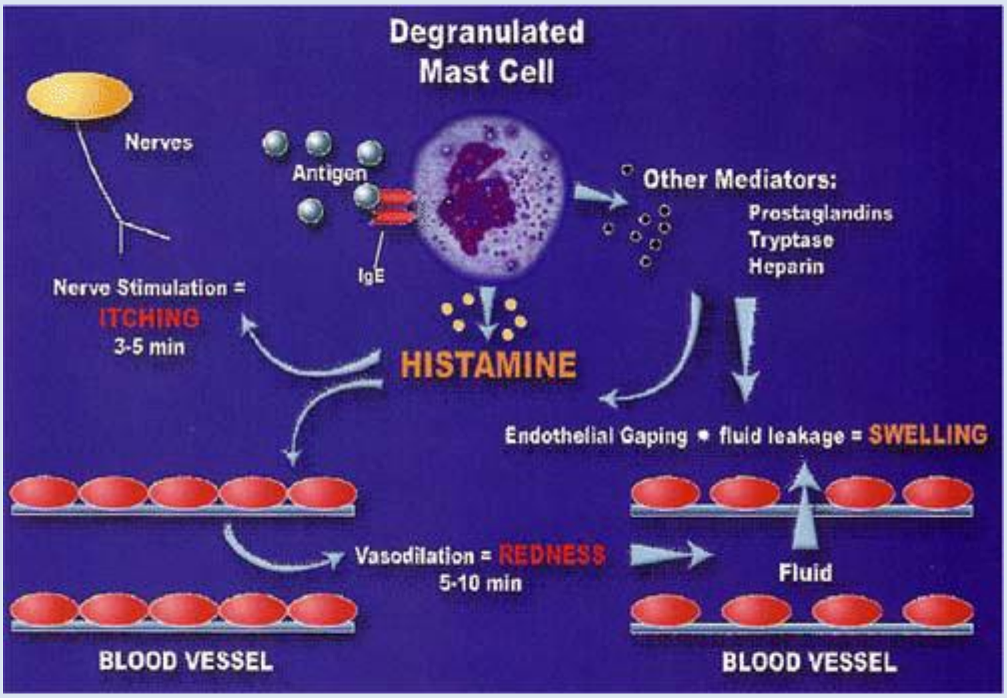

Figure 2: Mast cell mediated allergic response mechanisms (Google Image,2013).

EFFECT OF CLIMATE CHANGE ON ALLERGIC CONJUNCTIVITIS

Major factors in climate change like wind, smoke, dust, e. t. c., play a significant role in the cause of allergic conjunctivitis or they can make allergic response worse (Mbonile, 2011). Smoke is made up of a complex mixture of gases (carbon monoxide, carbon dioxide, nitrogen oxide and irritant volatile organic compounds) and fine particles (particulate matter) produced when wood and other organic matter burn. The biggest health threat from smoke comes from fine particles. Particulate matter is the term used for a mixture of solid particles and liquid droplets found in the air. Coarse particles (larger than 2.5 micrometers) come from a variety of sources including windblown dust and grinding operations. Fine particles (less than 2.5 micrometers) are found in smoke. When these particles (smoke and dust) get into the eye, they cause problems, one of which is allergic conjunctivitis.

Sources of Smoke Containing Fine Particles

Fuel combustion

Combustion of materials (such as wood, paper, plastics, e. t. c.)

Power plants

Exhaust pipes of l buses and trucks.

Bush burning

Climate change has led to increase in temperatures, thereby making regions which normally have high temperatures to become even hotter, a situation which predisposes people to Allergic Conjunctivitis. In addition, it has also affected the occurrence of disease-causing microorganisms across the globe. For instance, some fast mutating viruses have been identified recently to be linked with chronic conjunctivitis in certain parts of the world (Mbonile, 2010).

Effects of Allergic Conjunctivitis on the Patient

Allergic conjunctivitis is unpleasant and can disrupt the smooth running of day-to-day activities. Although there may be no pain or serious visual impairment, however the itching and gritty sensation can cause great discomfort to the patient (Moloney and McCluskey, 2007). This discomfort can even prevent sleep or good appetite, could affect the person's concentration and this could have frustrating and devastating long term effects. It also affects the social life as a good number of people would not like to come very close to someone with red teary eyes for fear of being infected.

Treatment of Allergic Conjunctivitis

-Use of antihistamines

-Patients should avoid rubbing their eyes

-If patient wears contact lenses then it should be stopped until symptoms are gone because in as much as the eye could be contaminated, touching the eyes would worsen the inflammation.

-Cold compress may ease symptoms

- Avoidance of cause of allergy

Complications Of Allergic Conjunctivitis

Although complications are rare, they could occur if condition is left untreated. There is a risk of the cornea becoming inflamed (known as keratitis). Keratitis can cause ulcers to form on the cornea, significantly raising the risk of scarring which can cause permanent impairment of vision.

REFERENCES

Beilory L, Friedlaender MH., 2008. *Allergic conjunctivitis. Immunology and Allergy Clinics of North America* 28 (1); 43-58.

Khaw PT, Shah P and Elkington AR, 2004. ABC of eyes (4th edition). BMJ Publishing Group, London.

Leibowitz HM, 2003. The red eye. *New England Journal of Medicine*. **343** (5):345-51.

Mbonile, 2011. Acute haemorrhagic conjunctivitis epidemics and outbreaks of Paederus spp. keratoconjunctivitis ('Nairobi red eyes') and dermatitis. *South African Medical Journal* **101** (8):541-543.

Moloney G, McCluskey PJ, 2007. Classifying and managing allergic conjunctivitis. *Medicine Today*. **8** (11): 16-21.

Niederkorn JY, 2008. Immune regulatory mechanisms in allergic conjunctivitis *Current Opinions in Allergy and Clinical Immunology* **8** (5):472-476.

Schmid KL, Schmid LM. , 2000. Ocular allergy: causes and therapeutic options. *Clinic of Experimental Optometry* 83 (5):257-270.

Singh K, Bielory L. 2007. Ocular allergy: A national epidemiologic study. *Journal of Allergy and Clinical Immunology* 119 (1 suppl):S154.

Stahl J.L. and Barney N.P, 2004. Ocular allergic disease. *Current Opinions in Allergy and Clinical Immunology* **4** (5):455-459.

Climate Change and Health Delivery: A Case Report On Chronic Leg Ulcer of Fungal Origin

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ABSTRACT

Fungi thrive in cold and damp climate. Their natural habitat is mainly in the soil, plants and on other damp objects including household office equipment and gadgets. They also find habitat in animals and human beings where they infect the skin, the internal organs and or the blood system. Fungal infection is posing an epidemiological threat in the sub-Sahara region where there is fluctuating climate change. A case of chronic leg ulcer of fungal origin is hereby reported. The report is on a 59 year old male Executive harboring a chronic leg ulcer of 30 years duration. What is the contributing factor to its chronicity?

Is it Climate variation, or what? Findings showed that here was a co-infection of another chronic infection of public health interest.

Keywords: Skin infection, Fungi, Mycobacterium leprae, Climate Change

BACKGROUND

Climate Change (CC) is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e, more or fewer extreme weather events). Climate change is caused by factors that include oceanic processes (such as oceanic circulation), biotic processes, variations in solar radiation received by Earth, plate tectonics and volcanic eruptions, and human-induced alterations of the natural world; these latter effects are currently causing global warming, and "climate change" is often used to describe human-specific impacts. Locally, as a slang, it also refers to changes in political, economic and social status!

- Fungal infection is an inflammatory condition caused by a fungus (pl. - fungi)
  Fungi can be found on different parts of the body:
    - Tinea - fungal infection of the hair, skin, or nails.
    - Athlete's foot – fungal infection between the toes, sometimes toe-nails and the bottom or sides of the feet.
    - Jock itch - fungal infection of the groin and upper thighs.
    - Candida is yeast, similar to a fungus. It most often affects the skin around the nails or the soft, moist areas around body openings. Diaper rash in babies can be from one type of candida infection, as can thrush (white patches often found in the mouths of babies.) Older girls and women may develop another form of candida infection in and around the vagina. This is called a yeast infection.
- **Leprosy**, also known as **Hansen's disease** (**HD**), is a chronic infection caused by the bacterium Mycobacterium leprae and M. lepromatosis. It is primarily a granulomatous disease of the peripheral nerves and mucosa of the upper respiratory tract; skin lesions are the primary external sign.[3] Left untreated, leprosy can be progressive, causing permanent damage to the skin, nerves, limbs and eyes. Contrary to folklore, leprosy does not cause body parts to fall off, although they can become numb or diseased as a result of secondary infections; these occur as a result of the body's defenses being compromised by the primary disease.[4][5] Secondary infections, in turn, can result in tissue loss causing fingers and toes to become shortened and deformed, as cartilage is absorbed into the body

Case Presentation

Consent was sought for and granted to take picture of the foot and wound.

A 59 year old Banker (graduate in Accountancy) presented with 30 year history of chronic leg ulcer on the left foot, dorsal region, gradually spreading upwards to ankle and lower leg. It started as a small rash, associated with occasional itching until it grew to an open wound (perhaps with scratching). No numbness on feet, only occasional pains.

Treated in clinics, chemists, private hospitals (evasive about mentioning name of clinic or doctor) – doubtful. Medications used include:

a. Creams:- Betnovate N, Dactarin Endix G, Whitfield ointment.
b. Tablets:- Lincocin tablet.

PMH, F&SH: No history of hypertension, D.M, respiratory disease, no known allergies. Does not smoke, takes alcohol occasionally. Not a swimmer, not on any corticosteroids. Uses simple body cream (Vaseline), and Soap (Eva). Does not keep any pets. Married, with four grown up children; he is a grandfather. Wife is a secondary school teacher. Lives in low density area in 3 bedroom flat.

On Examination: A healthy looking Executive Officer, neatly dressed with left foot in gauze dressing wearing closed shoes with socks. The left foot dressed in gauze.

On opening of wound: a wide spread ulcer with patches of hypo-pigmentation/ hyper-keratinisation of left foot from the toes to above the ankle with fungating deposit at the supra malleolar area. Weight= 68kg, CVS: P=68bpm, BP= 130/70mmHg; RS – Chest clinically clear, CNS and UGS – nil abnormal.

Tentative Diagnosis:

1. Chronic Dermatosis, ? Fungal origin
2. Kaposi sarcoma, R/O Immuno-suppressive disease
3. Chronic phlebitis, with ? Osteomyelitis
4. R/O Diabetic ulcer, with ?Osteomyelitis

Investigations and Results.

- FBC: Hb 12.3g/dl, RBC 4.5x10^{12}/dl (normal 4.5-5.5), normal morphology – Lymphocytes 68%, Neutrophils 29%, Monocytes 3%

- ESR: 56mm/hr (Westergren); Blood culture: no culture after 72 hours.
- FBS: 3.5mg/dl; Serology –ve (Western Blot), VDRL –ve, HBsAg –ve, HbC –ve
- SC&E: Cl slightly increased, Urea slightly increased
- Skin snip: 6 samples (at various sites)
  M/ C/S: Candida spp ++
  Zeil Neilson stain: Mycobacterium leprae ++
- X ray left foot: PA and Lateral views shows normal bone shadows with small osteophyte on the head of 5th proximal phalanx.

Working Diagnosis: Chronic Ulcerative Candidiasis with co-infection Mycobacterium leprae

Management

i. Adequate debridement (daily) with Savlon and dressing with Aloe – Conazole cream
ii. Tab. Ciprofloxazine 500mg bd x 7 dys
iii. Tab. Itraconazole 200mg (2 tabs) bd x 7 dys, and 100mg bd x 7 days. 1 week break, followed by repeat pulse
iv. Calcium-Magnesium–Zinc Caps. 300mg dly x 14 days
v. Oral Parentrovite 1 vial dly x 3 dys, and Caps. 1 dly x 14 days
vi. Advised to reduce salt and red meat intake; Reduce wearing of closed shoes; Care of footwear

Outcome:

Wound cleared remarkably, slough dropped, regression of the ulcer within one week. (see pictures before and after treatment).

Before Treatment

One week after treatment

There was further regression of the ulcer within two weeks of treatment and dressing. In-view of the diagnosis of leprosy, client was to be referred to State Leprosy Centre. But he declined, and absconded!

DISCUSSION

There is no doubt about climate change and its effect globally and locally. Weather patterns have changed. In Nigeria there is no more clear cut **rainy** season (April – September) with a month August break, and **dry** season (October – March) with a tangible dusty cool **harmattan** period in December – January.

In the South-South rain forest belt of Nigeria where Akwa Ibom State is situated, over the past 5 – 7 years, we now have rains spread over the year January to December. There is increasing flooding. Washed clothes hardly get properly dried; there is dampness within the living home and offices, encouraging growth of moulds.

This has impacted on the health sector, with changes in disease pattern – Increased morbidity, and mortality in Africa and emerging variants. A case is presented here.

Conclusion

Science and Technology, Government, and Collective Community and Social Responsibility need to bail us out here:

1. There is the need to reduce the humidity in the living homes and offices, with appropriate heating up or cooling effect as the case may be.
2. Clothes need to be properly ironed to destroy fungal spores and other infective agents.
3. Government MUST with URGENCY rise up to the responsibility of providing affordable STEADY CONTINUOUS POWER SUPPLY to the entire community.
4. Increase Health Awareness on –
   i. Appropriate dressing, especially footwear
   ii. Periodic spring cleaning
   iii. Environmental care and preservation
5. Improve and increase access to health care provision
6. Increase funds for research.

REFERENCES

Tarun Narang et al, Co-localization of Pityriasis versicolor and BT Hansen's disease: Case Reports, International Journal of Leprosy and Other Mycobacterial Diseases: Vol. 73 , No. 3 , pp. 206 – 207

Sasaki S, Takeshita F, Okuda K, Ishii N (2001). "Mycobacterium leprae and leprosy: a compendium". *Microbiol Immunol* **45** (11): 729–36. PMID 11791665.

"New Leprosy Bacterium: Scientists Use Genetic Fingerprint To Nail 'Killing Organism'". *ScienceDaily*. 2008-11-28. Retrieved 2010-01-31.

Kenneth J. Ryan, C. George Ray, editors. (2004). Ryan KJ, Ray CG, ed. *Sherris Medical Microbiology* (4th ed.). McGraw Hill. pp. 451–3. ISBN 0-8385-8529-9. OCLC 52358530 61405904.

"Lifting the stigma of leprosy: a new vaccine offers hope against an ancient disease". *Time* **119** (19): 87. May 1982. PMID 10255067.

"Q and A about leprosy". American Leprosy Missions. Retrieved 2011-01-22. "Communicable Diseases Department, Leprosy FAQ". World Health Organization. 2006-05-25. Retrieved 2010-01-31.

WHO (1995). "Leprosy disabilities: magnitude of the problem". *Weekly Epidemiological Record* **70** (38): 269–75. PMID 7577430.

Walsh F (2007-03-31). "The hidden suffering of India's lepers". BBC News.

"Leprosy". *WHO*. 2009-08-01. Retrieved 2010-01-31.

TE (2006-09-13). "Ignorance breeds leper colonies in China". Independent News & Media. Retrieved 2010-01-31.

"Do fingers and toes fall off when someone gets leprosy? No. The bacillus attacks nerve endings and destroys the body's ability to feel pain and injury. Without feeling pain, people injure themselves on fire, thorns, rocks, even hot coffee cups. Injuries become infected and result in tissue loss. Fingers and toes become shortened and deformed as the cartilage is absorbed into the body."

Japan repealed its "Leprosy Prevention Laws" in 1996 but former patients still reside in sanatoriums. "Koizumi apologises for leper colonies". BBC News. May 25, 2001. and Ex-Hansen's disease patients still struggling with prejudice Japan Times June 7, 2007

Climate Change and Health Delivery: Non-Conventional Therapy of *Salmonella Typhi Infection* Using Garlic (*Allium Sativum* Linn.)

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INTRODUCTION

Salmonella typhi infection (typhoid fever) is still a serious problem in most developing countries. This is because of the low level of hygiene and lack of potable water in most communities. This situation however becomes worse when there is massive flooding (one of the consequences of climate change) because when this happens, all the sources of potable water become polluted and this eventually leads to increase in incidence of waterborne diseases of which typhoid fever is one. Not only this, massive flooding may also prevent access to conventional therapy of the infection therefore there is the need to search for alternative therapeutic measures. Garlic (*Allium sativum*) is well known for its medicinal, antibacterial, antiparasitic, pesticidal and antitumour properties (Tung-Nsi and Chung-Mag, 1989; Amagase *et al.*, 2001; Groppo *et al.,* 2007). Therefore, it becomes worthwhile to investigate whether it can be used as an alternative to conventional antibiotics in treating *Salmonella typhi* infection. This study therefore was designed to investigate whether garlic has antibacterial activity against *Salmonella typhi* and whether it can be used to treat *Salmonella typhi* infection in rats.

Keywords: *Salmonella typhi, Allium sativum,* antibacterial activity, therapeutic effect, rats

MATERIALS AND METHODS

Test Bacteria: *Salmonella typhi* used in this study was collected from the Microbiology Laboratory of a Hospital in Akure, Ondo State, Nigeria. It was confirmed in the laboratory according to the method of Holt *et al.* (1994).

Experimental animals used: Albino rats, eight to ten weeks old were used for this assay. These rats were got from Animal Production and Health Department, Federal University of Technology, Akure, Ondo State, Nigeria.

Garlic bulbs used: Fresh garlic bulbs were purchased from King's market, Akure. Ondo State, Nigeria.

Source of antibiotics used: The various antibiotics used in this study were purchased from a NAFDAC approved pharmaceutical shop in Akure, Ondo State, Nigeria.

Preparation of garlic homogenate: Garlic (bulblets) cloves were cleaned, surface sterilized using hypochlorite solution and were again washed in sterile distilled water to remove any trait of the hypochlorite solution. The cloves were then deskinned and crushed using sterile mortar and pestle. The homogenate was obtained by filtering the crushed garlic using sterile cheese cloth and the homogenate was collected into sterile universal bottle, covered, labeled and used immediately.

***In vitro* determination of growth inhibitory activity of garlic homogenate on *Salmonella typhi*:** This was carried out using agar diffusion method of Adebolu *et al*. (2010).

Determination of the infective dose of *Salmonella typhi* used for infecting the rats. This was done using the method of Olorunfemi and Adebolu (2012).

Treatment of rats infected with *S. typhi* with garlic homogenate: This was carried out using agar diffusion method of Adebolu *et al*. (2010).

RESULTS

Growth inhibitory activity of garlic homogenate on *S. typhi*: The garlic homogenate used inhibited the growth of *S. typhi* on agar plate with diameter of zone of inhibition averaging 23. 8mm. This inhibition was superior to that of the antibiotics used except streptomycin that inhibited the growth of the organism with a zone of inhibition of 24.0mm (Fig 1).

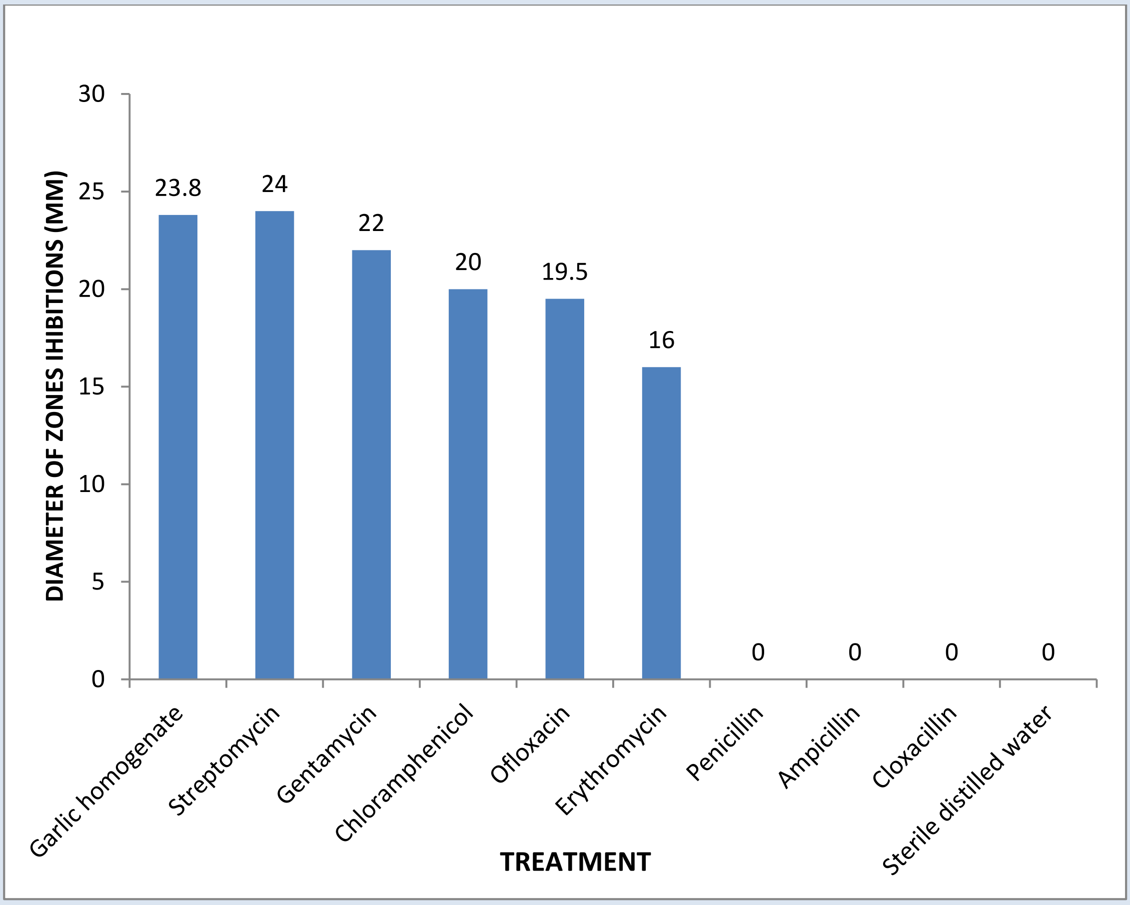

Figure 1 : Growth Inhibitory effect of Garlic/Antibiotics on Salmonella Typhi

Effect of administration of garlic homogenate on rats infected with *S. typhi* : Administration of garlic homogenate to treat rats infected with *S. typhi* caused the rats to start recovering by the fifth day unlike the control rats that did not recover throughout the duration of the research (8days) (Table 1).

Table 1: Effect of treating rats infected with *S. typhi* with garlic homogenate

Day	Appearance of rats and their stool	
	Rats treated with garlic	**Control rats**
1	W, LA ,US	W, LA, US
2	W, LA, US,	W, LA, US
3	W, LA, US,	W, LA, US
4	W, LA, US,	W, LA, US
5	A, FS,	W, LA, SPF
6	A, FS	W, SPF
7	A, FS	W, SPF
8	A, FS	W, SPF

Key: A= Active, LA= Loss of appetite, W= Weak, VW= Very weak
SPF= Stool partially formed, US= unformed stool
FS= Formed stool

DISCUSSION

In this study, the growth inhibition mediated by garlic homogenate on the test organism shows that garlic contains chemical components that are more potent than that of all the antibiotics used except streptomycin. These components according to Fleschauer and Arab (2001), Banerjee and Maulik (2002) and Bjarnsholt *et al*. (2005) include alliin, alline, ajorene, diallyl sulfides (DAS), diallyl disulfides (DADS), diallyl trisulfides (DAT), S-allylcysteine (SACS), organosulfur compounds and allylsulfur. The reduction in the duration of infection of the infected rats to 5days after treatment with the homogenate showed that the chemical and biological factors of the rat's system did not have negative effect on the chemical components present in garlic and therefore the homogenate was intact to inhibit the proliferation of the organism in the gastrointestinal tract of the infected rats. Therefore, since garlic has antibacterial activity against *S. typhi* on agar plate and also in rats, moreover, since it also reduced the duration of infection in rats from >8d to 5d, it is conceivable that it could be used for the treatment of *S. typhi* infection in humans in the absence of conventional antibiotics.

REFERENCES

Adebolu, T. T., Oseni, J. J, Omogbehinwa, A. F., Komolafe, B. M. and Ogundare, A. O. (2010). Effects of raw maize "ogi" on the gastrointestinal flora of albino rats and its potential in controlling diarrhoea caused by *Escherichia coli*. *TWOWS Africa International Journal of Science and Technology* 1(1): 39 – 45.

Amagase, H., Petesch, B. L., & Matsuura, H. (2001). Intake of garlic and its bioactive components. *Journal of Nutrition* 131: 9555-9265.

Banerjee, S.K. & Maulik, S. K. (2002). Effect of garlic on cardiovascular disorders: a review. *Nutrition Journal* 1: 4

Bjarnsholt, T., Ostrup Jensen, P., Rasmussen, T. B. Christophersen, L., Calum, H., Hougen, H. P., Rygaard, J., Mosen, C., Eberl, L., Halby, N. & Gisvkovs, M. (2005). Garlic blocks quorum sensing and promotes rapid clearing of pulmonary *Pseudomonas aeruginosa* infections. *Microbiology* 151: 3878 - 3880.

Fleischauer, A. T., and Arab, L. (2001). Garlic and Cancer: a critical review of epidemiologic literature. *Journal of Nutrition* 131: 1032S – 1040S.

Groppo, F., Ramacciato, J., Motta, R., Ferraresi, P. & Sartoratto, A. (2007). Antimicrobial activity of garlic against oral Steptoccocci . *International Journal of Dental Hygiene* 5(2): 109-115.

Holt, J.D., Krieg, N. R., Sneath, P. H. A., Staley, J. T. and Williams, S. T. (1994). Bergey's Manual of Determinative Bacteriology. 9th Edition. Williams & Wilkins, Baltimore, Maryland. 786pp.

Olorunfemi,O.B.and Adebolu, T. T. (2012). Immunomodulatory and therapeutic effects of whey on rats infected with diarrhoeagenic bacteria. *Biosciences, Biotechnology Research Asia* 9(1): 173- 179.

Tung-Nis Yu and Chung- May Wu (1989). Stability of allicin in garlic juice. *Journal of Food Science* 54(4): 977.

Climate Change and Health Delivery

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ABSTRACT

Climatic change is the gradient fall in the chemo-physical interaction in the atmosphere particularly in the stratosphere/mesospheric regions. This interaction brings about a negative change of the chemical compositions of the atmosphere. The interaction of zone (O_3) oxygen molecule with carbon compounds e.g. sulphur from fossil fuel releases some acid radicals which causes tearing of ozone layer, resulting in acid rain, with subsequent degradation of the soil elements causing corrosion and undue flood and erosion. These developments affect the developing countries such as Nigeria. Subsequently areas in Anambra like Aguleri in Anambra-North , Ogbaru in Anambra-West were severely submerged with water from the flood and people were rendered homeless, became destitute with serious negative psychological impacts as farmlands and crops were wasted .Most individual ran bizarre, it was a moment of darkness in Anambra State for several weeks until Government s, both federal, state Government and health care delivery system intervened by embarking on rescue missions, then provided camps to accommodate the owners and the inhabitants of the submerged homes. Reliefs of food and medicine were provided to the camps. Already the extremes of age, that is infants, neonate (under a month old) and the very old where most vulnerable with ailments like pneumonia, gastrointestinal tract diseases, Malaria fevers with shivering and typhoid. The paper examines climate change and its effect on public health delivery system. This work clearly exposes the flood disasters as a result of the climate change as it affects part of Anambra state Nigeria with pictures of submerged farmlands and homes.

INTRODUCTION

The term climate covers meteorological phenomena over a lengthy period of time, for example trends in temperature, storm activity or rainfall. In other words it is a significant and lasting change in the distribution of weather patterns over periods ranging from decades to millions of years. It is a major weather and climatic conditions in our environment recorded over a long period of time. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate that is attributed directly or indirectly to human activities that alters the composition of the global atmosphere in addition extended to natural climate variability over extended periods of time (UNFCCC, 2000). Climate change results from natural phenomena such as changes in the intensity of the sun or slow changes in the movement of the earth round the sun, this has occurred periodically throughout history sometimes with catastrophic effects such as the extinction of various species during the ice ages. Over the past two decades a growing body of scientific evidence has been established that suggests that the most recent changes in the earth's climate have been substantially influenced y human activity, so-called anthropogenic effects. Some of these anthropogenic activities may include industrial pollution like burning of fossil fuel, urbanization, deforestation, desertification, improper waste disposal e.t.c. The effect of these human activities can be summarized with a global term "global warming".

Global warming is now seen as the major cause of changes in our climate. It's direct impact is observed with increasing rise in the earth's temperature as a result of human activities. The cause of this global warming is attributed to emission of "green gases"- carbon dioxide (Co_2), methane (CH_4) nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoroide (SF_6). All these are generated by diverse human activities (EPA, 2009).

Climate change is presently having its impacts in various sphere of human activities particularly in Environment, Agriculture, Rural Development, Energy, Mining, Infrastructure, Poverty, Urban Development and Health.

Climate change has enormous impacts on the health of the world population. Industrialized countries have begun to protect themselves by starting adaptation programme while developing countries have limited resources to do so. They however and especially the least developing countries are suffering more from climate change. The damaging impacts of climate change which included excessive rainfall and the subsequent flooding and erosion were greatly felt in the sub-saharan Africa region including Nigeria in the year 2012. The flood disaster which was recorded as one of the worst since the existence of the country cuts across over twelve states out of the 36 states in Nigeria with damaging consequences. The unusual flooding resulted to loss of agricultural lands, structural properties, disruption of socio-economic activities, various disease epidemics and loss of human lives and livestock.

CAUSES OF CLIMATE CHANGE

Whereas natural phenomena such as oceanic circulation, variation in solar radiation received by the earth as well as volcanic eruptions causes climate change, the most prominent causes are anthropogenic i.e as a result of human activities. These human activities results in the increase in global warming due to emission of green houses gases from various human industrial activities. Some of the anthropogenic causes of climate change include:

a. Incomplete combustion of fossil fuels in automobiles and generating sets.
b. Gas flaring in petrochemical industries
c. Deforestation
d. Desertification
e. Improper disposal of wastes

Substantial amounts of human-induced greenhouse gases (CH_4, NO_0, HCFs, PFCs, SF_6) have come from the increased use of fossil fuels burned to power new machineries, generate electricity and propel transport vehicles. The amount of emissions has accelerated in the last 200years, reflecting increases in the world's population, economic development and increased production and consumption in a globalised economy.

- **Gas flaring**

Gas flaring is the burning of natural gas that is associated with crude oil when it pumped up from the ground. This is mostly predominant in oil exploration location and petrochemical companies or refineries. Nigeria, the highest producer of gas in Africa is ranked second to Russia in flaring of natural gases. The emission of these gases into the atmosphere reacts with the ozone layer thereby causing its depletion. In more developed nations, these gases are converted for more useful purposes such as in generation of electricity

- **Acid rain**

Due to global warning, green gases such as sulphur oxide and nitric oxide are released into the atmosphere as a result of incomplete combustion of fuel and other emissions from industries. These gases react with water molecules in the atmosphere to produce acids. The acid rain destroys metallic structures by corrosion. It results to the death of most top soil and subsoil microorganism which are useful in plant growth and soil structures. This also affects the structure/chemistry of the soil, making it more porous and gritty, thus unable to hold water such soils are then susceptible to erosion.

IMPACT OF CLIMATE CHANGE

Climate change has consequences in various aspect of human life which includes impacts on the Environment, Energy, Transportation, Mining, Agriculture, Rural Development infrastructure, Poverty, Urban Development and Health. However, this paper focuses on the impact of climate change on delivery.

CLIMATE CHANGE IMPACT ON HEALTH DELIVERY

Climate change will have grave consequences on the health of the world population. The World Health Organisation (WHO) assigns increasing importance to the relation between climate change and health. WHO considers climate change to be the most important health challenge of the 21st century (WHO 2010). Climate change affects health via a cascade of different mechanism as illustrated below

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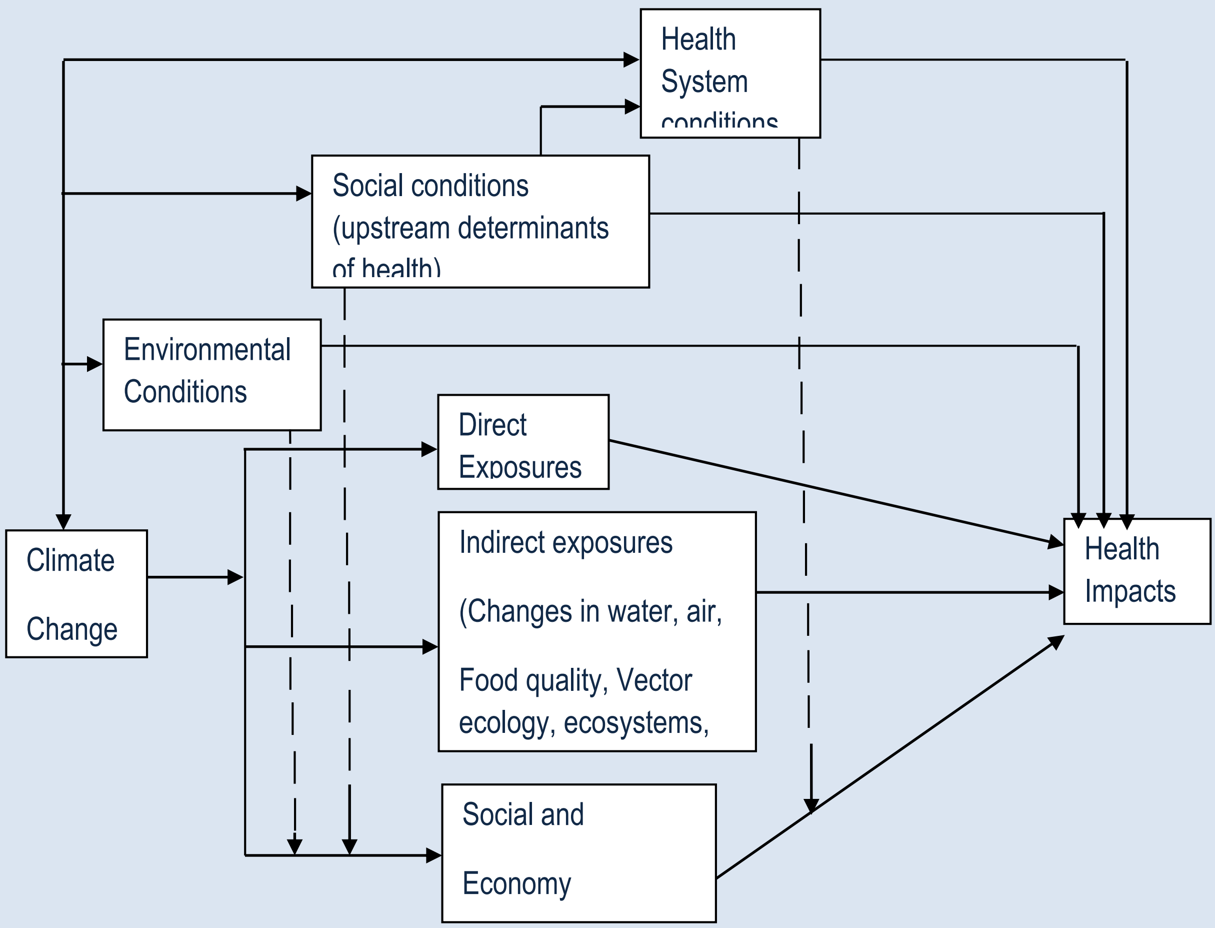

Fig 1: Mechanism of climate change affecting Health (IPCC, 2007)

The effects of climate change on health may be classified as direct and indirect. **Directs effects** are diseases and deaths as a result of extreme weather events like heat, flooding, mudslides, storms and hurricane. **Indirect effects** are those that result from changes in the ecosystem such as conditions that facilitates infectious diseases, changes in agricultural production and the availability of portable water. Other indirect effects include drought, flooding, famine, epidemics and movement of refuges.

The health care delivery system suffers from the consequences of climate change in the following ways:

- **Damage of Health Facilities:** Hospitals and health centres can be damaged by tornadoes, hurricane or by flooding. In Anambra State during the 2012 flood disaster most of the health centres and hospitals were submerged. Over 58 communities were affected in 8 different Local Government Area in the state. This poses a great health care delivery challenge. The hospital and medical centers nearby were not enough to accommodate the victims and clients. There were shortage of beds and other medical facilities to care for the victims

- **Access to Health Facilities:** Injured and sick persons were not able to access the closest medical facilities. The roads were flooded with water, victims were ferried on boats and canoes, most sick persons died on their way, and some were able to swim across the water to dry land where they were assisted to the nearby hospitals and other available medical facilities.
- **Increase in Demand of Medication:** climatic changes also result to widespread of various diseases. In Anambra State, cholera epidemics were recorded during the flood period. Most victims couldn't access the appropriate medications as the available drugs and infusion fluids were not enough to cater for those in need. There was also outbreak of pneumonia across extreme of age (young and old persons). The flood rendered thousands of hundreds homeless and thus they were exposed to all kinds of weather conditions such as cold.
- **Availability of Health Personnel:** There may be a resultant shortage in health personnels as must health personnels scamper from devastated areas for safety. For instance, in Anambra State, during the period of the ravaging flood in 2012, there were reports of shortage of health personnels as most have moved away from the ravaged areas to safety, thus victims were inadequately catered for.

EPIDEMICS

The change in climate may also result to the prevalence of certain diseases. There may be increase of death and illness from the spread of infectious and diarrhoeal diseases as well as from extreme weather conditions (Bals *et al.,*2008)

- Also the rise of the average temperature most likely will result in an expansion of rodents population size which in turn acts as transmitters for viruses, bacteria and parasites (Meerburg, 2009).
- Survival and reproduction of mosquitoes may increase as a result of global temperature rise. Chikungunya-fever was diagnosed in 2007 and its transmitter, the Aedes mosquito was found near the lower Rhine in 2007 (Hibbeler, 2009).
- The spread of ticks as a result of global warming will increase the threat of Borreliosis and Meningoencephatitis; toxic sea algae grow better in warmer temperatures (IPPC 2007) and sand flies-vectors of Leishmaniosis established themselves in Germany in 1999.
- Although still controversial if climate change results in an increase of UV-radiation there will be an increase in skin cancer as well as an earlier and more frequent occurrence of ocular cataracts (US Global Change 2011).

CONSEQUENCES FOR DEVELOPING COUNTRIES

Health damages in industrialized countries will be considerable and the cost to counteract them will be high. Yet the major health consequences of climate change will be borne by developing countries.

- They will encounter a sharp increase in problems that already exist now.

- They will face new health threats for which they lack the economic or social capability to respond.
- Extreme weather events-as a consequence of climate change are on the increase in industrialized as well as in developing countries. Without doubt the health consequences will be much more severe than in industrialized countries. Floods like Sept.2012 in Nigeria are on the rise. Over 5 million people became homeless and were forced to leave their destroyed fields and villages.
- Agriculture and nutrition will be especially compromised. Currently, under-nutrition is one of the biggest health problems in the world; about 800million people were already suffering from chronic under-nutrition before the food crises of 2008. Majority of who are from developing nations. As a result of global warming, in the near future, food crops in the tropics and subtropics may shrink by 20-40% (Battisti 2009). Productivity of forests animal husbandry and fisheries will be adversely affected as well.
- Currently, diarrhea kills about 2 million people per year mainly children in developing countries. Effective treatment is cheap and easy but frequently not accessible to patients. Most likely this problem will increase substantially in the near future.
- Dissemination of malaria depends on many factors, mosquitoes, temperature and resistance. Currently in Africa alone about 600 million people are exposed to malaria. More recent considerations suggest that the number will increase by additional 390 million people by 2030 (WB 2010).

WHAT NEEDS TO BE DONE

- Relevant laws need to be passed to ensure the protection of the ozone layer. Such laws will include ban on gas flaring by petrochemical industries and other allied industries.
- Construction of adequate drainages to combat the effects of erosion and flooding.
- Major rivers need to be dredged to accommodate more water mass so as to avoid water overflowing river banks during excessive rainfalls.
- Sanitation laws should be well enacted so as to ensure proper waste disposals and thus prevent indiscriminate waste disposals such as disposal of wastes in drainages.
- Health intervention by Government departments and agencies. The Government should be able to initiate relevant health programmes to mitigate the effects of climate change on the populace. The Government should collaborate with relevant non-governmental organizations and health institutions such as the WHO, UNICEF, etc. to achieve this.
- **Awareness:** There should be regular awareness programmes to enlighten the public about the impacts of climatic changes and how to adapt to them. Also they should be educated on what to do at various circumstances. The National Metrological Centre should be able to release warning information about impending impacts of climatic change, when such are forecasted.
- **Internationally**, Ministries of Health, professional bodies, health institutions and all organization dealing with health should not only be concerned with adaptation but urgently need to play an important role in promoting mitigation
    - Because the health sector is energy intensive and contributes substantially to global warming;
    - Because of the negative health effects of global warming for the world population.

CONCLUSION

Already climate change has negative consequences for the health of humankind especially in developing countries. This will merely increase with time. The international discussion on climate change needs to do a better job of integrating the health consequences. As in the Kyoto summit in 1997, where for the first time since the climate discussion started, an international and legally binding agreement to reduce emissions of greenhouse gases was signed by most industrialized countries. Its intent was to prevent a rise in global temperature to dangerous levels above the preindustrial era. This agreement however ended in 2012. The climate summit in Durban in December 2011 once more failed to agree on news and binding measures. However time is running out, projections need to be revised again and again as it becomes apparent that global warming is occurring more rapidly than previously expected.

REFERENCES

Bals C. Harmeling, S. and Windfuhr, M., (2008). Climate change, Food Security and The Right to Adequate Food. http://www.brot-fueredie-accessed 4.8.2013.

Battisi D.S and Naylor R.L., (2009). Historical warnings of future food insecurity with unprecedented seasonal heat. *Science;* 323: 240-44

Environmental Protection Agency, EPA (2009). Green house gases, threaten public health and the environment. Press release, US EPA

Intergovernmental Panel on Climate Change, IPCC (2007). Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change http://www.pcc.ch/publications accessed 6.8.2013.

Meerburg, B., Singleton, G and Kijlstra, A. (2000). Rodent borne diseases and their risks for public health. *Critical reviews in Microbiology* 35(13):221-270

US Global Change Research Program(2011). http://www.globalchange.gov. accessed 4.8. 2013.

United Nations framework. Convention on climate change (2000).http://unfcc.int/cooperation-support/least-developed-countries accessed 6.8.2013

WHO (2010). Parma declaration on environment and health; fifth ministerial conference on environment. http://www. euro.who.mt/data/assest accessed 4.8. 2013

World Bank (2010). World development reports and climate change. Washington D.C.

Climate Change and Increases in Infectious Disease Spread

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ABSTRACT

Climate change refers to significant changes in world weather patterns that have led to shifts in weather conditions to extreme levels. These changes have led to global warming, with rises in average environmental temperatures as well as changes in precipitation, winds and other indicators. One of the main impacts of global climate changes is the wide-ranging effects on human health. Concerns have arisen over the effects of climate change on increased risk of respiratory diseases, vector-borne infections and higher levels of food and water borne diseases like cholera as well as the emergence and re-emergence of certain bacterial and viral infections. This paper discusses the relationship between effects of climate change on the incidence and persistence of infectious agents and diseases.

Key words: Climate change, weather patterns, global warming, cholera, infections

INTRODUCTION

Climate change refers to significant changes in world weather patterns that have led to shifts in world weather patterns to extreme levels. It can be identified by changes in temperature, precipitation, winds and other indicators. Global climate change is expected to affect the frequency, intensity and duration of extreme water related weather events such as excessive rainfall, storm surges, floods and droughts [1, 2, 3]. Recent extreme water-related weather events have included droughts in Russia, flooding in Sri Lanka, the Philippines, Pakistan, Australia and Brazil [4] and Nigeria.

Climate change is not just a change in the global temperature; it is also a change in the weather. While climate describes the average conditions expected at a specific place at a given time, and is measured over a long period, weather, which is measured over a short period, describes the atmospheric condition at a specific place at a specific point in time and refers to day-to-day temperature and precipitation activity. Climate may include precipitation, temperature, humidity, sunshine, wind, velocity, and phenomena such as fog, frost and hailstorms over a long period of time. Weather on the other hand, includes sunshine, rain, winds, hail, snow, flooding, thunderstorms, excessive heat and heat waves.

Temperatures affect the potential ranges of infectious diseases and their vectors, while weather affects the timing, intensity and location of outbreaks. As warming occurs, weather patterns are shifting, with more extremes of both signs (hot and cold, wet and dry), more major outliers, and the appearance of novel events (e.g., a hurricane in the Southern Atlantic) [5]. Moreover, growing weather instability breeds sequences of extremes (e.g., droughts, punctuated by heavy rains; series of strong hurricanes), and these can be particularly conducive to disease outbreaks. Mozambique in 2000, for example, in a span of six weeks, experienced three cyclones and incessant heavy rains, leading to widespread flooding and a five-fold spike in malaria in the affected regions [6].

The factors that cause climate change can be divided into two categories, those related to natural processes and those related to human activity. Natural causes refer to factors that are external to the climate system, such as changes in volcanic activity, solar output, and the Earth's orbit around the Sun. Of these, the two factors relevant on timescales of contemporary climate change are changes in volcanic activity and changes in solar radiation. Human causes of climate change include human activities such as the burning of fossil fuels and the conversion of land for forestry and agriculture. These activities change the land surface and emit various substances to the atmosphere, which in turn can influence both the amount of incoming and outgoing energy and can have both warming and cooling effects on the climate. The dominant product of fossil fuel combustion is carbon dioxide, a greenhouse gas and its build up in the atmosphere has led to an enhancement of the natural greenhouse effect.

Weather is expected to become more extreme and variable due to acceleration of the water cycle caused by atmospheric heating. Altered pressure and temperature patterns, caused by global warming may also shift the distribution of when and where extreme water-related weather events usually occur [7]. The frequency of heavy precipitation events is thought to have increased over many mid-latitude regions since 1950, while the area affected by drought is thought to have increased since the 1970s in many areas of the world [7].

Excessive or heavy rainfall events can mobilize pathogens in the environment and increased run-off of water from fields, transporting them into rivers, coastal waters and wells [1, 8]. Such events can therefore increase raw water turbidity, which has been found to be associated with gastrointestinal illness [9]. Heavy rainfall can also lead to changes in the direction of flow of water through channels that would not normally occur [10]. Periods of heavy rainfall may lead to treatment plants being overwhelmed, with cross-contamination between sewage and drinking water pipes, particularly in areas with old water infrastructure, sewage overflow or bypass into local waterways [11].

Extreme precipitation events may also increase the risk of flooding in many areas, increasing human exposure to water borne pathogens [12], while droughts or extended dry periods are known to reduce the volume of river flow and so potentially increase the concentration of effluent-derived pathogens due to reduced dilution by stream-receiving waters [13].

Waterborne diseases are expected to rise with increases in extreme rainfall and deterioration in water quality following wider drought events [2]. It is important to establish the current impact of such events on public health to allow future predictions, aid policy formulation, and improve adaptive capacity. The impact of recent events demonstrates that even high-income countries are not well prepared to cope with extreme weather events [2].

2.00 Impacts of Climate change on infectious diseases

The impacts of climate change on infectious diseases are complex and multifaceted [1, 14], and has been a subject of debate, speculation and serious study for centuries [15]. According to Henle [16], heat and moisture favour the production and propagation of infusoma and contagia, therefore, miasmatic-contagious diseases are most often endemic in warm moist regions and epidemics in the wet summer months. Cholera and yellow fever were included by him as being among the miasmatic-contagious diseases.

Climate exerts both direct and indirect effects on the appearance and spread of human and animal infectious diseases. The impact of climate change on the transmission and geographical distribution of vector-borne diseases, including zoonoses (infections transmissible between vertebrate animals and humans), has been associated with changes in the replication rate and dissemination of pathogen, vector and animal host populations, which are sensitive to changing temperature and rainfall [17]

According to Prüss-Üstün and Corvalán [18], some 2.5 million people die every year from non-infectious diseases directly attributable to environmental factors such as air pollution, extreme weather events, stressful conditions in the workplace, exposure to chemicals such as lead, and exposure to environmental tobacco smoke. Changes in climatic conditions and climate variability represent a further factor which can affect human health directly or indirectly via changes in biological and ecological processes that influence the transmission of several infectious diseases [19].

Direct effects on human health include, for example, thermal stresses due to increased frequency and intensity of heat waves (cardiovascular and respiratory diseases, heat exhaustion), and deaths and injuries due to extreme weather events. Indirect effects include malnutrition, food-, water- and vector-borne diseases, together with increased morbidity due to the combined effect of exposure to high temperature and air pollution [20].

Changes in precipitation amounts and patterns can bring about increases in water flows and floods, leading to contamination of drinking, recreational or irrigation water, and increased risk of outbreaks of cryptosporidiosis and vero-toxin-producing *E. coli* (VTEC) infections [21]. Higher water temperature also increases the growth rate of certain pathogens like *Vibrio* spp that can cause food-borne outbreaks (sea food) or on rare occasions, lead to severe necrotic ulcers, septicemia and death in susceptible persons with wounds bathing in contaminated waters.

Elevated air temperature could negatively affect the quality of food stuff during transport, storage and food handling. Generally, increasing temperature shortens arthropod life cycles and the extrinsic incubation periods of vector-borne pathogens, potentially leading to larger vector populations and enhanced transmission risks. Long term seasonal changes will affect both vectors and host animals and may locally affect land use changes and human behavior with implications for the geographical distribution, seasonal activity and prevalence of many vector-borne diseases in Europe [1].

Water-borne diseases

In 2001 it was estimated that 20% of the world's population lacked access to safe drinking water, and that more than five million people died annually from illnesses associated with unsafe drinking water or inadequate sanitation [22]. An adequate supply of safe water is therefore vital to the health and well-being of the global population [23]. Weather events have become an emerging concern, among the many factors that could contribute to the occurrence of a water-borne disease outbreak. Weather is likely to have its greatest impact at the point the pathogen enters the drinking water system, and also its survival in the drinking supply, since according to Prescott *et al.* [24] pathogen growth and reproduction are temperature dependent.

Rain and spring thaw events influence the horizontal and vertical movement of pathogens at the soil level [25], and increased water flow resulting from these events could increase the speed at which the pathogen enters the source water and drinking water supply, as well as pathogen load [26]. Reports on the contribution by weather to outbreaks of water-borne infections include: the 1993 Milwaukee outbreak of *Cryptosporidium* in which spring rains and snow melt were implicated [27], the Victoria BC toxoplasmosis outbreak of 1994/1995 [28] and the Walkerton, ON *E. coli* 0157:H7 outbreak of 2000 [29, 30] in which increased rainfall contributed greatly. According to Curriero *et al*. [31], over half of the water-borne outbreaks in the US between 1948 and 1994 were preceded within two months by an extreme rainfall event.

Cann *et al*. [4], in a systematic review of scientific literature and PROMED reports on extreme water-related weather events and water borne disease, made the following findings: out of 83 papers that described 93 accounts of 87 different water-borne outbreaks that involved extreme water-related events from 29 different countries, the most commonly reported pathogens involved were: *Vibrio* spp (28.4%) and *Leptospira* spp (17.6%). Most reported outbreaks of *Vibrio* spp following these events occurred in Asia, followed by Africa and South America, while most reported outbreaks due to *Leptospira* spp were in N. America or Asia.

Over half of the reports that gave details of how the event was thought to have led to the outbreak, gave the cause of the outbreak as coming through contamination of the water supply, usually through increased run-off of water from the surrounding area or by inundation. Also implicated were exposures to contaminated water by physical activity as well as contact with flood water which occurred while wading or during the clean-up process. A change in the survival rates of pathogens due to changing environmental conditions like water temperature or stagnation was also a factor. Other implicated factors were: the route of infection, which were either from the mains water supply, other treated water or well supply.

Majority of the PROMED reports were from Africa, followed by Asia and the North America. Amongst the pathogens implicated, *V. cholera* was the commonest of which 65.4% occurred in Africa and 20.6% in Asia. The most common events were also by flooding, followed by heavy rainfall. The most likely causes of the water-borne outbreaks as outline by 41.7% of the reports were: contamination of water, shortage of clean drinking water, poor sanitation and hygiene following the event.

Outbreaks caused by the contamination of community water systems have the potential to cause extensive disease [32], particularly where the public health infrastructure is not very strong, like in the developing world. Water borne diseases are one of the major contributors to global disease burden and mortality [33].

Food-borne infections

Climate change and variability are among the multiple factors that can provoke changes in the nature and occurrence of food safety hazards. These hazards can arise at various stages of the food chain, from primary production to consumption, and climate change may have direct and indirect impacts on their occurrence [34]. There are many pathways through which climate related factors may impact food safety including: changes in temperature and precipitation patterns, increased frequency and intensity of extreme weather events, ocean warming and acidification, and changes in the transport pathways of complex contaminants.

Temperature increases and changes in rainfall patterns have an impact on the persistence and patterns of occurrence of bacteria, viruses, parasites and fungi and the patterns of their corresponding foodborne diseases. Such changes also have an impact on microbial ecology and growth, plant and animal physiology and host susceptibility which may result in the emergence, redistribution and changes in the incidence and intensity of plant and animal diseases and pest infestations, all of which could impact foodborne diseases and zoonoses [35].

Extreme weather events such as floods and droughts may lead to contamination of soil, agricultural lands, water and food and animal feed with pathogens, chemicals and other hazardous substances, originating from sewage, agriculture and industrial settings. Emergency situations after natural disasters are of special concern for water and food sanitation. Ocean warming, and climate change related acidification and changes in ocean salinity and precipitation also affect the biochemical properties of water, along with water microflora, fisheries distribution, fish metabolic rates, and persistence and patterns of occurrence of pathogenic vibrios, harmful algal blooms and chemical contaminants in fish and shellfish [34].

In addition to the relatively direct impacts of climate change on food contamination and foodborne diseases, climate change and variability may affect other underlying drivers of food safety such as agriculture, crop production and plant health, animal production and animal health, fisheries, aquaculture, food trade, food and feed manufacturing, processing and handling and consumer’s behavior [34]. Studies have shown that climate factors such as increased temperature, relative humidity, and episodes of increased rainfall and runoff affect the incidence of diarrhea significantly [36, 37].

Ambient temperatures were reported to be positively associated with the rates of replication and survival of diarrhea-causing bacteria, protozoa, and food-borne microorganisms [38, 39]. According to Checkley *et al.* [40], higher temperatures extend the survival of gastroenteritis causing bacteria, such as *Escherichia coli*, in contaminated food. Higher temperatures may also indirectly affect behavior patterns, such as increased consumption of water and lax hygiene, which may promote diarrhea transmission [36]. Climatic factors can affect the sources, modes of transmission and the growth and survival of pathogens in the environment as well as the microbial ecology and the food matrix, among others [35]. Infectious (bacterial, viral and parasitic) and non-infectious (food intolerances or intestinal diseases) diarrhea, remains a major public health problem worldwide and a primary cause of increased morbidity and premature mortality globally, leading to 2 billion diarrheal cases and 2 million deaths each year [41]. Table 1 shows a list of microbial agents that could be affected by climate change.

Vector-borne infections

Global climate change can potentially increase the transmission of mosquito vector-borne diseases such as malaria, lymphatic filariasis, and dengue fever in many parts of the world. These predictions are based on the effects of changing temperature, rainfall, and humidity on mosquito breeding and survival, the more rapid development of ingested pathogens in mosquitoes and the more frequent blood feeds at moderately higher ambient temperatures [42]. Climate change parameters most often considered for their impact on mosquitoes are temperature, rain- fall, and humidity, but others such as atmospheric particle pollution and wind can also have an impact. Primary changes in such parameters, caused principally through the increased emission of greenhouse gases into the atmosphere, can alter the bionomics of mosquito vectors and therefore the rates of transmission of mosquito-borne diseases [43].

Mosquito survival in areas with less than optimal temperatures will be increased if climate change results in warming to temperatures closer the optimum for the mosquito species concerned. Thus a mosquito vector whose optimal survival temperatures are found in lowland areas of the tropics may spread to higher latitudes of the sub-tropical and temperate zones and to the higher altitudes in tropical countries [42]. A limited rise in temperature will also favour an increase in the human biting rate, hasten mosquito development and therefore increase the relative vector density (ratio of the number of vector mosquitoes to the number of humans), and reduce the extrinsic incubation period [44].

Climate change alters rainfall which has a direct effect on humidity, and ptimal humidity significantly increases mosquito survival. Furthermore, rainfall, rate of evaporation, and humidity will influence the availability of habitats for ovi-position and pre-imaginal development of the mosquito vectors and therefore influence the ratio of mosquitoes to humans. An expansion of habitats for pre-imaginal development as a result of climate change will therefore tend to increase vector density in relation to the human population, favouring disease transmission [42].

Peak malaria transmission closely follows the rainy season in tropical countries, e.g. SriLanka [45, 46]. Rainfall forms surface pools of fresh water that are favoured preimaginal development habitats for the major fresh water *Anopheles* vectors in SriLanka and other tropical countries [45, 46, 47]. However, excessive rainfall can wash away larvae and eggs and reduce the numbers of small puddles thereby temporarily lowering the rates of malaria transmission.

Less than normal rainfall in tropical wet zones results in the drying up of rivers and formation of pools in river beds which can also increase malaria transmission. *Aedes aegypti*, the principal urban vector of dengue, can develop indoors in water containers, and its development is therefore less dependent on rainfall [48]. *Aedes albopictus*, the alternative vector of dengue in mainly peri-urban and rural settings, tends to undergo larval development in water collections outdoors and is therefore more dependent on rain-fed habitats, e.g., water collections in leaf axils, tree holes, and discarded containers [48].

Emerging and re-emerging infections

Climatic factors influence the emergence and reemergence of infectious diseases, in addition to multiple human, biological, and ecological determinants [49]. Emerging and reemerging infectious diseases are defined as those increasing in incidence in the recent past or threatening to increase in the near future [50, 51]. They can also be defined as infections that have newly appeared in the population, or have existed but are rapidly increasing in incidence or geographic range [52, 53]. Recent examples of emerging diseases in various parts of the world include HIV/AIDS; classic cholera in South America and Africa; cholera due to *Vibrio cholerae* O139; Rift Valley fever; hantavirus pulmonary syndrome; Lyme disease; and hemolytic uremic syndrome, a foodborne infection caused by certain strains of *Escherichia coli* (in the United States, serotype O157:H7) [54].

The entry and subsequent establishment of a pathogen into a new human population must occur for a disease to emerge successfully [54]. Climatic conditions play a role in such dynamics, and climatologists have recently identified an accelerated change in long-term global climate

trends [55, 56, 57, 58]. Many newly emerging diseases in humans are actually long-standing zoonoses of animal host species that surface in human populations after a climatic or environmental change [51]. For example, the pulmonary Hantavirus epidemic in the southwest United States was felt to be due to an upsurge in rodent populations related to climate and ecological conditions [59]. Six years of drought, followed by extremely heavy spring rains in 1993, resulted in a 10-fold increase in the population of deer mice, which are the known reservoir of Hantavirus [60, 61]. In sub-Saharan Africa, meningococcal meningitis follows a distinct seasonal pattern. Epidemics consistently erupt during the hot dry season and subside soon after the onset of the rainy season [62]. In Nigeria during 1977 through 1979, peak meningitis incidence was strongly correlated with the highest mean maximum temperatures of the season and inversely correlated with absolute humidity to a lesser extent, though still significantly [63].
Diseases expected to be affected by climate change are listed in Table 2.

Table 1: Examples of microbiological agents that could be affected by climate change and variability and their mode of transmission to humans

Bacteria	**Host**	**Mode of transmission**
Salmonella	Poultry and pigs	Faecal/oral
Campylobacter	Poultry	Faecal/oral
Vibrio spp	Shellfish, fish	Faecal/oral
E. coli 0157	Cattle and other ruminants	Faecal/oral
Anthrax clostridium	Livestock and wild birds	Ingestion of spores through environmental routes, water, soil and feeds. Associated with outbreaks after droughts.
Yersinia	Birds and rodents with regional differences in the species of animal infected. Pigs are a major reservoir	Handling pigs at slaughter is a risk to humans
L. monocytogenes	Livestock	In the northern hemispheres, listeriosis has a distinct serological occurrence in livestock, probably associated with feeding of silage
Leptospira	All farm animals	Leptospirae shed in urine to contaminate pasture, drinking water and feed
Virus	**Host**	**Mode of transmission**
Rift valley fever virus	Multiple species of livestock and wild life	Bllod or organs of infected animals (handling of animal tissue), unpasteurized or uncooked milk of infected animals, mosquitoe, hematophagous flies
Niphah virus	Bats and pigs	Direct from bats to humans through food and the consumption of date palm sap. Infected pigs present a serious risk to farmers and abbatoir workers
Hendra virus	Bats and horses	Secretions from infected horses
Hanta virus	Rodents	Aerosol route from rodents – outbreaks from activities such as clearing rodent infested areas and hunting
Hepatitis E virus	Wild and domestic animals	Feacal-oral, pig manure is a possible source through contamination of irrigation of water and shell fish
Encephalitis, tick borne virus	Sheep, goats	Unpasteurized milk

Parasites	Host	Source of transmission
Tapeworm *Cysticercus bovis*	Cattle	Faecal-oral
Liver fluke	Sheep, cattle	Eggs are excreted in faeces
Protozoan parasites Toxoplasma gondii	Cats, pigs, sheep	Cat faeces are a major source of infection. Handling and consuming raw meat from infected sheep and pigs
Cryptosporidium	Cattle, sheep	Feacal-oral transmission, water borne, (oo)cytes, are highly infectious with high loadings, livestock feaces pose a risk to animals handlers
Giardia	Cattle, cats, dogs	Faecal-oral transmission. Water borne

Source: Tirado *et al*., (34)

Table 2: Status of Major Vector-borne Diseases and Predicted Sensitivity to Climate Change

Disease	**Populations at Risk, Millions †**	**Prevalence of Infection, Millions ‡**	**Present Distribution**	**Possible Change of Distribution as a Result of Climatic Change**
Malaria	2100	270	Tropics, subtropics	Highly likely
Lymphatic filariases	900	90.2	Tropics, subtropics	Likely
Onchocerciasis	90	17.8	Africa, Latin America	Likely
Schistosomiasis	600	200	Tropics, subtropics	Very likely
African trypanosomiasis	50	25000 new cases per year	Tropical Africa	Likely
Leishmaniasis	350	12 million infected + 400 000 new cases per year	Asia, southern Europe, Africa, South America	Not known
Dracunculiasis	63	1	Tropics (Africa, Asia)	Unlikely
Arboviral diseases Dengue	……..	……..	Tropics, Sub-tropics	Very likely
Yellow fever	……..	……..	Africa, Latin America	Likely
Japanese encephalitis	……..	……..	East, South East Asia	Likely
Other arboviral diseases	……..	……..	Tropical to temperate zones	Likely

Source: World Health Organization [64]
†Based on a world population estimated at 4.8 billion (1989)
‡Ellipses indicate no estimates available

CONCLUSION

Warming of the climate system is now unequivocal, and Africa is the most vulnerable continent where climate change is threatening to roll back many years of development and growth. This is because of its over-dependence on rain-fed agriculture, compounded by widespread poverty and weak capacity. Governments of African countries therefore need to be committed to developing and implementing policies, including creating greater awareness of the relevant issues, which will reduce these climate-induced impacts in other not to decimate the continent.

REFERENCES

1. Semenza, J. C. and Menne, B. (2009). Climate change and infectious diseases in Europe. Lancet Infectious Diseases 9: 365-375.
2. Pachauri, R. K. and Reisinger, A. (eds). (2007) Contribution of working groups I, II and III to the fourth assessment report of the \intergovernmental panel on climate change, IPCC, Geneva Switzerland {http://www.IPCC.ch/publications_and_data/ar4/syr/eu/contents.html}
3. Füssel, H.M. (2000). An updated assessment of the risks from climate change based on research published since the IPCC fourth assessment report. Climate Change. 97: 469-482.
4. Cann, K. F., Thomas, D, R. H., Salmon, R. L., Wyn-Jones, A. P. and Kay, d. (2013). Systematic Review: Extreme water-related weather events and water borne disease. Epidemiological Infection 141: 671-686.
5. Epstein, P. (2010). The ecology of climate change and infectious diseases: comment. Ecology. 91: 925-928.
6. Epstein, P. R. and Mills, E. (2005). Climate change futures: health, ecological and economic dimensions. Centre for Health and Global Environment, Harvard Medical School Boston, Ma. USA. {http://www.climatechangefutures.org/pdf/CCF_Report_Final_10.27.pdf}.
7. Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M. and Miller, H. L. (2007). Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on climate change. Cambridge University Press, Cambridge, UK.
8. Canada Communicable Disease Report (CCDR). (2000). Water borne outbreak of gastroenteritis associated with a contaminated municipal water supply, Walkerton, Ontario, May-June, 2000. Canada Communicable Disease Report. 26: 170-173.
9. Tinker, S. C., Moe, C. L., Klein, M. Flanders, W. D., Uber, J., Amirtharajah, A., Singer, P. and Tolbert, P. E. (2010). Drinking water turbidity and emergency departmental visit for gastroenteritis illness in Atlanta, 1993-2004. Journal of Exposure Science and Environmental Epidemiology 20: 19-28.
10. Hunter, P. R. (2003). Climate change and water borne and vector-borne disease. Journal of Applied Microbiology. 94: 37-46.
11. Semenza, J. and Nichols, G. (2007). Cryptosporidiosis surveillance and water-borne outbreaks in Europe. Eurosurveillance. 12: E13-E14.
12. Fewtrell, L., Kay, D., Watkins, J. Davies, C. and Francis, C. (2011). The microbiology of urban UK flood waters and a quantitative microbial risk assessment of flooding and gastrointestinal illness. Journal of Flood Risk Management. 4: 77-87.
13. Senhorst, H. A. J. and Zwolsman, J. J. G. (2005). Climate change and effects on water supply quality: a first impression. Water Science and Technology. 51: 53-59.
14. Randolph, S. E. and Rogers, D. J. (2010). Nature Reviews in Microbiology. 8: 361-371.
15. Shope, R. E. (1991). Global climate change and infectious diseases. Environmental Health Perspectives 96: 171-174.
16. Henle, J. (1938). On miasmata and contagia (translated by G. Rosen). Johns Hopkins Press, Baltimore, MD. P. 54.
17. European Academies Science Advisory Council (EASAC) (2010). Climate change and infectious diseases in Europe: the view from EASAC, March 2010. www.easac.eu. 1-16.
18. Prüss-Üstün, A. and Corvalán, C.F. (2006). Preventing Disease through Healthy Environments. Towards an Estimate of the Environmental Burden of Disease; World Health Organization: Geneva, Switzerland.

19. World Health Organization (WHO). (2003) Climate Change and Human Health. Risks and Responses; McMicheal, A.J., Campbell-Lendrum, D.H., Corvalan, C.F., Ebi, K.L., Githeko, A.K., Scheraga, J.D. and Woodward, A., (Eds.) WHO, Geneva, Switzerland.
20. Grasso, M., Manera, M., Chiabai, A. and Markandya, A. (2012). The health effects of climate change: a survey of recent quantitative research. Int. J. Environmental Research and Public Health 9: 1523-1547
21. Lindgren, E., Andersson, Y., Suk, J. E., Sudre, B. and Semenza, J. C. (2012). Monitoring European Union emerging infectious disease risk due to climate change. Science 336: 418-419.
22. Hunter, P. R., Colford, J. M., Lechevallier, M. W., Binder, S. and Berger, P. S. (2001). Water-borne diseases Emerging Infectious Diseases. 7: s544-545.
23. Thomas, M. K., Charron, D. F., Waltner-Tolws, D., Schuster, C., Maarouf, A. R. and Holt, J. D. (2006). A role of high impact weather events in water-borne disease outbreaks in Canada, 1975-2001. International Journal of Environmental Health research. 16(3): 167-180.
24. Prescott, L., Harley, J. and Klein, D. (1996). Microbiology 3rd edn. Dubuque, 1A: William C. Brown Publication.
25. McGechau, M. and Lavis, D. (2002). Transport of particulate and colloid-sorbed contaminants through soil part 1. General Principles and Biosystems Engineering. 83: 255-273.
26. Unc, A. and Goss, M. (2003). Movement of faecal bacteria through the vadose zone. Water, Air and Soil. 149: 327-337.
27. MacKenzie, W. R.., Hoxie, N. J., Proctor, M. E., Gradus, M. S., Blair, K. A., Peterson, D. E, et al. (1994). A massive outbreak in Milwaukee of cryptosporidium infection transmitted through the public water supply. N. Engl. J. Med. 331: 161 – 167.
28. Bowie, W. R., King, A. S., Werker, D. H., Isaac-Renton, J. L., Bell, A., Eng, S. B. and Marion, S. A. (1997). Outbreak of toxoplasmosis associated with municipal drinking water. Lancet 350: 173 – 177.
29. Auld, H., Klassen, J. and Geast, M. (2001). Report on an assessment of the historical significance of rainfalls in the Walkerton area during May, 2000. Toronto, Canada: Environment Canada.
30. O’Connor, D. R. (2002). Part One: A summary report of the Walkerton inquiry: The events of May 2000 and related issues. Toronto, Canada: Queen’s Printer for Ontario.
31. Curriero, F. C, Patz, J. A., Rose, J. B., Lele, S. (2001). The association between extreme precipitation and waterborne disease outbreaks in the United States, 1948 – 1994. Am. J. Public Health 91:1194 – 1199.
32. Karanis, P, Kourenti, C. and Smita, H. (2007). Water-borne transmission of protozoan parasites: a worldwide review of outbreaks and lessons learnt. Journal of Water and Health. 5: 1-38.
33. Prüss, A. and Havelaar, A. The global burden of disease study and applications in water, sanitation and hygiene. In: Fewtrell, L. and Bartram, J. (eds). Water Quality: Guidelines, standards and Health. IWA Publishing London, pp43-59.
34. Tirado, M. C., Clarke, R., Jaykus, L. A., Mcquatters-Gollop. A. and Frank, J. M. (2010). Climate change and food safety: A review. Food Research International. 43(7): 1745-1765.
35. Food and Agricultural Organisation (FAO). (2008). Food safety and climate change. FAO conference on food security and the challenges of climate change and bioenergy. {http://www.fao.org/ag/agn/agns/files/HlCI_climate_change_and_food_safety.pdf}.
36. Chou, W. C., Wu, J. L., Wang, Y. C., Huang, H., Sung, F. C. and Chuang, C. Y. (2010). Modeling the impact of climate variability on diarrhea-associated diseases in Taiwan (1996-2007). Science of the Total Environment. 409: 43-51.
37. D′Souza, R. M., Hall, G. and Becker, N. G. (2008). Climatic forces associated with hospitalization for rotavirus diarrhea in children under 5years of age. Epidemiological Infection. 136: 56-64.
38. Black, R. E. and Lanata, C. F. (1995). Epidemiology of diarrheal diseases in developing countries. In: Blazer, M. J., Smith, P. D., Ravdin, J. I., Grenberg, H. P. and Guerrant, R. I. (eds). Infections of gastrointestinal tract. Raven Press. New York.
39. Semenza, J., Hoser, C., Herbst, S. Rechenburg, A., Suk, J. E., Frechen, T. and Kistemann, T. (2012). Knowledge mapping for climate change and food- and water-borne diseases. Critical review of Environmental Science Technology. 42: 378-411.
40. Checkley, W., Epstein, L. D., Gilman, R. H., Cabrera, L. and Black, R. E. (2003). Effects of acute diarrhea on linear growth of Peruvian children. American Journal of Epidemiology. 157(2): 166-175
41. World Health Organisation (WHO). (2009a). Diarrheal disease fact sheet No 330 August. Available in: http://www.who.int./mediacentre/factsheets/fs330/en/index.html.
42. Ramasamy, R. and Surendran, S. N. (2012). Global climate change and its potential impact on disease transmission by salinity-tolerant mosquito vectors in coastal zones. Frontiers in Physiology. (3): 1-14.
43. Sutherst, R. W. (2004). Global change and human vulnerability to vecto-borne diseases. Clinical Microbiology Review. 17: 136-173.

44. Lindsay, S. W. and Birley, M. H. (1996). Climate change and malaria transmission. Annual Tropical Medicine and Parasitology. 90: 573-588.
45. Ramasamy, R.., DeAlwis, R., Wijesundera, A., and Ramasamy, M. S. (1992a). Malaria transmission in a new irrigation scheme in SriLanka: the emergence of *Anopheles annularis* as a major vector. Am. J. Trop. Med. Hyg. 47:547–553.
46. Ramasamy, R., Ramasamy, M.S.,Wijesundera, D. A., Dewit, I., Wijesundera, A. P., Dewit, I., Ranasinghe, C., Srikrishnaraj, K. A., and Wickremaratne, C. (1992b). High seasonal malaria transmission rates in the intermediate rainfall zone of Sri Lanka. Ann. Trop. Med. Parasitol. 86, 591–600.
47. Surendran, S. N. and Ramasamy, R. (2010).The *Anopheles culicifacies* and *Anopheles subpictus* species complexes in Sri Lanka and their implications for malaria control in the country. J. Trop.Med.Hyg. 38, 1–11.
48. World Health Organization. (2009b). Dengue Guidelines for Diagnosis, Treatment, Prevention and Control. WHO/HTM/NTD/DEN/2009.1. Available at: http://whqlibdoc.who.int/publications/2009/9789241547_eng.pdf
49. Patz, A. J., Epstein, P. R., Burke, T. A. and Balbus, J. M. (1996). Climate change and emerging diseases. Journal of American Medical Association. 275: 217-223.
50. Centers for Disease Control and Prevention. 1994). Addressing emerging infectious disease threats: a prevention strategy for the United States. Atlanta, GA: US Dept. of Health and Human Services, Public Health Service

51. Lederberg, J, Shope, R. E., Oaks, S., C. (Jr.) eds. (1992). Emerging Infections: Microbial Threats to Health in the United States. Washington, DC: Institute of Medicine, National Academy Press.
52. Morse, S. S. and Schluederberg, A. (1990). Emerging viruses: the evolution of viruses and viral diseases. Journal of Infectious Diseases. 162: 1-7.
53. Epstein, R. R., Ford, T. E. and Colwell, R. R. (1993). Marine ecosystems. Lancet 342: 1216-1219.
54. Morse S. (1995). Factors in the emergence of infectious diseases. Emerging Infect Dis. 1:7-15.
55. Houghton, J. T., Jenkins, G. J., Ephraums, J. J., (eds). (1990). Climate Change: The IPCC Scientific Assessment. Cambridge, England: Cambridge University Press.
56. Houghton, J., T., Callander, B. A., Varney, S. K., (eds). (1992). Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment. Cambridge, England: Cambridge University Press.
57. Karl, T. R., Knight, R. W., Plummer, N. (1995). Trends in high-frequency climate variability in the twentieth century. Nature. 377: 217-220.
58. Mitchell, J. F. B., Johns, T. C., Gregory, J. M., Tett, S. F. B. (1995) Climate response to increasing levels of greenhouse gases and sulphate aerosols. Nature. 376:501-504.
59. Wenzel, R. P. (1994). A new Hantavirus infection in North America. N Engl J Med. 330: 1004-1005.
60. Levins, R., Awerbuch, T., Brinkmann. U., et al. (1994). The emergence of new diseases. Am Sci. 82:52-60.
61. Stone, R. (1993). The mouse-pinon nut connection. Science. 1993: 262:833.
62. Moore, P. S. (1992). Meningococcal meningitis in sub-Saharan Africa: a model for the epidemic process. Clin Infect Dis. 14:515-525.
63. Greenwood, B. M., Blakebrough, I. S., Bradley, A. K., Wali, S. and Whittle, H. C. (1984). Meningococcal disease and season in sub-saharan Africa. Lancet. 1:1339-1342.
64. World Health Organization. (1990). Potential Health Effects of Climatic Change. Geneva, Switzerland: World Health Organization.

Climate Change and Its Impact on Health in Nigeria

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ABSTRACT

Climate change or global warming is the phenomenon that has recently become a torn in the flesh of earth's inhabitants globally. It has come with so much deleterious effects that cut across agriculture, water needs, food shortages, storms, floods, poverty, malnutrition, general health debility, and even fire outbreaks. Climate change can mean a change in such weather condition for a particular location over time. Deforestation by humans also is a major cause of climate change whereby the trees/bushes are cut and the debris are burnt thus releasing more gases into the atmosphere in addition to increasing the earth's temperature. Furthermore, during the process of deforestation, infection-carrying vectors are displaced and released to the environment to cause diseases. Excessive usage of generator as an alternative power supply in Nigeria with its resultant release of carbon monoxide into the atmosphere is great contributor to climate change. This has posed a lot of health hazard to families in Nigeria and there have been cases where entire family members were wiped out after inhaling carbon monoxide from generators kept inside their houses. Another source of climate change in Nigeria is vehicle pollution. Lots of vehicles and motorcycles emit smoke that contributes to warming the environment in addition to causing respiratory tract infections and allergy to humans. In northern Nigeria, climate change has led to desertification whereby the land has become very dried and does not absorb water. When it rains, the water runs off and this in turn leads to excessive flooding. Diseases and death are aftermath of lack of hygiene, deprivation, hunger and malnutrition. Pests and diseases can adversely affect animal husbandry. It also causes human suffering with infections like malaria, cholera, typhoid and dengue fever which in turn affects the effectiveness and productivity of Nigeria's labour force. All these factors are challenge to health care delivery.

Key words: Climate change, health, impact, Nigeria.

INTRODUCTION

Climate change or global warming is the phenomenon that has recently become a torn in the flesh of earth's inhabitants globally. It has come with so much deleterious effects that cut across agriculture, water needs, food shortages, storms, floods, poverty, malnutrition, general health debility, and even fire outbreaks. Climate change can mean a change in such weather condition for a particular location over time. Climate change can mean a change in such weather condition for a particular location over time. It can be due to human behaviour as well as natural disasters (Uche, 2012). According to Uche (2012), what causes this change cannot be treated in isolation without looking at greenhouse effect which is caused by the release of destructive gases by human action which in turn brings about the warming of the earth surface by increase in the earth's temperature. The increase in temperature in turn causes the melting of ice which contributes to the rise in sea level among other disastrous consequences.

Deforestation by humans also is a major cause of climate change whereby the trees/bushes are cut and the debris are burnt thus releasing more gases into the atmosphere in addition to increasing the earth's temperature. Furthermore, during the process of deforestation, infection-carrying vectors are displaced and released to the environment to cause diseases. Excessive usage of generator as an alternative power supply in Nigeria with its resultant release of carbon monoxide into the atmosphere is great contributor to climate change. This has posed a lot of health hazards to families in Nigeria and there have been cases where entire families were wiped out after inhaling carbon monoxide from generators kept inside their houses. Another source of climate change in Nigeria is from vehicle pollution. Lots of vehicles and motorcycles emit smoke that contributes to warming the environment in addition to causing respiratory tract infections and allergy to humans. The use of incandescent bulbs has been shown to contribute to climate change. Such bulbs release lots of wasted energy that damage the environment. The use of compact fluorescent energy-saving bulbs is presently being advocated.

In northern Nigeria, climate change has led to desertification whereby the land has become very dried and does not absorb water. When it rains, the water runs off and this in turn leads to excessive flooding. Desertification has led to cattle grazers not having enough grass for their cattle thus causing them to move to the southern part of the country. This is not without its concomitant effect as most often these cattle graze on people's crops, causing poor yields, affecting the farmers socio-economically and even health-wise. The cattle in addition to grazing also drink from streams that villagers use for the domestic needs thus leading to infectious diseases. In many cases this has led to communal clashes between the farmers and cattle-rearers that even ended in losses of lives.

Nigeria has had its share of global warming especially as concerns the flood of 2012. The Nigerian flood that occurred between July and October, 2012 displaced 2.1 billion people who became homeless and were forced to leave their homes. A death toll of 363 lives was recorded (Reuters, 2012). Diseases and death resulted from lack of hygiene, deprivation, hunger and malnutrition. Worse hit were women and children. In one of the refugee's camp, 4 pregnant women delivered their babies during their stay. In another report, the presence of crocodiles and snakes as well as other dangerous animals brought in by the floodwaters into the houses of people were reported. (Virtuos, 2012).

Zachar (2012) reported that climate change affects health via a cascade of different mechanisms. Direct effects are diseases and deaths as a result of extreme weather events like heat, flooding, mud slides, storms and hurricanes. Indirect effects are those that result from changes in the ecosystem, such as conditions that facilitate infectious diseases, changes in agricultural production, and the availability of (clean) water. But climate change can also have indirect effects on health from the social and economic turmoil brought about by drought, flooding, famine, epidemics and movement of refugees. Urban populations are growing and contributing to environmental decay, and water, air and environmental pollution**.**

Water is an indispensible tool of life and Nigeria do not have enough water for its basic needs. Most rural Nigerians still depend on surface water for their daily need and where such water become polluted as a result of severe flooding, different types of infectious diseases ensues. It is obvious that rainfall variability, climate, soil, agrochemicals and diseases have a direct impact on water resources. Climate change has brought about changes in rainfall patterns, variability in rainfall, changes in the water level/volume of ponds, lakes, rivers and streams, and frequency of storms and drought (BNRCC Report).

Fishing and fisheries are important occupation and operations that provide income, employment and proteins to Nigerians. In a situation of global warming of between 1.5 – 2°C, fisheries in Northern Nigeria, as in other northern parts of West Africa, would evidently be impacted (IPCC, 2007).This in turn will lead to a considerable source of protein being lost. Women do most of the farming and fishing in most parts of the country. In fish processing, firewood are used extensively and are still been used in for cooking and other domestic activities in rural areas. Such activities are dominated by women and children and these could impact on their health.

SOURCES OF DATA COLLECTION

Study was undertaken by the use of secondary and primary data obtained from various sources. These include National Emergency Management Agency (NEMA); Annual Reports and Newsletter; Dailies and by distribution of questionnaires to the flood affected victims. There were also personal interviews with the flood affected victims.

EFFECTS OF CLIMATE CHANGE AND ITS IMPACT ON HEALTH

Nigeria as a nation recorded her own experience of the negative impacts of climate variability in flooding in 2010, 2011, 2012 and 2013. In 2012 flooding occurred in 23 states of the federation. It affected 7,705,398 and displaced 2,157,419 people. It caused the death of 363 and destroyed 597476 houses. An estimate of 2.6 trillion naira was lost and resulted in unprecedented ecological damage. There were reports of people who were killed by flooding. Examples include the report given by Head, Disaster Management and Red Cross Society on Oct 3, 2012 that 148 people died as a result of flooding in 21 states of Nigeria, 64,000 rendered homeless, and about 10,000 victims will receive assistance. An estimated 134,000 people had been affected by the floods and there were growing concerns about the spread of water borne diseases like cholera. Deaths from epidemics may be higher than loss of lives from the flooding incident. The states affected included Adamawa, Taraba, Kogi, Plateau, Katsina, Cross River, Jigawa, Benue, Edo and Anambra.

Personal interactions and by the use of questionnaires in two L.G.As viz Anambra East and Ogbaru indicated the following. Flooding and windstorm were recorded in these two states between 2010 and 2013. Effect of flooding rendered many households homeless and forced them to evacuate their farmlands and homes. Lives were lost including mothers and children. Reptiles from oceans and rivers were found in the flooded homes. Livestock were destroyed leading to lack of source of protein. Diverse outbreaks of diseases like respiratory tract infections; fever; measles; cholera; dysentery; rashes following intense itching which leaves behind dark spots and patches; rheumatism; gastroenteritis due to contaminated foodstuffs occurred in the midst of flood affected victims. Residents were also subjected to hunger due to loss of foodstuff. Some developed high blood pressure. There were also pest invasion; fear; mosquito breeding sites developed or increased in number. Residents were bitten by reptiles that invaded the communities from the water bodies.

INTERVENTIONS

Refugee camps were provided for the displaced residents of these communities. Relief materials including foodstuff; medicines, mosquito nets, beddings amongst others were made available to the affected residents. Blocked drainages were opened up. Enlightenment programmes on the risk and effect of flooding. Communities were fumigated. But in some cases and areas, nothing was done. There had been no long term measures put in place at the moment to either prevent future losses from the ocean surge or flooding. A sum of 33.5 million naira was provided by IFRC's Disaster Relief Emergency Fund to start the operation.

HEALTH IMPLICATIONS

In a BNRCC Report, pests and diseases are implicated in climate change. Significant climatic conditions such as temperature, precipitation, sunshine and wind can affect and accelerate their dispersion and their increase. Food crops are affected by their presence (creating economic problems because of low agricultural yields and food shortages, as well as human population problems such as malnutrition). Pests and diseases can adversely affect animal husbandry. It also causes human suffering with infections like malaria, cholera, typhoid and dengue fever which in turn affects the effectiveness and productivity of Nigeria's labour force.

A shift could occur in the location of some vector-borne diseases, such as malaria (mosquitoes), sleeping sickness (tsetse fly), yellow fever (mosquitoes). In response to shifts in the patterns of rainfall and temperature; mosquitoes currently thrive in locations where water logging and poor drainage typify the landscape (IPCC, 2007). High flood frequency and water-logging due to climate change in ecozones previously un-associated with malaria will enhance the breeding of mosquitoes and thus the spread of malaria. Malaria will also increase due to the preponderance of stagnant pools of water resulting from sea-level rise related flooding. New evidences with respect to micro-climate change due to land-use changes such as swamp reclamation and deforestation suggest an increase spread of malaria to new areas (IPCC, 2007).

Direct impacts include health problems induced by increasing incidences of heat waves may have direct impacts on the health problems. Examples are increased cases of cerebro-spinal meningitis (CSM), which is higher during harmattan and extreme dry seasons in Northern Nigeria. The occurrence of skin cancer from direct ultra-violet radiation could become more common, as could increase incidences of cardiovascular respiration disorders.

Aneto (2012) described the impact of climate change as the biggest health threat of the 21st Century. He stated that though vector- borne diseases will spread beyond traditional boundaries, the indirect effects of climate change on water supply, food security, and extreme climate events will most probably have the biggest effect on global health. He also noted that the most vulnerable sub-populations affected are women and children on whom the perpetuation of the human race depends. Furthermore, he stated that if current collective efforts at curtailing these damaging effects of man’s relentless activity are not sustained the existence of man will be threatened.

It has been noted that eclampsia, haemorrhage and unsafe abortions are common causes of high maternal mortality in Nigeria. Recent reports indicate that environmental pollution that increases with climate change is a factor. The link between climate change and disease must be understood and necessary actions and policies instituted including the principle of host resistance. Furthermore, appropriate public health systems with an inclination for maternal and child health should be put in place to address adverse outcomes.

CONCLUSION AND RECOMMENDATIONS

Nigeria spends a lot of fund on management of natural related disaster which affects Nigerians. Taking care of the environment will reduce loss of lives and epidemic of diseases. Proper infrastructure and adequate health facilities should be provided for emergency situations. Adequate trained personnel should be in place for emergencies.

Climate change mitigation through the reduction in the use of fossil fuels will have long term effects on global warming. It will also have immediate and mid-term consequences on health through the reduction of diseases. Adaptation measures for the health consequences of climate change means the improvement of existing but insufficient Primary Health Care Systems battling to cope with the upcoming increased health risks like malnutrition, diarrhoea, malaria, dengue and other diseases. Reduction in population through effective family planning programmes. Smaller families lead to less carbon-dioxide emission and so contribute less to global warming. Enlightenment programmes to create awareness in the health community about environmental issues, climate change and its relevance to the health sector.

Dredging of rivers and opening up of blocked drainages will help to accommodate higher volumes of flood and channel it properly. Alternative accommodation should be provided which will help to accommodate the displaced individuals to avoid loss of lives and properties. Disaster fund should be provided to assist in times of emergency. Medicines and portal water should also be provided. Massive enlightenment programmes should be sustained to educate and encourage the residents of the flood prone areas to take the right decisions as the need arises.

REFERENCES

Agada A. (2012): The Rage of flood: The world poverty day: Poverty worsens as flood renders 42 million Nigerians homeless. Vanguard, Wednesday, October 17 p.9

Akinsuyi Y. and Sanni T. (2013): 31 States to experience devastating flood - This day Thursday, August 22 p. 1

Amaize E. (2012): The Rage of flood: Ex-militants donate N52.7 m to victims in Nigeria delta. Vanguard Wednesday, October 17 p.8

Aneto J. (2012)Impact of Climate Change on Maternal and Child Health: Ameliorative Role of the Translational Medicine. Paper presented at the 47th conference of Association of Medical Laboratory Scientists of Nigeria.

Anucha E. (2012): Flood displaces 100,000 persons in Rivers: Sacks over 90 communities Daily Sun, Monday, October 15 p.6

Atta A (2012): Flood babies: Triplets, 2 sets of twins, 4 others born in one week, 2000 pregnant women set to deliver. Expert warns on imminent epidemic, famine Sunday Sun, October 14 ,p.5

Costello, A., Maslin, M., Montgomery, H., Climate change is not the biggest global health threat – Author's reply, Lancet 374, (974-975), Sept. 2009

Edike T. (2012): Over 5,000 Kogi flood victims now refugees in Enugu. Vanguard, Monday October 1 p. 13

Ekpunobi D. (2013): Flood displaces 200 in Nkpor Daily Sun, Tuesday, July 23 p.7

Etim .W. (2012): Bayelsa … Groaning under the ravaging water. The Guardian, Sunday, October 14 p. 5

BNRCC: Building Nigeria's Response to Climate Change

Reuters Agency report (2012). Nigeria floods kill 363 people displaced

Folaranmi F. (2012): Jonathan Visits Bayelsa flooded communities, assures rehabilitation Daily Sun, Monday, October 15 p.6

IPPC, Intergovernmental Panel on Climate Change, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html

Kurukulasuriya, P & Mendelsohm, R.(2006): A Ricardian analysis of the impact of climate change on African cropland CEEPA Discussion paper No. 8. Centre for Environmental Economic and policy in Africa, University of Pretoria.

Lobell, D.B, and Burke M. B et al (2008): Prioritizing Climate change adaptation needs for food security in 2030" Science 319 (5863): p. 607-610

Maigida E. (2010): Department of relief and rehabilitation. In: NEMA (2010) Annual Report p.44- 56

Maigida E. (2011): Department of relief and rehabilitation. In: NEMA (2011) Annual Report p.64- 74

National Emergency Management Agency (2013): NEMA donates materials to displaced persons in Kaduna. NEMA Newsletter Vol 5 No 15 p.3.

News Agency of Nigeria (NAN 2013): 20 corpses unearthed by flood in Kano.

News Agency of Nigeria (NAN 2013): Nasarawa Government begins construction of drainages in flood prone areas in Lafia.

Odum F. (2012): FG plans food distribution, employs satellite to monitor flood: The Guardian, Sunday, October 14, p.9

Ogugbuajah .C. (2012): More donations for victims as floods recede, The Guardian Tuesday November 6 p.8

Ogugbuajah C. (2012): More donations for victims as floods recede, The Guardian, Tuesday, November 6, p.8

Okah E. (2012): Coping with the flood: Sunday Sun October 14 p.16

Okoro J (2013): Mudslide Wipes out Family of 8 .Daily Sun ,Friday September 6 p.6

Onwuchekwa D. (2012): As crocodiles, scorpions, invade Anambra homes: Community laments sharp rise of food crops Sunday Sun October 14 p.11

Taiwo – Obalonye J. (2012): As victims turn roadside beggars. Daily Sunday, Monday October 15, p.6

Taiwo – Obalonye J. (2012): Flood victims go haywire, force Jonathan to change itinerary in Yenogoa, Daily Sun Monday, October 15 p.6

Tope Templer Olaiya (2012): Rage of the floods: City file; The Guardian, Sunday, October 14, p.4

Uche, N. (2012) Climate change: Any impact on Nigeria. In Viewpoint (VANGUARD Newspaper 29/10/2012)

Ujumadu V. (2012): Flood sacks corps members in Anambra. Vanguard, Monday, October 1 p.13

Virtuos (2012) Nigeria Floods Brings Crocodiles And Hippos Into Homes http://www.bbc.co.uk/news/world-africa-19818180.

Zacher W. (2012) Climate change and health – Time to act.Germanwatch v (Publisher). Bonn. Retrieved from Http/www.germanwatch.org on 30/4/2013.

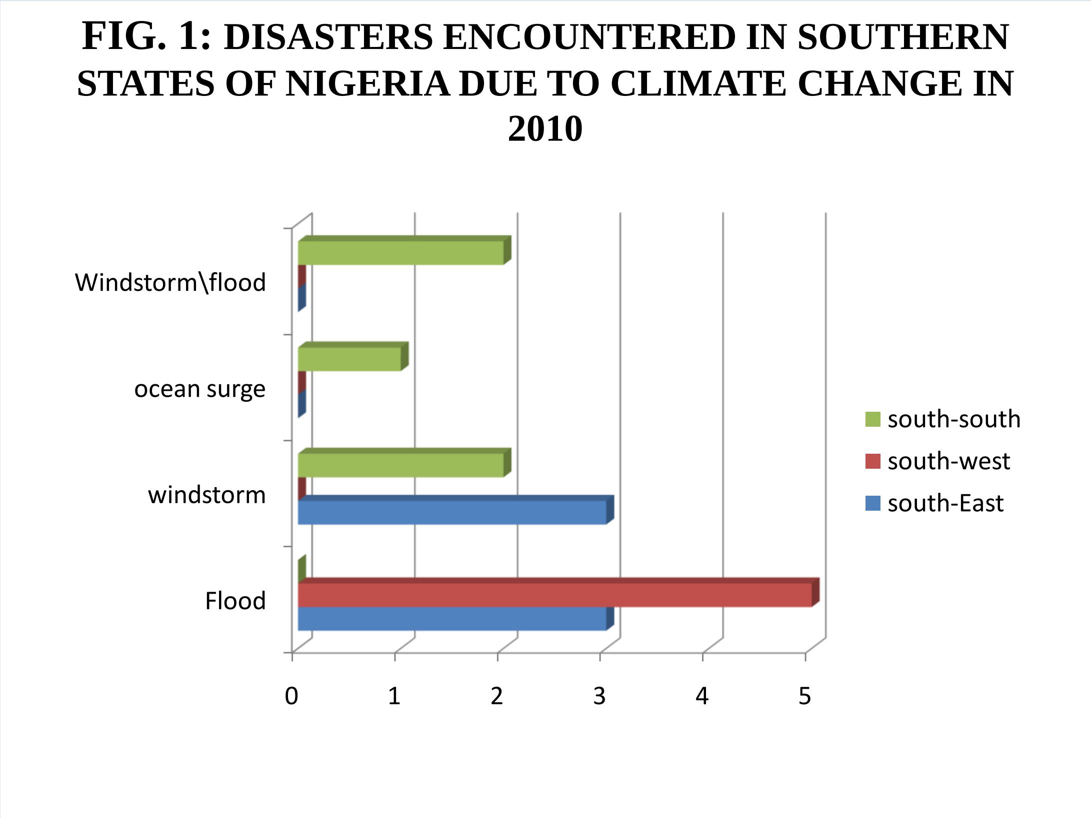

FIG. 1: DISASTERS ENCOUNTERED IN SOUTHERN STATES OF NIGERIA DUE TO CLIMATE CHANGE IN 2010
Windstorm\flood
ocean surge
windstorm
Flood
0
1
2
3
4
5
south-south
south-west
south-East

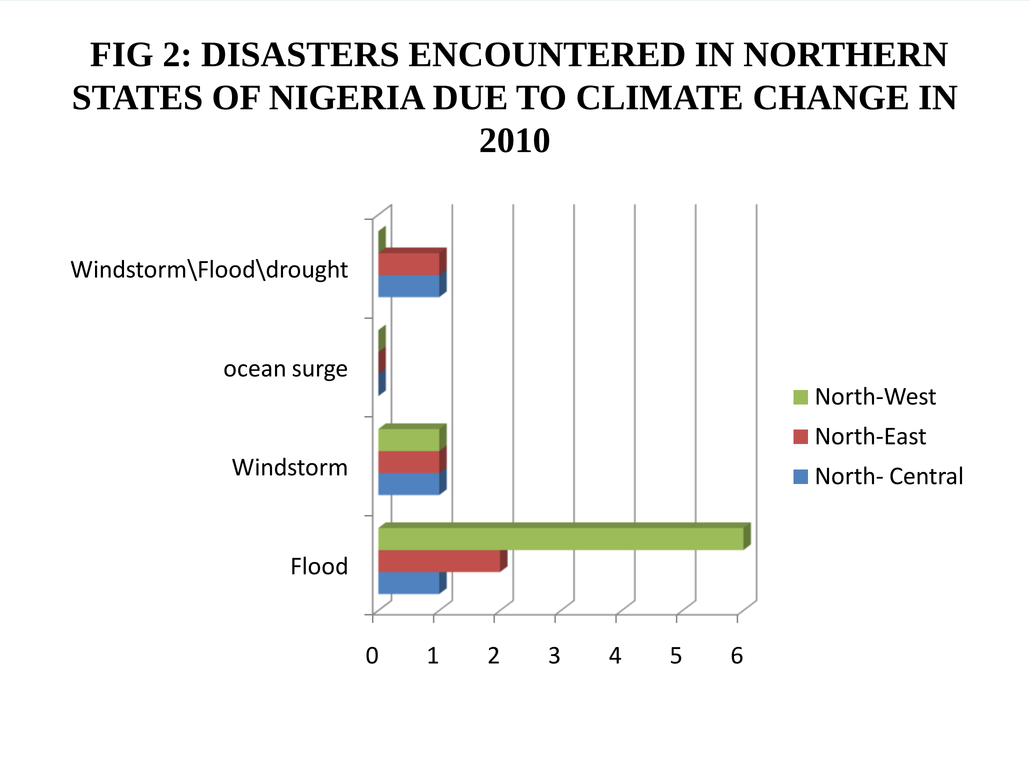

FIG 2: DISASTERS ENCOUNTERED IN NORTHERN STATES OF NIGERIA DUE TO CLIMATE CHANGE IN 2010
Windstorm\Flood\drought
ocean surge
Windstorm
Flood
0
1
2
3
4
5
6
North-West
North-East
North- Central

FIG 3: DISASTERS ENCOUNTERED IN VARIOUS PARTS OF NIGERIA DUE TO CLIMATE CHANGE IN 2011

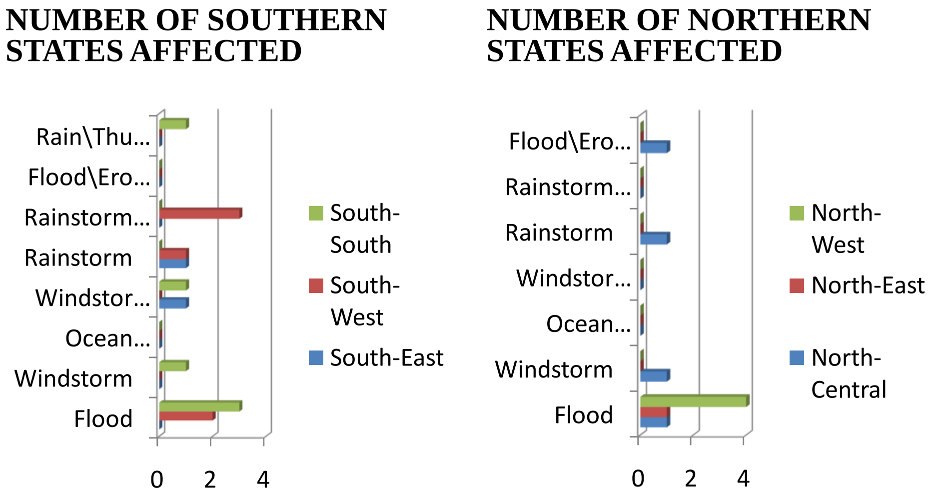

FIG 4: DISASTERS ENCOUNTERED IN VARIOUS PARTS OF NIGERIA DUE TO CLIMATE CHANGE IN 2012

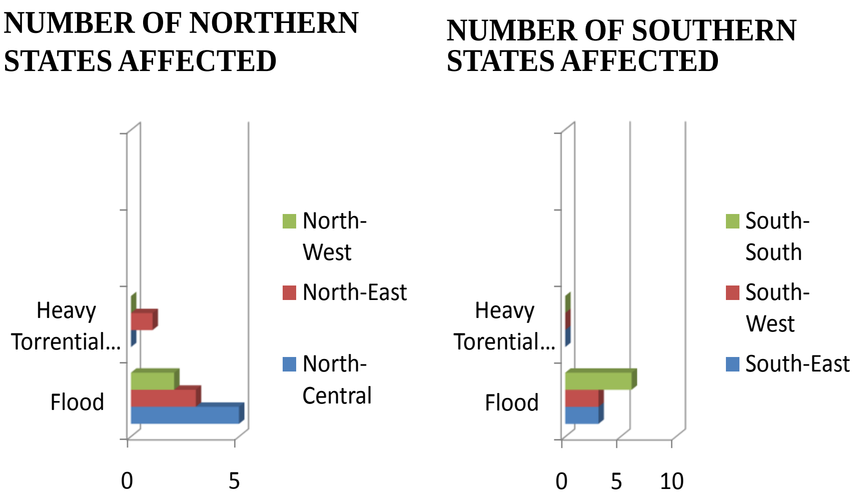

TABLE 1: EFFECT OF CLIMATE CHANGE IN TWO L.G.As.IN ANAMBRA STATE. NIGERIA IN 2012

Local Government Areas	No of persons interviewed	Occupation Type	Age Range in years (no)	No of Death	No of persons in Household (no of households involved)	Estimated monetary value of Farm Produce Lost
Ogbaru and Anambra	23	Farmers (10), Traders(6), Artisan(2), Civil Servant(2), Tailor(1), Student (3)	11-20(1), 21-30(5), 31-40 (3), 41-50 (4), 51-60(4), >61 (6)	New born baby (7), male adults (9) Female adults (7)	3persons(1); 4persons(1); 5persons(7); 6persons(4); 8persons(3); 9persons(2); 10persons(1); 14 persons (4)	10,000 - 250,000 naira

Climate Change and Malaria, a Case Study in Uyo Metropolis, Akwa Ibom State, Nigeria

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ABSTRACT

Malaria remains a dreaded disease and multi-faceted problem in sub-Saharan Africa. Malaria is cause by parasites that are transmitted to people through bites of infected mosquitoes. The distribution and seasonal transmission of malaria is affected by climate as both vector and parasites are sensitive to temperature. Investigation of the different species of malaria parasites, Plamodium falciparum, and Plasmodium vivax in providing strategic insights into the effects of climate change on malaria transmission was made using both slide method and a standard rapid immuno-chromotographic test. We evaluated 400 blood samples from patients presenting with feverish symptoms between the periods of February 2012 to January 2013. Our results showed that ***P*** falciparum was found to be at the peak between the months January and February being the beginning of raining season compared to the period of October to December, April having the least number of patients. The co-infection of ***P*** falciparum and ***P*** vivax were also common during this season. Conclusively, the parasite transmission is strongly climate dependent in Uyo metropolis of Akwa Ibom State.

Keywords: Malaria, Climate change, Vector, Transmission

INTRODUCTION

Malaria is serious, sometimes fatal parasitic disease which is usually characterized by fever, chills and anaemia and is caused by a parasite that is transmitted from one human to another by the bite of an infected female anopheles mosquito.[6] Malaria remains a very complex problem in Africa as a whole, it is caused by four distinct species of plasmodium parasites, the vectors are mostly abundant in the tropical and sub tropical regions, although they are also found in limited numbers in the temperate climates[2]

In most African countries over 75% of cases were due to ***P*** falciparum, whereas in most other countries with malaria transmission other less virulent Plasmodial species predominate [4].

The life cycle of malaria parasites starts out with the bite of an infected mosquito. Mosquitoes are not born with malaria; they get it from an infected person. The mosquito bite injects the sporozoa, those sporozoites are usually cleared from circulation in about 20 minutes, and they settled in the liver and undergo asexual development in the liver cells, at this stage they are haploid organisms, after about one week's development in the erythrocytes (red blood cells) that are usually associated with the pathology that we think of malaria. [3]

The most important malaria species are ***P*** falciparum, very pernicious and *p* vivax, less pernicious, more temperate in its range; it has a development cycle of 48hr, from the time of invasion to the time of rupture and re invasion.

During the period of infection, most infected people develop a very synchronous infection, the chills and fever of malaria that occur every other day. This is because of the parasite going back into the red cells.

Other things happen in the circulation because for reasons not yet known, some of the parasites instead of developing asexually in the red blood cells will go ahead and develop as sexual parasites, the gametocytes, the micro and the macrogametocytes. All the time that is happening, most of these people sleep in mosquito prone environment, they are being fed on by the mosquitoes. The mosquitoes are feeding every night on them, they are taking a blood meal and in that blood meal we have malaria parasites. And if they are gametocytes in those malaria parasites, those gametocytes will then undergo gametogenesis in the gut of the mosquito. There are eggs and sperm like microgametes form then there is fertilization and for the first time there is a diploid organism which then develop in the gut of the mosquito, again myosis takes place, the sporozoites get to the salivary glands, and about ten days after that mosquito has fed, it is ready to infect again.

Despite several measures targeted at preventing the breeding places for the vectors, malaria still remains a major public health problem in Nigeria as a whole. It is responsible for 60% outpatient visit to health facilities, 30% childhood death, 25% of death in children under one year and 11% of maternal death (4,500 die yearly). In Nigeria a child will be sick of malaria between 2 to 4 times in one year and 20% of pregnant women suffer from malaria; contributing to maternal anaemia; low birth weight, still birth, abortion and other pregnancy related complications.[9]

This study was carried out to highlight the patterns of infection of malaria with the seasonal changes as a factor and looking at the types of plasmodium infections in the area of study.

AREA AND TIME OF STUDY

Four hundred samples were collected randomly between February 2012 to January 2013 from patients who presented themselves for laboratory tests in two major private laboratories (Jil Medical Laboratory and Abasiakara Medical Laboratory) in Uyo metropolis of Akwa Ibom State. Nigeria.

METHODS

Whole blood samples collected were processed immediately on arrival in the laboratory using two different methods, clean slides were used for thick blood film and stained using standard staining procedure[6] and the serum was tested using a standard immunochromatographic test to detect malaria antibodies.

STATISTICAL ANALYSIS

Data was entered and analysed using Stata Version 10. Data was described in %, ages and chi square was used to test for association with P value of less than 0.05 considered significant.

RESULTS

We found from the results that the respondents who presented in the rainy and dry seasons were similar in age and sex characteristics. There is no significant different in parasite distribution among the two sexes.

Throughout the study plasmodium vivax was not demonstrated alone but in combination with ***P*** falciparum. ***P*** falciparum only occurs more in the raining season; but occurs in combination with ***P*** vivax more in the dry season

Table 1: Age and sex characteristics of the participants by season of presentation in Uyo

Variable	**Season**		**Total**	**Statistical indices**
	Rainy (n=208)	**Dry (n=192)**	**(n= 400)**	
Age (years)				
Less than 10	13 (6.3)	8 (4.2)	21 (5.3)	χ^2=3.4614
11-20	31(14.9)	31 (16.2)	62 (15.5)	Df = 6
21-30	91 (43.8)	76 (39.6)	167 (41.2)	P value =0.763*
31-40	31 (14.9)	34 (17.7)	65 (16.3)	
41-50	32 (15.4)	34 (17.7)	66 (16.5)	
51-60	8 (3.9)	5 (2.6)	13 (3.3)	
61 and above	2 (1.0)	4 (2.1)	6 (1.5)	
Mean (SD)	29.9 (12.4)	30.1 (12.5)	30.0 (12.4)	Df=398 t=- 0.2787 P value=0.8287

Sex				χ^2=0.2896
Female	115 (55.3)	101 (52.6)	216 (54.0)	Df = 1
Male	93 (44.7)	91 (47.4)	184 (46.0)	P value =0.590
Average patients/month	30	38	33	

Table 1 shows that the respondents who presented in the rainy and dry seasons are similar in age and sex characteristics

Table 2: Distribution of parasite sps by sex of the participants in Uyo

Parasite sp	**Sex**		**Total**	**Statistical indices**
	Male (n=184)	**Female (n=216)**	**(n= 400)**	χ^2=3.8514 Df = 2
None	33 (17.9)	37 (17.1)	70 (17.5)	P value =0.396
***P* falciparum only**	140 (76.1)	172 (79.6)	312 (78.0)	
***P*.falciparum and *P.* vivax**	11 (6.0)	7 (3.2)	18 (4.5)	

Table 2 shows the distribution of parasite species by sex among the respondents. There is no significant difference in parasite distribution among the two sexes. Plasmodium vivax was not demonstrated alone in this study but in combination with P falciparum

Table 3: Distribution of malaria parasite sp by different age groups of the participants in Uyo

Age group (years)	**None (n=70)**	***P* falciparum (n=312)**	**Both *P*.falciparum and *P* vivax (n=18)**	**Total (n=400)**	**Statistical indices**
Less than 10	12 (17.0)	7 (2.2)	2 (11.1)	21 (5.3)	
11-20	13 (18.6)	46 (14.7)	3 (16.7)	52 (15.5)	χ^2=32.3790
21-30	18 (25.7)	142 (45.5)	7 (38.9)	167 (41.2)	Df = 12
31-40	12 (17.1)	49 (15.7)	4 (22.2)	65 (16.3)	P value
41-50	13 (18.6)	52 (16.7)	1 (5.6)	66 (16.5)	=0.0001*+
51-60	2 (2.9)	10 (3.2)	1 (5.6)	13 (3.3)	
61 and above	0 (0)	6 (1.9)	0 (0)	6 (1.5)	

+ significant value.* fischer exact test

Table 3 describes the distribution of malaria parasites across different age groups. There is significant association between age groups and malaria parasite demonstrated parastemia is demonstrated more among the middle age groups compared to extreme of ages.

Table 4: Distribution of parasite sp by season of presentation in Uyo

Parasite sp	season		Total	Statistical indices
	Rainy (n=208)	Dry (n=192)	(n=400)	χ^2=7.0936
None	35 (50.0)	35 (50.0)	70 (100.0)	Df = 2
***P.* falciparum**	169 (54.2)	143 (45.8)	312 (100.0)	P value =0.028+
***P* falciparum and *P* vivax**	4 (22.2)	14 (77.8)	18 (100.0)	

Table 4 shows the distribution of parasite across the two seasons. Whereas the demonstration of ***P*** falciparum only occurs more in the rainy season, it occurs in combination with ***P*** vivax more in the dry season

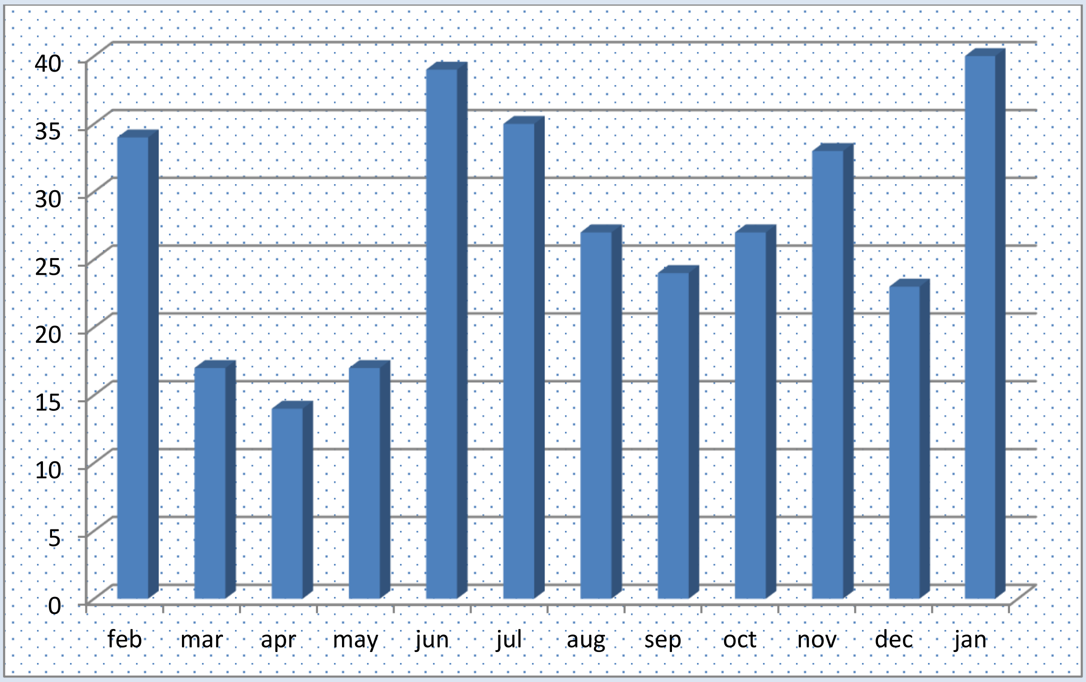

Figure 1 Monthly distribution of patients who presented for malaria test in Uyo, 2012

The figure 1 above shows that more patients come for malaria test in the months of January and December and April shows the months with the least number of patients

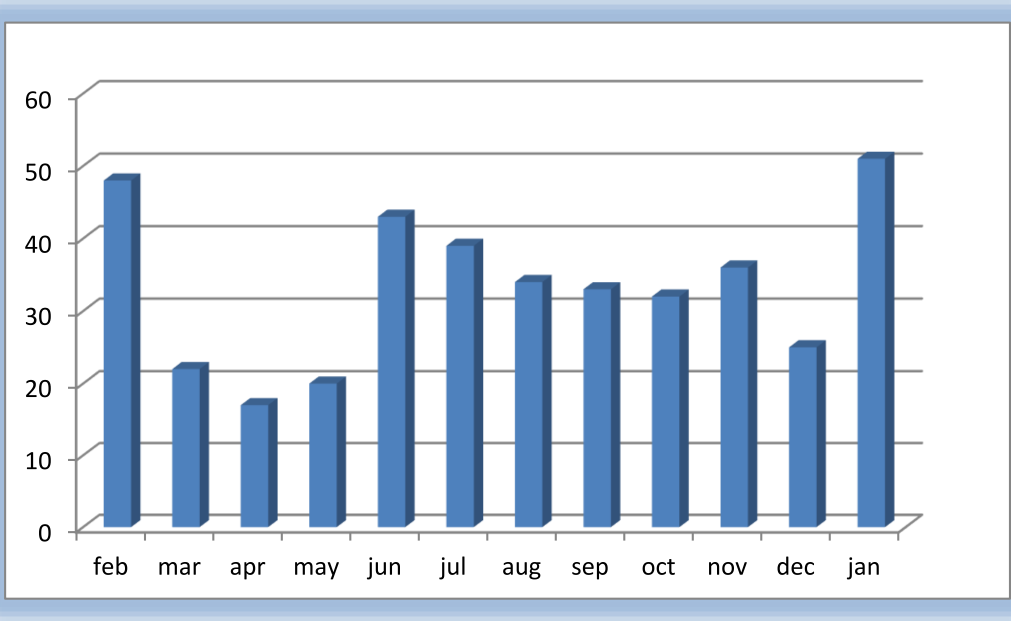

Figure 2 Monthly demonstration of parasitemia among the respondents in Uyo 2012

Figure 2 shows the monthly distribution of patients with parasitemia. It shows that the highest level of parasitemia is seen in the month of January follow by June. The month February shows the least level of parasitemia

DISCUSSION

This study and findings is similar to the results [5, 7, 13, 12, 14, 15,] which indicate that transmission of malaria varies by weather, which also affects the ability of the main carrier of malaria parasite, anopheles mosquitoes to survive or otherwise [2]

Our results showed that *P* falciparum was at peak between the months of January and February. The co infection of *P* falciparum and *P* vivax was common during the dry season, while *P* falciparum alone occurs ore during the raining season.

The peak period which is onset of raining season usually has the harmattan haze which could make malaria parasite more active. This corresponds to the metrological prediction which puts the cold phase between December and February as being able to make the parasites more active [10]

The result pattern suggests that heavy rainfall could have effects on the breeding places, most places flood during the raining season, it could interrupt the development stages the eggs, or larvae. The floods could flush them off.

However, malaria remains the most devastating human parasitic infection in the world today [11]

In Nigeria, available evidence indicates that malaria which is highly endemic remains a major public health problem and is the most common cause of hospital attendance in all age groups [1]

Preventive measures must be targeted at the vector to reduce malaria transmission at the community levels. Gutters must have good drainage system and kept clean at all times. All empty cans must be properly disposed. For individuals, personal protection against mosquito bites represents the first line of defense for malaria prevention. In case where a person is infected, an early diagnosis and treatment reduces the severity of the disease and prevents deaths. It also contributes to reducing malaria transmission.

TREATMENT

The best available treatment, particularly for p falciparum is artemsinin based combination therapy [ACT]

CONCLUSION

Although this study shows that seasonal changes affects the pattern of malaria infection in Uyo, Akwa Ibom State. Nigeria. There is need for further research to ensure proper malaria control programs.

REFERENCES

[1] Anumudu C. I. Adepoju, A. Adedrian M, Adeoye O, Kassim A, Oyewole I et al. Malaria Prevention and Treatment Seeking behavior young Nigerian Adults. Annuals of Afr Med. 2006, 5(2); 82-88.
[2] Ayanlade, N. O. Adeoye and Babatimetin 2010: Climate change/variability and malaria transmission in Sub-saharan Africa: A case of Nigeria in climate change and security. An international conference on the occasion of the 250th anniversary of royal Norwegian
[3] Bob Gwadz 2001: Malaria in Africa: An overview. A report from symposium held at 2001 AAAS Annual meeting
[4] Duval, L., M. Fourment, E. Nemenet, D. Rousset, S.A. Sadenh, S.M. Goodman, N.V. Andaholinriria, M. Randrianrivel, Ojosia, R. E, Paul V, Robert, F. J. Ayala, F. Ariey (2010) African apes as reservoirs plasmodium falciparum and the origin and diversification of the Laveraria subgenus Proceedings of the National Academy of Science of the United.

[5] Graig, M. H., Snow R. W. and Le Sueur D, 1998, A Climate-based Distribution Model of Malaria Transmission in Sub-Saharan Africa. Parasitol Today 15, 105-111.
[6] Malaria p f/pv 2009: Standard diagnostics Inc.
[7] McMichael, A. J. Campbell-Lendrum, D. H., Corvalan, C. F., Ebi, K. L., Githenko, A. K., Scheraga, J. D., Woodward, A., (eds), 2003, Climate Change and Human Health: risks and Responses, WHO, Geneva. www.who.int/globalchange/climat./summarry/en.
[8] Monica Cheesbrough 2000 pg 393: District laboratory practice in tropical countries.
[9] National Population Commission, 2006 Population Commission and Household Data Survey for Nigeria. Published by the Federal government of Nigeria.
[10] Nigerian Meterological Agency (Nimet) 2011 Seasonal Rainfall Prediction.

[11] Oshikoya, K. A. Malaria Treatment in Lagos Private Clinics/Hospitals: Physicians Compliance with the World Health Organisaiton Recommendations. Nig. Med Pract 2006. 49(5); 102-110.
[12] Thomson M, Graves P. M., Barnston A. G., Bell M., Ceccato P. Cannor S, del Corral J, Giannini A, Obsomer, V, Wolde-Georgis . Jaiteh M, Levy M, Lukang L, 2005a. Towards a Malaria Early Warning System for Entrea. Final Report to Environmental Health Project, Washington, DC: USAID.
[13] Thomson M. C. and Connor S. J., 2001, The Development of Malaria Early Warning Systems for Africa. Trends Parasitol 17, 438-445.
[14] Thomson M. C., Connor S. J., Phindela, T., Mason, S. J., 2005 b, rainfall and Sea Surface Temperature Monitoring for Malaria Early Warning in Botswana. Am J. Trop Med Hyg 73, 214-221.
[15] Wagbatsoma V. A. and Ogbeide O., 1995, Towards Malaria Control in Nigeria, the Journal of the Royal Society for the Promotion of Health, 115,(6) 363-365.

Flooding and Its Impact on Health Care Services in Anambra State, Nigeria

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ABSTRACT

The potential health effects of climate change can be substantial particularly when disruption of access to health care due to flooding is in the perspective. This is so because flooding can disrupt the capacity of health care systems to respond to health crises. Health facilities may become submerged in flood resulting in loss of infrastructure and increased difficulty in providing services for patients. This study was to determine what health workers and adults of selected local government areas in Anambra State attribute as causes of flooding as well assess hoe flooding impact on health care services in Anambra State, South East Nigeria. Four research questions were raised to guide the study. A cross-sectional descriptive survey design was used for the study. Twenty health care providers and one hundred and two health care users were conveniently selected from five flood affected areas. Eighteen researcher-developed questionnaire were used to collect data for the study. Data obtained were analysed descriptively using means and percentages. Majority of the people did not have a good knowledge of causes of flood. All the respondents (100%) agreed that health care services were provided. Damage to the roads leading to the facilities; none availability of drugs and high cost of the available drugs affected the utilization of facilities after flooding. It was evident from the results that health facilities are underutilized as 90% of the respondents lack access to the facilities. The capacity of health care providers needs to be strengthened to create awareness and assist in accessing health information and services within the community. There is need for adequate planning using a wide, multisectoral, all-hazards approach to emergency preparedness. Health facilities should be built in appropriate areas avoiding flood plains and structural protection and flood-proof provided. Additional funding, staff and staff training is necessary to effectively respond to flooding.

Keywords: Climatic change, behaviour change modification, local government health workers

INTRODUCTION

Flooding is arguably the weather-related hazard that is most widespread around the globe. It can occur virtually anywhere. Flooding can also be described as the result of a complex interaction between rainfall, urban and rural land surfaces, soil types, topography, drainage and river channels, and other man-made changes. Flood is defined as water overflowing onto land that usually is dry. Flooding is often thought of as a result of heavy rainfall, but floods can arise in a number of ways that are not directly related to ongoing weather events.

Flood according to [1] is an overflow of water that submerges or "drowns" land. In developing countries it occurs as a result of blocking of natural and manmade drainages and poor maintenance of water dams/ reserviours which seldom give way after persistent heavy down pours. In coastal lowlands and swamp lands, flooding is aided mainly by blocked channels and indiscriminate sand fling of coastal swamp areas and natural drainage channel for urban development/constructions.

Often times flooding is caused by climate change, especially in the developed economy where scientific mitigating options are highly employed. The recent flood disaster in Anambra State South East Nigeria which caused physical damage to structures, social dislocation, contamination of clean drinking water, spread of water-borne diseases, shortage of crops and food supplies, death of non-tolerant tree species, disruption in transportation system, serious economic loss and psychological trauma is a function of climate change. Proper management of the drainage systems and good maintenance of the dams are good option towards saving the environment.

Natural disasters are shocks to both the supply and demand of health services. On the supply side, natural disasters can profoundly affect the delivery of services; facilities may experience diminished staff levels and capacity because of damaged buildings and supplies. For example, Alison and colleagues [2] examined services provided by a temporary field hospital after a hurricane and found that most services provided were not storm related but were routine medical services. On the demand-side natural disasters can either increase or decrease demand for care, making short and long term effects obvious. Disasters can increase disease and injury incidence and acute levels of distress, thereby increasing service demand. It can reduce demand as the costs of travel to facilities increase; time costs generally increase owing to competing needs such as home reconstruction, and the provision of substitute low-cost services increases.

The long-term effects of natural disasters on the use of medical services are not easily determined or well studied. One of the few reports of Bennet in [3] such as 1968 floods in Bristol and Englandexamined changes in health care use and found significantly more hospital use during the year after the floods by residents with flooded houses than by those in the control group. Abrahams and colleagues in [3] found that after an Australian flood, the percentage of persons consulting their physician three or more times during the year following the flood was significantly higher than in a matched control group. To these can be added the uncertainties of how flood risk will change in a changing climate. In order to reduce flood damage, research is needed to better understand these processes. While much has been achieved, major challenges remain [4].

Climate change has become a very prominent issue in the media and in international and national policy processes. The 4th Assessment Report of the Intergovernmental Panel on

Climate Change [5] summarized the expected impacts of climate change and served as a wake-up call for policy-makers and the public alike. Climate change has become a global issue in recent times, manifesting itself in variations of different climate parameters including cloud cover, precipitation, temperature ranges, sea levels and vapours pressure.[6[The variations in climate parameters affect different sectors of the economy such as agriculture, health, water resources, energy etc. The main cause of climate change has been attributed to anthropogenic (human) activities. [6]

Flooding is an unpleasant situation which has affected the lives of people and natural endowments. In some communities, flooding is one of the natural disasters people face as a challenge. It is estimated that ground water flooding affects a few hundred thousand properties in some of our communities [4]. Ground water flooding occurs as a result of water rising up from the underlying rocks or from water flowing from abnormal springs. This tends to occur after much longer period of sustained high rainfall. Higher rainfall means more water will infiltrate into the ground and cause the water table to rise above normal levels.

Flooding has extensive and significant effects on health, ranging from drowning and injuries to infectious diseases and mental-health problems. Health effects observed during and after floods include injuries, infections, and poisoning and greater mental-health problems. The longer-term health effects result from displacement, shortage of safe water, injuries, disruption of access to health services and delayed recovery [7]. The flooding of health facilities disrupts services and increase difficulty in providing routine care for patients with chronic diseases.

Statement of the Problem

Flooding is widespread climatic hazard and poses multiple risks to human health, but little research has been done on health outcomes and how vulnerable populations and health systems respond to these risks.

In Anambra State, South East Nigeria, heavy flooding affected 5 local governments in 2012 and submerged several communities. The worse hit is Ogbaru, Ayamelum, Anambra east, Anambra west and Awka north. These displaced persons run into thousands of homes, lost all they had, including farmland, and productivity estimated at billions of Naira. The primary, secondary and tertiary effects of flood were called into play in the last flood disaster in Anambra State. Given the prospect that flood hazards may increase as a result of climate change, it is timely to assess the effects of flood on the utilization of health services

In many parts of the world, major costs are incurred in protection and recovery from floods. Flooding is one of the most widespread of climatic hazards and poses multiple risks to human health, yet there has been little systematic research work on health outcomes and the means by which vulnerable populations and health systems respond to those risks. Given the prospect that flood hazards may increase as a result of climate change, it is timely to make a strategic assessment of the existing knowledge base on health and flood risk. [8].

In Anambra State, Nigeria, heavy flooding has submerged several communities and about eight local governments were affected, but

Even the most advanced countries can suffer large scale destruction, loss of life, economic costs and disruption. The predicted impacts of climate change are that the size and frequency of future floods will change across and throughout the world. Floods produce damage through the immense power of moving water and through the deposition of dirt and debris when floodwaters finally recede. In most cases, the damage potential of the flood is magnified by the debris that the waters carry such as trees, vehicles, boulders (large rock or stone), buildings, etc. When the waters move fast enough, they can sweep away all before them, leaving behind scenes of terrible destruction [9].
The mud and debris left behind when floodwaters recede can be costly to clean up and represent a health hazard, as well, especially when there are decomposing bodies of drowned wild and domestic animals in the debris. In some situations, floods drive wild animals (including invertebrates of all sorts) from their normal habitats and into human habitations near and within the flooded areas, which can create various problems, especially when the animals are venomous or aggressive. [9]
Thus, there is a critical need to assess the knowledge and perceptions of health providers and health care users regarding public health impacts of climate change especially flooding and to assess the utilization of health facilities after flooding in Anambra State.
The following four research questions guided the study:

1. What is the health users and health care providers' knowledge about causes of flooding?
2. What health care services were available during the flooding in these areas?
3. How accessible were health services?
4. To what extent were the health care services utilized?

METHOD AND MATERIALS

Cross-sectional descriptive survey design was used for this study. Area of study were communities in five Local Government Areas that experienced flooding. The LGAs are Ogbaru, Anambra East, Anambra West, Ayamelum and Awka North.
The sample size constitutes of one hundred and two health care users and twenty health care providers who were purposively drawn from the population. An inclusion criterion was any adult, who was met in the health facilities and between ages of 20- 65 years was included in the study. The individual must be an indigene of study communities, mentally alert and willing to participate.
Researcher-structured questionnaire on knowledge of causes of flood and use of healthcare services was the instrument for data collection. The questionnaire was in four sections. Split-half reliability of the instrument using Pearson's Product Moment Correlation Coefficient was 0.84. The responses were collated and analyzed using frequencies and percentages.

RESULTS AND DISCUSSIONS

Table 1: Demographic and socio-economic characteristic of the respondents

		Health care providers		Health care users	
		f	%	f	%
Sex	Male	2	10	21	21
	Female	18	90	79	79
		20	100	100	100
Age	20 – 29	4	20	24	24
	30 – 39	8	40	45	45
	40 – 49	5	25	21	21
	50 – 59	3	15	8	8
	>60	0	0	2	2
		20	100	100	100
Marital status	Single	3	15	11	11
	Married	6	30	52	52
	Separated	5	25	15	15
	Widowed	2	10	13	13
	Divorced	4	20	9	9
		20	100	100	100
Educational Level	Non formal	0	0	29	29
	Primary	3	15	44	44
	Secondary	4	20	22	22
	Tertiary	13	65	15	15
		20	100	100	100
Occupation	Civil Servant	20	100	12	12
	Artisan	0	0	32	32
	Farming	0	0	49	49
	Student		0	4	4
	Unemployed	0	0	3	3
		20	100	100	100

Respondents of almost all ages were represented (ages 20 through to over 60). Table 1 show that 45% of the health care users' respondents were in their prime age of 30 to 39 years while the providers' at this age category accounted for 40%.A further 24% of the users' and 20% of the providers' were within 20 – 29 years while21% and 25% respectively were within the age of40 – 49 years. Providers' (15%) and users' (8%) were within the age of 50 – 59. The oldest age bracket (60 years old and above) accounted for only 2% of the users' respondents. This indicated that the aged using the facilities and services were not actually represented and could be attributed to the fact that these old people are taken care of in their homes.

The findings of the study showed that 10% (providers) and 21% (users) were males while 90% (providers) and 79% (users) were female. Owing to the fact that the criterion inclusion was based on those respondents present in the facilities, it could be said that most men in these areas were engaged in outdoor work during the survey. Table 1 also showed that 30% providers and 52% users were married and living with their spouses, while 25% users and 15% providers were separated. A further 10% (providers) and 13% users were widows, 15% (providers) and 11% users were single. The providers accounted for 20% divorced respondents, while 9% of the users were divorced. Female-headed households, widows/widowers and their children according to [11] were generally perceived to be more vulnerable to floods as compared with their counterpart households with both spouses. [12], and [13], explained that households with both spouses are better placed both financially and psychologically. They further stated that they are able to respond to flood risks in a better mental and emotional state than their single counterparts.

The study findings showed that on educational attainment, 65% (users) had tertiary education; 20% had attended secondary education; and 15% had primary education. The level of education of these workers attest to their ability to manage the facilities as majority had above secondary education. However, the facilities are being supervised by these groups of providers who have obtained Nursing, Midwifery or Community Health Extension Workers (CHEW) training. Among the users, 29% had no formal education, while 44% had primary level of education. Furthermore, 22% and 15% had secondary and tertiary level of education respectively. Occupation of the users indicated that 49% were farmers, 32% were artisans, 12% were civil servants, 4% were students and 3% were unemployed.

Table 2: Respondents' knowledge about causes of flooding

	Health Care Providers	**Health Care Users**
Overflowing of the river bank	4(20%)	9(8.8%
Poor road maintenance	6(30%)	44(42.1%)
Dumping of refuse into the river	10(50%)	31(30.4%)
Witch craft	0(0%)	2(2.0%)
Evil in the world	0(0%)	1(1%)
Do not know	0(0%)	16(15.7%)

Table 2 indicated that majority (50% providers and 44% users) of the respondents understand flooding to be dumping of refuse into the river and poor road maintenance respectively. Surprisingly only 20% providers and 9% users understand flooding as the overflowing of the river bank.

Table 3: Availability of health services during flooding

	Health care providers		Health care users	
	f	%	f	%
Services offered at the health facilities				
Treatment of minor ailments	20	100	100	100
Immunization Services	20	100	100	100
Geriatric Services	5	25	20	20
Maternal and Child Health Services	20	100	100	100
How often health is facility opened: Every day	13	65	24	24
Once weekly	2	10	8	8
Twice weekly	3	15	52	52
Thrice weekly	2	10	16	16
TOTAL	20	100%	100	100%

Key: A- Treatment of minor ailments; B- Immunization Services
C- Geriatric Services; D- Maternal and Child Health Services
(Multiple responses permitted)

The findings of the study (Table 3) showed that all the respondents (100%) agreed that all the services were provided and clinics were opened at least twice a week. However some of the respondents verbally told the researchers that there is at least one health facility with two or more health staff depending on the day.

Accessibility of health services to the users

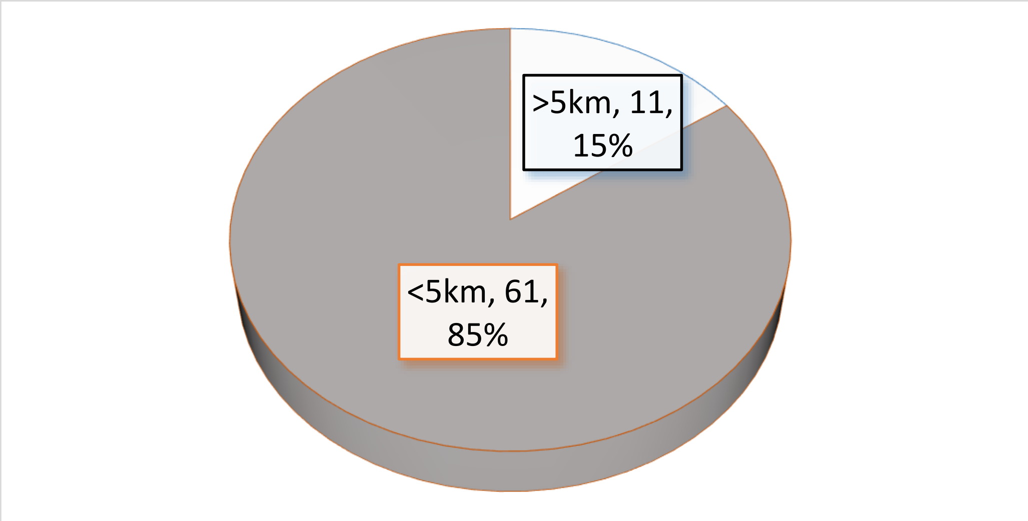

Figure I: How far the health facility is from respondent's house

Table 4: How much respondents paid for the various health care services

	N100	N200	N300	N400	≥ N500
Treatment of minor ailments	15 (15%)	5(5%)	28(28%)	22(22%)	30(30%)
Immunization	5(5%)	9(9%)	11(11%)	30(30%)	45(45%)
Geriatric services	18(18%)	30(30%)	25(25%)	19(19%)	8(8%)
Maternal and child health services	13(13%)	11(11%)	18(18%)	30(30%)	28(28%)

Figure I indicated that 85% of the users live in areas more than five kilometres from the health facilities while 15% live within 5km and less from the health facilities. Also, in Table 4 on how much they pay for the services, majority of the users indicated that treatment of minor ailments and immunization were the most frequently used services and the most expensive (30% and 45% respectively).They pay more than five hundred naira for each treatment received.

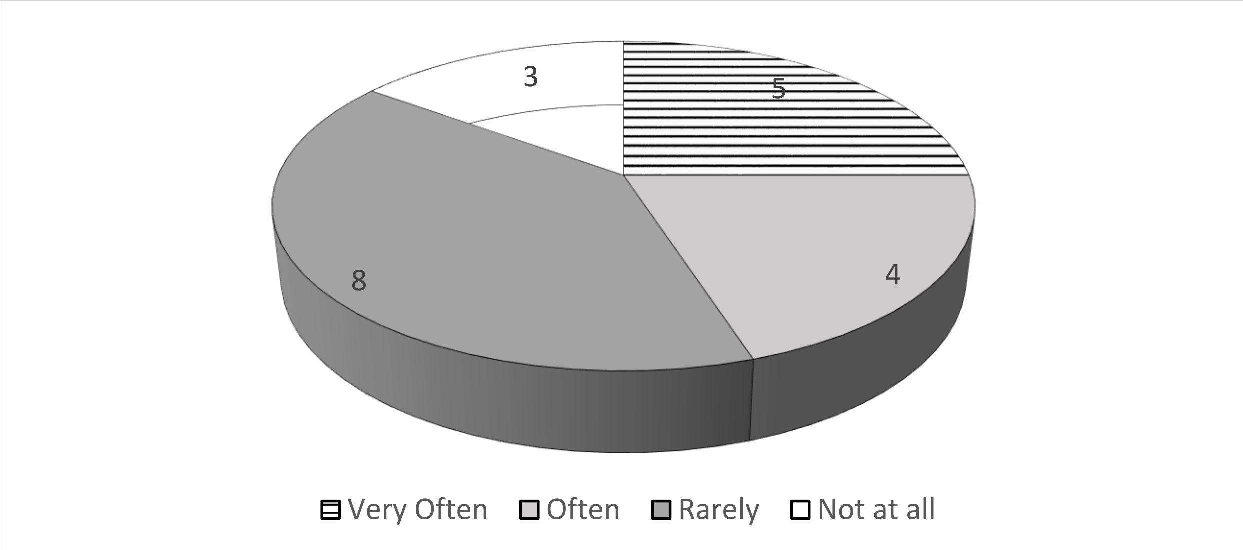

Figure II: Extent of utilization of health services

Table 5: How respondents perceive flooding as affecting their utilization of health services

	Health Care Providers	Health Care Users
Damage to the facilities	17(85%)	80(80%)
Damage to road leading to the facilities	20(100%)	100(100%)
Shortage of health staff due to transfers	12(60%)	70(70%)
Non availability and high cost of drugs	20(100%)	100(100%)

From the findings of the study, Table 5 shows that majority (40%) were of the opinion that the health services are not often utilised. However 15% agreed that the facilities are not used at all.

Furthermore, all users and providers of health care services indicated that damage to the roads leading to the facilities; none availability of drugs and high cost of the available drugs affected the utilization of facilities after flooding. However 80% of the users and 85% of the providers agreed that damage to the facilities affected utilization of the facilities.

DISCUSSIONS

Majority of the people did not have a good knowledge of causes of flood. There was, therefore, evidence of poor knowledge of flooding as 16% of the users do not even know what flooding is all about. This group of respondents said they just saw that everywhere was filled with water and they attributed the mishap to “evil in the world”. Majority of the young people did not have a good command of flood knowledge. This could be attributed to their inexperience. This finding matches those of [10] which acknowledge that knowledge lack accountability within communities themselves especially with the younger generation. Also [14] agreed that there is gap in knowledge which ought to be studied. They further stated that flood memories and associated informal knowledge and heritage have potential for social learning for public/community resilience to flooding. This often poses questions as to how such flood memories and informal knowledge impact on communities’ capacities to prepare for, and recover from floods. They concluded that flood knowledge is critical in understanding the complexity of physical flood processes and in making informed comparisons between flood modelling and the flood as experienced on the ground.

The findings indicated that all respondents accepted that all the services were provided and clinics were opened at least twice a week. This agreed with the study by [16] that a health system serving the medically underserved can prove resilient and display improved adaptive capacity under adverse circumstances to ensure access to primary health care for vulnerable subgroups.

Long distance travel to access health care was in agreement with the United States Institute of Peace [17] which reported that the Universal Declaration of Human Rights states that everyone has the right to adequate medical care and other physiological needs. Restoring access to medical care is therefore necessary after flooding to ensure the survival of the affected population. This agrees to [16] that posited the fact that flooding can disrupt health care services by restricting the movement of either staff or patient to the health care facilities. Providing access to medical care is essential during flooding to ensure the survival of the affected population.

Treatment of minor ailment as the most frequent health care services available to the settlers could be attributed to the fact that these services generate Internal Revenue (IGR) for these facilities based on the Drug Revolving Funds (DRFs) in which, after an initial capital investment, drug supplies are replenished with monies collected from the sales of drugs. The inaccessibility of health care for some of the flood displaced persons showed the facilities were not used at all by these respondents. This result was contrary to Domino, Fried, Moon, Olinick, and Yoon [3], which noted that there is significantly more hospital use following flooding by residents. Damage to the roads leads to the facilities; none availability of drugs and high cost of the available drugs affected the utilization of facilities after flooding. The high rate of damage to facilities which in turn hindered respondents' utilisation of the care services is worrisome. However, this finding was contrary to Runkle, Zhang, Karmaus, Brock-Martin, and Svendsen, [16], which documented secondary surges in primary care volume in the weeks and months post disaster.

CONCLUSION

Majority of the people did not have a good knowledge of causes of flood. Flood knowledge is critical in understanding the complexity of physical flood processes. All the respondents (100%) agreed that health care services were provided. Providing access to medical care is therefore necessary during flooding to ensure the survival of the affected population. Damage to the roads leading to the facilities; none availability of drugs and high cost of the available drugs affected the utilization of facilities after flooding.

Adequate planning is vital to minimize the health effects of floods: using a wide, multisectoral, all-hazards approach to emergency preparedness in developing local plans that include public health and primary health care. There is a need to strengthen the capacity of health care providers to create awareness and to promote food security, water and environmental sanitation and health services within the community. This can be done by ensuring that health services are available and accessible. People should be assisted in accessing health information, highlighting the need for health promotion and flood warning activity.

Recommendations

- Adequate plans should be made to build health facilities in appropriate areas avoiding flood plains, structural protection and flood-proofing of health care facilities.
- There should be information and communication strategies, particularly to reach the people most at risk and most vulnerable (such as those with chronic diseases, who require continuous treatment).
- Additional funding, staff and staff training to respond effectively to flooding is required for itt was evident from the results that health facilities are underutilized.
- Behaviour change modification through health education is vital for all to imbibe positive health protecting and environmental friendly practices.

REFERENCES

1. Don Okpala, U. V. (2012). The environmental effects of flood disaster in Anambra State. Retrieved July 5, 2013 from http://www.pelagiaresearchlibrary.com/
2. Alison, R., Alexander, D., Leonard, R. B. & Stringer, L. W. (1993). Analysis of medical treatment at a field hospital following hurricane Andrew. Retrieved July 5, 2013 from http://www.ncbi.nlm.nih.gov/pubmed/8214863
3. Domino, M. A., Fried, B., Moon, Y., Olinick, J., & Yoon, J. (2003). Disasters and public health safety net: hurricane Floyd hits the North Carolina Medicaid programme. American Journal of Public health. 93,7,1122-1127.
4. Center for Ecology & Hydrology (CEH) (n.d.).Integrated Science for Our Changing World: Understanding Floods. Retrieved July 26th ,2013 from http://www.ceh.ac.uk/products/publications/documents/understandingfloods_brief_lowres.pdf
5. Intergovernmental Panel on Climate Change (IPCC, 2007). Climate change 2007- the physical science basis: contribution of working group 1 to the fourth assessment report of the Intergovernmental panel on climate change. Cambridge University Press Cambridge. Retrieved July 7,2013 from http://www.ipcc.ch/pdf/presentations/himalaya-statement-20january2010.pdfhttp://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml#.UhIMuvm1Hw4
6. Ministry of Environment. Federal Republic of Nigeria (MOE, FRN, (2003). Nigeria's first national communication under the United Nations Framework Convention on Climate Change (UNFC). Abuja. Retrieved July 6, 2013 from http://www.scholarlyjournals.com/sjas/archive/2013/may/pdf/Nnadi%20et%20al. pdf
7. Maibach, E. W., Chadwick, A., McBride, D., Chuk, M., Ebi, K. L. and Balbus, J. (2008) Climate Change and Local Public Health in the United States: Preparedness, Programs and Perceptions of Local Public Health Department Directors. PLoS ONE 3(7): e2838. doi:10.1371/journal.pone.0002838
8. Few R., Kovats, S., Matthies, F., & Ahern, M. (2004). Floods, health and climate change: a strategic review. Tyndall Centre for Climate Change Research, Retrieved August 6, 2013 from http://ec.europa.eu/health/climate_change/extreme_weather/ flooding/index_en.htm).
9. Doswell III, C. A. (n. d.). Flooding. Retrieved July 26th, 2013 from http://www.flame.org/~cdoswell/publications/Flooding_EncycHoltonpdf

10. Bhatta, B. R. (1999). Rehabilitation of degraded lands. (In Nyakundi, H., Mogere, S. Nwanzo, I. &Yiteambe, A. (2010). Community perceptions and to flood risk in Nyando district, Western Kenya. Retrieved August 2, 2013 from www.jamba.org.za/index.php/jamba/article/viewFile/35/35.

11. Nyakundi, H., Mogere, S. Nwanzo, I. &Yiteambe, A. (2010). Community perceptions and to flood risk in Nyando district, Western Kenya. Retrieved August 2, 2013 from www.jamba.org.za/index.php/jamba/article/viewFile/35/35.
12. SERA (Strengthening Emergency Response Abilities). (2000). In Nyakundi, H., Mogere, S. Nwanzo, I. &Yiteambe, A. (2010). Community perceptions and to flood risk in Nyando district, Western Kenya. Retrieved August 2, 2013 from www.jamba.org.za/index.php/jamba/article/viewFile/35/35.
13. Yamano, T. & Jayne, T. (202). In Nyakundi, H., Mogere, S. Nwanzo, I. &Yiteambe, A. (2010). Community perceptions and to flood risk in Nyando district, Western Kenya. Retrieved August 2, 2013 from www.jamba.org.za/index.php/jamba/article/viewFile/35/35.
14. Ehlert, J. (2007). Local and global knowledge on flood management. Retrieved August 8, 2013 from http://www.zef.de/fileadmin/downloads/forum/docprog/ Term papers/2007_1_Ehlert.pdf
15. McEwen, L., Krause, F., Hansen, J. G., & Jones, O. (2012). Flood histories, flood memories and informal flood knowledge in the development of community resilience to future flood risks. Retrieved August 8, 2013 from http://www.hydrology.org.uk/assets/2012%20papers/McEwen_34.pdf
16. Runkle, J. D., Zhang, H., Karmaus, W., Brock-Martin, A. &Svendsen, E. R. (2012). Prediction of unmet primary care needs of the medically vulnerable post-disaster: an interrupted time series analysis of health system responses. International Journal of Environmental Research and Public Health. 9, 3384-3397.
17. United States Institute of Peace (n. d.). Access to and delivery of basic needs services. Retrieved August 9, 2013 from http;//.www.usip.org/guiding-principles-stabilization-and reconstruction-the-web-version/10-social-well-being/access-and-

Health Impact of Climate Change on African Women and Adaptation Strategies

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ABSTRACT

Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. There is more than 90% probability that human activities over 250 years have warmed the planet. The United Nations intergovernmental panel on climate change concludes that over consumption of food, material goods, fossil fuels and non renewable resources are putting a huge toll on planet exceeding its capacity to sustain us. Naturally occurring gases in the atmosphere, known as greenhouse gases – this includes carbon dioxide (CO2), trap this heat like a blanket, keeping the Earth at an average of 15 degrees Celsius – warm enough to sustain life and the overuse of fossil fuels increases the CO2 in the atmosphere, trapping more and more heat and warming the Earth. As a result, we are seeing more dramatic weather patterns across the globe resulting in devastating natural disasters and shrinking the world's ice shelves and glaciers due to warming sea water. When floods strike or droughts persist, women are among the first to feel the impacts on their livelihoods, health and daily lives. As managers of household resources, they may struggle to secure water, fuel and food. As small-scale farmers—the vast majority in some areas of the world—they have far fewer resources than men to cope with crop failures or pursue methods of farming more adapted to climate shifts. As migrants and refugees pushed from areas of climatic stress, they confront greater risks of disease and violence. Climate change is a significant and emerging threat to public health, especially to women and requires adaptation strategies.

Keywords: Health Impact, Climate Change, Africa, Women, Adaptation Strategies.

INTRODUCTION

The earth's climate has changed many times in response to natural causes, however since the 1900s our climate has changed rapidly due to persistent man made changes in the composition of the atmosphere or land use (African women's Development and Communication Network, 2013).

Intergovernmental Panel on Climate Change (IPCC) refers to climate change as any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines “climate change” as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (WHO, 2009).

The United Nations intergovernmental panel on climate change concludes that over consumption of food, material goods, fossil fuels and non renewable resources are putting a huge toll on planet exceeding its capacity to sustain us. Naturally occurring gases in the atmosphere, known as greenhouse gases (this includes carbon dioxide (CO_2)) , trap this heat like a blanket, keeping the Earth at an average of 15 degrees Celsius – warm enough to sustain life and the overuse of fossil fuels increases the CO_2 in the atmosphere, trapping more and more heat and warming the earth. As a result, we’re seeing more dramatic weather patterns across the globe resulting in devastating natural disasters and shrinking the world’s ice shelves and glaciers due to warming sea water. Because ice acts as a solar reflector, the less ice, the less heat the Earth reflects. Women and men face different vulnerabilities to climate change and environmental degradation. (Earth Hour, 2013).When floods strike or droughts persist, women are among the first to feel the impacts on their livelihoods, health and daily lives. As managers of household resources, they may struggle to secure water, fuel and food. As small-scale farmers—the vast majority in some areas of the world—they have far fewer resources than men to cope with crop failures or pursue methods of farming more adapted to climate shifts. As migrants and refugees pushed from areas of climatic stress, they confront greater risks of disease and violence. During disasters that follow natural hazards, they count higher among the dead. Climate change is a significant and emerging threat to public health, especially to women. Generally women bear a disproportionate burden of climate change consequences such as decreased food security, impact on livelihoods, water resources-shortage and access and as primary care givers, increased burden of care giving.

Karanja (2013) reported that experts have been analyzing the vulnerability of different sectors of economies due to climate change. In many parts of Africa, climate change threatens to unravel women’s lives putting to danger decades of efforts aimed at improving women’s lives and livelihoods. Unfortunately, women in rural areas lack knowledge on the imminent dangers posed by climate change. Despite the fact that women living in poverty are the most threatened by the dangers that stem from global warming, they are also key actors in ensuring their communities’ ability to cope with and adapt to climate change. In general, women’s lives are more intimately connected to the environment more than men.

There is an urgent need to increase women's economic equality, not only to reduce their vulnerability to the effects of global financial crisis but also as part of the effort to support equality in other priority areas including participation in all levels of decision-making and elimination of violence against women (Karanja, 2013). The effects of climate change on a region are the same for all its inhabitants but men and women have different assets and resources at their disposal to tackle these effects. Women are therefore more vulnerable, and the impact on their livelihood is greater (Gonzalez and Belemvire, 2011).

Experts said global warming may bring some localized benefits in certain areas, the overall health effects of a changing climate are likely to be overwhelmingly negative. Climate change affects social determinants of health - clean air, safe drinking water, sufficient food and secured shelter. (African Women Development & Communication Network, 2013).

CLIMATE CHANGE AND HEALTH

The major global environmental changes significantly affecting health according to WHO (1996) and McMichael (1996) include climate change and ozone layer depletion. Developing countries, like Nigeria have most vulnerable effects of climate change, Nigeria particularly; because of its dependency on climate-sensitive resources. The primary activity in Nigeria that adds to climate change is the release of harmful substances into the atmosphere from the oil and gas extraction sector, mainly from gas flaring throughout the Niger Delta and off shore. The secondary activity is the cutting of trees and loss of forest from logging and the use of trees as firewood and for wood-products. In fact, Nigeria destroys about 600,000 hectares of her forest annually in feeding these industries (Nwoke & Nwoke, 2008). And these have greatly affected the whole range of socioeconomic life of our people. Direct impacts of climate change stem from extreme events such as heat waves, floods, landslide, droughts, windstorms, and wildfires. Indirect effects of climate change on health may arise from the disruption of natural systems, causing infectious diseases, malnutrition, food and water-borne illnesses, and increased air pollution (Nwoke et al, 2005)

HEALTH IMPACT OF CLIMATE CHANGE

a) Heat waves and Ultra Violet Radiation (UV radiation)

Directly, an increase in mean summer and winter temperatures would mean a shift of the thermal-related diseases and deaths. National Science and Technology Council of USA (2008) reported that there has been a 50% increase in the number of unusually warm nights, which deprives the body of breaks from the heat. These lead to death, especially in the cities. There is evidence that vulnerability varies by sex, more women than men died during the 2003 European heat wave (WHO 2009),

Low-income families are especially vulnerable to heat because they may have less access to adaptive features (Hoerner and Robinson, 2008). Heat wave and UV radiation increase mortality, and women are more at risk in relative and absolute terms of dying in such events (Kovats and Hajat, 2008).

(b) Sea level rising/floods, Droughts, & Wildfires

Increase in temperature contributes to sea level rises, and precipitation is becoming heavier in and more variable in many regions. The vulnerability is differentiated by social dimensions. Saline contamination of dinking water sources affected pregnant women resulting to hypertension, Pre-eclampsia and Eclampsia, though no formal epidemiological study was done, this was by doctors blamed on salinity (Khan et al, 2008). Flooding is equally associated with stress related illnesses.

Human settlement is affected by climate change in a variety of ways. These include extreme climatic changes such as sea level rise, tropical storms, flood, landslides, winds, heat and cold. It has already threatened the facilities of low-lying coastal populations at risk, as evidenced in Lagos, Nigeria and some of the coastal communities in the Niger Delta region in Nigeria.

Sea level rise has disrupted urban and rural population and led to their relocation. Again, the intense rainfall has continued to increase the risk of flooding, which introduces chemicals, pesticides, and heavy metals into water systems and increase the risk of water-borne disease outbreak- causing high mortality and morbidity, especially among women and children.

Women and Children mostly suffer from nutritional imbalances. Droughts as a result of climate change destroy crops and grazing land, reduce the quantity and quality of water resources and cause famine because they ruin crops; consequently resulting to malnutrition. In fact drought exacerbates extreme poverty and hunger and women are the worse hit. Pregnant and lactating women face additional challenges, as they have an increased need for food and water, and their mobility is limited. Globally, at any given time, an average of 18–20% of the reproductive age population is either pregnant or lactating (Röhr, 2007).These biological factors create a highly vulnerable population within a group that is already at risk (Shrade & Delaney, 2000).

The frequency and intensity of wildfires have been increased by drought. In addition to destroying homes and property, these wildfires can cause eye and respiratory diseases (National Science and Technology Council of US, 2008). It also leads to post-traumatic stress disorder, grief, depression, anxiety disorders, and drug and alcohol abuse. The group mostly affected are women.

Indirect impacts

(a) One of the major indirect impacts of global climate change upon human health could occur via effects upon cereal crop production. Cereal grains account for around 66% of all foodstuffs consumed by humans. These impacts would occur via the effects of variations in temperature and moisture upon germination, growth, and photosynthesis, as well as via indirect effects upon plant diseases, predators-pest relationship, and supplies of irrigation water. Globally, approximately 800 million people are currently undernourished. Climate change is likely to further affect food production, distribution, and storage, especially in sub-Saharan Africa (Epstein, 2005). Resource scarcity coupled with population growth can lead to war, political instability, poverty, substance abuse, crop failure, rising consumer prices, and the disruption of social structure. This again makes it difficult to ensure environmental sustainability and eradication of extreme poverty and hunger in affected areas. When there is such resource scarcity, famine and war the women are mostly affected.

(b) Food and Water-borne Diseases

Water-borne pathogens often act in concert through two major exposure pathways: drinking water and recreational water use. WHO (1996) noted that with global climate change, outbreaks of food and water-borne infectious diseases such as diarrhea, *Cryptosporidium, Giardia, Salmonella, E. coli,* and rotavirus are projected to increase. These diseases occur as a result of the contamination of water supplies through the disruption of water and sanitation systems, which can be caused by toxic runoff from increased rainfall and flooding (Patz, 2005; Kovats et al., 2004). Developing countries are particularly susceptible to this, as water carries wastes, shallow water provides breeding conditions for mosquitoes, and drainage and sewage systems can become backed up. Water treatment facilities can become damaged, which can result in the distribution of untreated or improperly treated water. Sewer and water pipes can break, which can cause drinking water to become contaminated with sewage. Floods can also transport fecal matter from the ground or sewers that have over flown, and contaminate wells, boreholes and surface waters. Children are especially vulnerable to food and water borne-diseases because they are more likely to die from dehydration from diarrhea and vomiting. Minority children and children of lower socioeconomic status in areas that lack adequate capacity to provide food and water supplies are at the greatest risk (Kovats et al, 2004)

It is clear that in areas affected by food and water-borne diseases, it will be very difficult to achieve reduced child and maternal mortality and morbidity or to combat diseases. In view of the fact that women and children are most vulnerable to these diseases, universal primary education and gender equality and empowerment will be greatly hindered.

(c) Air Pollution and Aeroallergens

Extreme heat or higher temperatures cause ground-level ozone to increase, and short term exposure to ozone increases the rate and severity of asthma attacks, causes nasal and eye irritation, coughs, bronchitis, and respiratory infections. Again, higher temperatures enhance production of various secondary air pollutants and aeroallergens. Consequently, there is increase in the frequency of allergic and cardio respiratory disorders and deaths caused by these air pollutants. Urban air pollution may afterwards be costing a lot of people their health.

International Panel on Climate Change (2007) reported that children are more vulnerable to these effects because they take in more air per body weight than adults and have narrower airways. This therefore indirectly affects the mothers whose responsibility it is to take care of these children.

(d) Climate change and vector-borne diseases

The important determinants in the spread of vector-borne parasitic diseases are especially influenced by fluctuation in climatic variables, notably temperature, precipitation, humidity, surface water availability and wind as well as biotic factors. Against this background, the current climate change scenario is expected to cause widespread shift in the pattern of a number of infectious diseases and alter the life cycle dynamics of vectors and parasites (Nwoke et al, 2005). According to WHO (1996), vector borne diseases that are most likely to be affected by rising temperature are malaria (+++), schistosomiasis (++), river blindness/onchocerciasis (++) and dengue (++). Others that are less likely (+) include lymphatic filariasis, guinea worm, African and American trypanosomiases, leishmaniasis and yellow fever.

The influence of climate change on these vector-borne parasitic diseases can be direct or indirect on the vector biology. For instance, an increase in temperature accelerates the vector's metabolic rates, which consequently affects the nutritional requirement of the vector. Under such condition, the blood-sucking vectors, such as mosquitoes, sand flies and black flies feed more frequently, leading to increased egg production. This in turn increases the transmission potential of these vectors.

Other vector borne diseases have been observed to shift in their prevalence from known geographical boundaries. For instance, from 1953, the climatic conditions in the Sahel part of Africa (including Nigeria) have become drier and harsher; and as a result, the northern boundaries of tsetse fly and African trypanosomiasis distribution have shifted 50-100km southwards (Laveissiere and Hervouet, 1991). This no doubt has contributed to negative impact on the trypanosomiasis transmission and distribution in the Sahel region (Cattand, 1993). Linked also to higher temperature and low humidity is cerebro-spinal meningitis which endemicity boundary has now shifted southwards in Nigeria and leishmaniasis that hitherto none existing in Nigeria has now been reported in northern part of the country. Schistosomiasis is a major water-based parasitic disease and any climate change or environmental modification/degradation that affects the physical or chemical properties of the water bodies and human behaviour as well as the contact of man with snail-infested water bodies will definitely affect disease emergence and re-emergence (Prah & James, 1997; Nwoke at al, 2005; Nwoke & Nwoke, 2008).

These vectors borne diseases cause tremendous pain and suffering ranging from ulcers, internal damage and disabling anaemia, to gross deformities of face and limbs, blindness, brain damage and death. They constitute public health problem and intense human suffering, often among the poorest people on earth; rob people of their dignity, independence and hope (Nwoke & Oguariri, 1993).

As a cause of high mortality, they remove individuals' supply of labour years in the future; as a cause of disability, they withdraw the affected persons' potential supply of labour years (Benton, 1998). Desertation or depopulation of some major agriculturally fertile villages in Nigeria; and consequent population maladjustment has been attributed mainly to parasitic diseases (Nwoke, 1990). The resultant economic losses due to inefficiency, low productivity, absenteeism at work as well as the cost of caring for the victims of these endemic diseases are quite prohibitive (World Bank, 1993).

In areas where climate change provoke these vector borne diseases it will be difficult to eradicate extreme poverty and hunger, and the worse hit are women. Combating of endemic diseases in areas devastated by climate change can be very challenging.

CLIMATE CHANGE ADAPTATION STRATEGIES

Adaptation to climate change or indeed climate variability is dependent on issues such as wealth, technological power, access to information, all of which are major problem areas for women (Parikh, 2013). Earth's climate will continue to change, hence adaptation strategies must be considered to reduce disease burdens, injuries, disabilities and death. Adaptation actions are adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. And the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or cope with consequences is the adaptive capacity.

Case studies related to gender and natural disaster showed that women make an important contribution to disaster reduction, usually informally through participating in disaster management and acting as agents of social change. Women's resilience and women's networks are particularly important in household and community recovery (IPCC, 2007b).

We therefore present here the key recommendations for policies and programs to address climate change adaptation related to injury, disease and death related to natural disasters and heat waves, food borne, water borne and vector-borne illnesses; and premature death and disease related to air pollution as well as large human populations displaced by rising sea level, flood, drought and famine. These adaptive strategies when put in place will be of great help to man especially women who are the worse hit.

Immediate adaptive strategies

1. Rain harvesting and Bore holes

Extreme weather-related events can affect water availability, quality, or access, posing a threat to human populations. Rainwater harvesting and boreholes will create immediate alternative domestic water supplies, thereby reducing the outbreak of these water- and food borne diseases. The implementing agencies are the Communities, Local Government Areas, Water and Sanitation Authorities of countries and Federal Ministries countries in collaboration with UNICEF and other related agencies.

2. De-silting of earth dams and diversification of occupation

To reduce the malnutrition resulting from total dependence on rain fed agriculture, there is need for immediate de-silting of dams, especially earth dams. Also diversification of occupation of the population will reduce malnutrition and ensure good health. Ministry of Agriculture and River Basin Development Authority should lead in this adaptive strategy.

3. Immunization and treatment

In addition to vector borne diseases such as malaria, schistosomiasis, river blindness/onchocerciasis, dengue, lymphatic filariasis, African trypanosomiasis, leishmaniasis and yellow fever, other infectious diseases, especially water and food borne diseases (diarrhea, *Cryptosporidium, Giardia, Salmonella, E. coli,* and rotavirus) are on the increase or projected to be on the increase with climate change. The immediate immunization and or treatment of affected population or at risk population will help to minimize mortality and morbidity associated with these diseases. Local Government Areas, State and Federal Ministry of Health have leading role to play in this strategy. Sustainability of such programs can be achieved by community ownership of such control/preventive adaptations.

4. Distribution of insecticide treated nets

In-door biting insects transmit vector-borne diseases like malaria, dengue, lymphatic filariasis, and yellow fever; and the distribution and use of insecticide treated nets have proved very useful in their control and prevention. Like in immunization and treatment, Local Government Areas, and State and Federal Ministry of Health have leading role to play in this strategy. Again, sustainability of distributing these nets is achievable by community ownership of this adaptation.

5. Health Education and awareness

Public awareness on how to identify and manage health disorders associated with climate change in Africa has an immediate priority. Building capacity is an essential preparatory step in adaptive strategy in climate change. Education and awareness-raising enable people to take well-informed sustainable decisions necessary to effectively adapt to health impact of climate change. All the tiers of Government in various countries and communities are important in this strategy. There is immediate need for education and mass media campaigns strong enough to spark commitment and action among governments, international organizations, donors, civil society, business and communities, especially among the young people to anchor health at the heart of the climate change agenda. Support outreach activities, using gender-sensitive information, education, and communication strategies and materials for advocacy and training.

6. Maintenance of primary health infrastructure to be responsive
Immediate maintenance of primary health infrastructure specifically designed to reduce vulnerability to climate variability such as sanitation facilities, wastewater treatment system; laboratory buildings etc enhance adaptive capacity. Others include surveillance of diseases, early warning system for impending weather extremes (e.g. heat wave, storms) as well as disaster preparedness. The various Countries Federal, State and Primary Health Care Department working with LGAs and communities will definitely achieve the desired adaptation.

7. Provision of adaptive features against thermal related disorders.
Enhancing urban planning such as green spacing (planting tree within cities) and select materials with high albedo for roads, parking lots and roofs to reduce the urban "heat island" effect and reduce thermal related disorders. Implementation of climate-proofed housing design (shade, insulation, ventilation, and air conditioning) as well as implementation of work schedules for out door workers that avoid peak daytime temperature are also immediate adaptive strategies. Empowerment of women to strengthen their capacity to question and change harmful behavioural norms that put them at risk in the case of extreme events. All the tiers of Government and communities are important in this strategy.

Long-term adaptive strategies

1. Construction of water system with strong materials.
To reduce constant destruction of water pipes by flood and the consequent water contamination and outbreak of water and food borne diseases, the need to build water system with strong material becomes obvious. The commitment of individuals, LGA, State and Federal Water Boards and Public Utility in the countries is required to achieve this long-term strategy

2. Construction of sea level rising and flood control protecting structures

- To reduce the destructive impact of flood, the need for relevant Environmental Protection Agency policy to implement construction of flood protecting structure becomes very important. This will involve the implementation of engineering measures such as strengthening of sea-walls and ensure strict adherence to building regulations and standards in hurricane prone areas.
- The adoption of land-use planning to minimize erosion, flash flooding, avoidance of poor sitting of residential areas and deforestation will be of immense help.

3. Strengthen the primary health structure to be responsive to emergencies associated with climate Change

- In addition to health education, successful climate change adaptation requires information and skill. In general, countries and regions with more "human capital" or knowledge have greater adaptive capacity. Illiteracy increases a population's vulnerability to many problems. Health systems are labour-intensive and requires qualified and experienced staff, including those trained in the operation, quality control, and maintenance of public health infrastructure. This requires both immediate and long-term actions from all the tiers of government.

- Maintenance and strengthening of emergency management and disaster preparedness programme, including local public health service capacity to conduct rapid health needs assessment and to make psychological support interventions are very necessary.

4. Construction of new irrigation projects and facilities in drought prone areas

- With the establishment of irrigation projects in drought prone zones, agriculture will no longer be rain fed. This will lead to increased food production and consequently reduce malnutrition

CONCLUSION

Preparations for, and responses to, climate change need to be sensitive to gender dimensions of health care (including mental) and health-seeking behaviours. Adaptation strategies need to take into account women's and men's relative and different capacities, power, social resilience, vulnerabilities and resources, because gender norms, roles and relations can either enable or constrain adaptive capacities.

Equity and social justice cannot be achieved without recognizing the differences in vulnerability and strengths of women and men, and the various factors that contribute to vulnerability.Recognizing these differences is a necessary and important component of any prospective attempts to address the gendered health consequences of climate change. There is a need for the development of gender-responsive and accessible health services that reach the poorest populations, thereby addressing particular health needs of women a throughout their entire life-cycle.

REFERENCES

African Women Development and Communication Network (2013). How Climate Change Impacts your Health. All African Global Media.

Benton, B. (1998). Economic impact of onchocerciasis control through the African programme for Onchocerciasis control: an overview. *Ann, trop. Med. Parasitol* 92 (suppl.1):S33 – S3.

Cattand, P (1993). Human African trypanosomiasis: Meeting of interested parties on management and financing of the control of tropical diseases other than malaria, *CTS/MIP/WP/93.9.* WHO Geneva.

Earth Hour (2013). What is Climate Change? Earth Hour Global Community. Retrieved April 23, 2013 from www.earthhour.org

Epstein, PR (2005). Climate change and Human Health, *New England Journal of Preventative Medicine* 353: 1433-1436.

Gonzalez, AR and Belemvire, A (2001). Climate Change and Women Farmers in Burkina Faso: Impact and Adaptation Policies and Practices. Oxfam Research Reports. Retrieved April 22, 2013 from www.oxfam.org/grow.

Hoerner, JA and Robinson, N (2008) *A Climate of Change,* Oakland: The Environmental Justice and Climate Change Initiative, 2008, 11.

IPCC (2001) (International Panel on Climate Change*): What is Climate Change? Ministry of Environment and Forests.*

IPCC. (2007b). Climate change: Impacts, adaptation and vulnerability. Geneva, Intergovernmental Panel on Climate Change.

IPCC (2007) (International Panel on Climate Change, *Climate Change): Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. M. L. Parry et al. (Cambridge: Cambridge University Press.

Karanja W. (2013). Effects of Climate Change on Women in Africa. Yves Niyiragira. Retrieved April 23, 2013 from www. Google.com

Khan A et al. (2008).Saline contamination of drinking water in Bangladesh.*Lancet*, 371:385.

Kovats, RS et al (2004) "The effect of temperature on food poisoning: a time-series analysis of salmonellosis in ten European countries," *Epidemiology and Infection* 132: 443-453.

Kovats RS & Hajat S. (2008).Heat stress and public health: A critical review. *Annual Review of Public Health*, 29:41–55.

Laveissière, C & Hervouét, JP(1991). La trypanosomiase humaine en Afrique de I'ouest: Epidémiolgie et controle (Human African Trypanosomiasis in West Africa: Epidemiology and control). *ORSTOM,* Paris.

McMichael, AJ (1996). Human population health. In*: Climate Change 1995: Impacts, Adaptation and Mitigation of Climate change. Scientific Technical Analysis.* Watson, RT et al (Eds.) Cambridge University Press, Cambridge

National Science and Technology Council (2008), *Scientific Assessment of the Effects of Global Change on the United States,* Washington D.C.: Committee on Environment and Natural Resources, 2008).

Nwoke, BEB (1990). The socioeconomic aspects of human onchocerciasis inAfrica: The present appraisal. *J. Hyg. Epidemiol. Microbiol. Immunol.* 34(1): 37-44.

Nwoke, BEB & Oguariri, RM (1993). Tropical diseases: major obstacle to socioeconomic development in Nigeria. In: *Development Strategies for Nigeria.* 192-202. Aham Anyanwu & BEB Nwoke (Eds.) Alvan Global Publ. Nigeria

Nwoke, BEB; Anosike, JC; Ukaga, CN; Chukwuocha, UM; Nwoke, EA & Dozie, INS (2005). The impact of Nigerian environment and climate change on the epidemiology of malaria. *Medipharm Medical Journal* (Nigeria).2(3): 123-132.

Nwoke, B E B & Nwoke EA (2008). The impact of climate change on the emergence and r-emergence of parasitic disease. In: *Farming & Rural Systems Economics:* Climate Change and Adaptation in Nigeria (Germany)*.* 95:101-112.

Parikh, J (2013). Is Climate Change a Gender Issue. United Nations Development Programme (UNDP), India.

Patz, JA (2005). "Impact of regional climate change on human health," *Nature* 438: 310-317.

Prah, Sk & James, C (1997). The influence of physical factors on the survival and infectivity of miracidium of *S. mansoni* and *S. haematobium 1:* Effect of temperature and ultra-violet light *J. Helminthol*. 51:73:85.

Röhr U. (2007) *Gender, climate change and adaptation: Introduction to the gender dimensions*. Background paper prepared for Both Ends briefing paper Adapting to climate change: How local experiences can shape the debate.Berlin, Genanet.

Shrade E, Delane P. (2000). *Gender and post disaster reconstruction: The case of Hurricane Mitch in Honduras and Nicaragua*.Washington, World Bank

WHO (1996). *Climate Change and Human Health*. A.J. McMichael; A, Haines; R. Slooff & S. Kovoits (Eds.). (WHO/EGH/96.7), WHO Geneva.

World Bank(1993). *World Bank Development Report 1993: Investing in Health.* Oxford University Press, Oxford, UK.

WHO (2009). Gender, Climate Change and Health. Retrieved April 23, 2013 fromwww.un.org

The Effect of Climate Change and Urbanization on Mosquito Larval Populations and Ecology in the Ashanti Region of Ghana

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ABSTRACT

Introduction: Poor management of the urban environment coupled with the effects of climate change affects the physic-chemical parameters of breeding sites and hence mosquito larval populations. In the Ashanti region the cities are becoming urbanized at different rates and this will determine to a large extent the types of vector species that may breed in those areas. Climate change is expected to impact significantly on disease transmission and availability of adequate breeding sites. The physio-chemical parameters give an idea of pollution of the breeding sites and this will definitely affect larval development and fecundity. The intent of this study was to enable the formation of control strategies against these vectors through proper environmental planning and that will reduce larval habitats and make them less attractive to the mosquito adults.

Methods: The study took place in three selected communities in the Ashanti Region which is in the forest belt of Ghana, a highly malarious region. A total of 154 water bodies were identified and sampled for immature mosquitoes, the immature mosquitoes were then cage reared. The necessary environmental features of all breeding sites, and the physico-chemical parameters recorded. Data on climatic variables eg temperature and rainfall were obtained from Meteorological Station for each study area.

Results: A total of 1,482 larvae were collected from the breeding sites in both the dry and wet season. Habitat depth and presence or absence of of canopy cover influenced larval type and abundance. Culicines immature densities were higher than densities of Anopheles and this shows that These mosquitoes were highly adaptable and tolerated a wide range of temperatures. Temperature of breeding sites and most physio-chemical parameters did not influence the occurrence of mosquitoes. Anopheles mosquitoes preferred bodies of water that had high temperatures > 28^{o}C it was also observed that water bodies that had high colour values had high TDS (total dissolves solids) and high conductivity supported the least number of Anopheles mosquitoes breeding in it. Most adult mosquitoes collected in months with high rainfall values resulted in very low sporozoite rates. More mosquitoes were found breeding in Urban areas than in Rural areas.

Conclusion: That rapid unplanned urbanization has an impact on the natural ecosystems cannot be ignored. Various species adapt to existing situations and breed in these bodies of water. Climate changes also affect choice of breeding sites and this has major implication for vector control which may guide policy makers.

Key Words: Urbanization, Climate change, Physio-chemical parameters, Vectors

Climate Change: Potential Effects on Pregnancy Outcome and Its Controlling Strategies in Southeast of Nigeria

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ABSTRACT
The paper studied on climate change: potential effects on pregnancy outcome and its controlling strategies in southeast of Nigeria. The study adopted a survey research design. The population ion comprises of educated women, health officers and pregnant delivering women in southeast of Nigeria. Proportionate stratified random sampling was used in determining the sample size, where the elements were drawn randomly from each stratum in such a way that the relative parent proportions of the strata in the resultant sample were the same as in the parent's population. Sample size of 1,500 was determined by sampling academic women and pregnant women from each of the different state in Nigeria. A fifty four items Questionnaire was used for data collection. Data collected were analyzed using frequency, and mean. The findings include: factors that affects climate change in southeast of Nigeria, potential effects of climate change on pregnancy outcome in southeast Nigeria, and strategies for controlling pregnancy outcome in southeast Nigeria. Recommendations on factors that affect climate change, potential effects of climate change on pregnancy outcome, and strategies for controlling pregnancy outcome of climate change in southeast Nigeria were made based on the research findings.
Keywords; climate change, potential effects, pregnancy outcome, controlling strategies

INTRODUCTION

Climate change is a global change in weather conditions over a period of time. According to Wikipedia, the free encyclopedia (2013) Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods. It may be a change in the average weather conditions or in the distribution of weather around the average conditions (i.e. more or fewer extreme weather events). Climate change is a natural processes of ocean circulation, variations in solar radiation received by earth, plate tectonics and volcanic eruptions and as well as human induced alteration of the naturalists of the world. The effects of these natural processes and human alteration of the world makes climate to change. Consequently, Climate change, considering the long period of time, can be a change in the statistical properties of the Climate system. Climate change is a global effect that is caused by natural and human activities. Natural changes can influence climate change; changes within the sun and changes in earth's orbit. According to NRC (2008) and USGCRP (2009))'changes occurring in the sun itself can affect the intensity of the sunlight that reaches earth's surface. The intensity of the sunlight can cause either warming (during period of stronger solar intensity) or cooling (during periods of weaker intensity). NRC (2010) further identified that the earth's orbit, the tilt and position of the earth's axis can affect the amount of sunlight to earth's surface. Again the interaction of the ocean and the atmosphere is a very aspect of weather problem in the world. This is referred as the ENSO cycle which is characterized by coherent and strong variation in the sea surface temperature, rainfall, air, pressure, and atmospheric circulation across the equatorial pacific affect weather pattern. Again seasonal shifts in wind patterns and sea surface temperature in Atlantic can cause a change in climate.

Human activity is another strong factor that determines climate change. According to United Nations Enviromental Protection (1992) Climate change means a change of Climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural Climate variability observed over comparable time periods. This can be observed when the earth's energy balance is not in equilibrium, there must be a change in the climate system. This is because earth's temperature are as a result of equilibrium between energy input and output of the planet system, when input energy from the sun is absorbed by earth system, Earth warms and when the suns energy is released back into space, Earth cools. Therefore different factors, determine climate change and it is both natural and human. These factors are regarded as global warming. It is a global warming because there is a global change in the Climate as a result of the Greenhouse effect.

Greenhouse effect is the human activities or expansion that causes carbon base gases in the atmosphere to block heat from escaping and these long lived gasses remain one way or another permanent in the atmosphere. According to the United State Global Research Program (2008) they are described as **forcing** climate change, they respond to no chemical or physical reaction. This heats the ozone layer (that prevents rays of the sun) and causes free passage of the sun (due to lack of trees) it continues heating the ozone layer causing global warming or climate change. When the temperature increases, it causes flowing by melting the polar region that are full of ice and cause water to flow into rivers and seas leading to flood. They are generally called the **Greenhouse gases**. Such gasses are water vapour, which causes feedback (i.e. increases as earth warms) so are the clouds and precipitates, carbon dioxide (co2), methane, nitrous oxide, chlorofluorocarbons (CFCs), hydro chlorofluorocarbon (HCFCS). Per fluorocarbons (PFCs), sulphur hexafluoride (SF6). They are generally called **F- gases,** Trospheric ozone (o3) (United State Global Research Program (2009). According to the scientists, carbon dioxide gas is the greenhouse gas that is causing recent climate change because of human activities; burning of fossil fuel and changes in land use, release large amounts of carbon to the atmosphere, causing carbon dioxide concentration in the atmosphere to rise. According to NRC (2010) atmospheric co2 concentration have increased by almost 40% since pre-industrial times, from approximately 280 parts per million by volume. Further, stated that human activities currently release over 30 billion tons of co2 into the atmosphere every year. These are as a result of human activities.

According to the global ocean observing system, observed that the greenhouse gasses seriously increased since the onset of industrial age. Further stated that the human activities like fossil fuel burning and deforestations is also a cause for example though atmospheric carbon dioxide is at highest concentration. Abysmal removal of trees in the forest (deforestation) is also a pilot to climate change. The loss in biological diversity increases greenhouse effect (e.g. green plants trap atmospheric carbon (IV) Oxide during photosynthesis though it is little with greenhouse). Therefore due to deforestation greenhouse gasses increases by 50% because of burning of coal, industrial gasses among others. Deforestation reduces the rate of absorption of carbon dioxide in the atmosphere and this lead to destruction of ozone layer by excess carbon dioxide in the atmosphere. Ozone layer being a layer of gasses that protect the earth from the high intensity of the sun are being heated and destroyed by the excesses carbon dioxide, since there is lack of trees due to deforestation; this means limited trees that will take in this carbon dioxide to release oxygen. Hence lead to excess carbon dioxide with less quantity of oxygen in the atmosphere. Deforestation also leads to drought condition causing erosion and this affect food production which creates famine.
Neel and Neel (2008) identified that as population increases, it leads to over use of limited resources, and there is depletion of soil nutrient and decrease of its life supporting abilities that guide the use of fertilizers, pesticides, herbicides, fungicides, bactericides, virucides among others for agriculture. Some of these contain mercury, arsenic, lead, Dieldrin, D.D.T, Aldrin, and chlorinated hydrocarbon. The chemical are extremely difficult to breakdown because they are non degradable. And they remain in the soil as a dangerous factor to the environment. These chemicals are agricultural waste, from soil and crops washed into streams, springs, rivers and ocean (Adekoya 1991). Further, stated that these chemicals not only cause death to aquatic organisms but also animals including man. O'Brien (1986) pointed out that pesticides are capable of causing cancer and liver damage in human beings.

Other pollutants are natural contaminants and are from forests and grasslands that are discharged into rivers and this polluted water is the major source of water supply. The contaminated water can cause enteric disease like typhoid, guinea worm, cholera. Enger and Smith (2004) argued that most of the land pollutants are from industrial solid wastes include; paper, packaging materials, resins, solvents, glass, ceramics, rubber, leather among others. They pointed; it has a wide range of environmental toxicity which is as a result of climate change. Taieba (2010) indentified that all these hazardous wastes have dominated environmental issues because of their potential to cause toxic effects on human health and the environment. and can be seen as caused by industrial development. Industrial and technological development today is a great pollution in the environment that creates climate change. Miller (1984) identified that industrial and technological development leads to more use of machine to do factory work, has resulted to pollution. He further explained that pollution is the presence of impurities in an environment to the extent that it can no longer support life. The industrial and technological pollution are categorized into air, water and land pollution. But the major source of air pollution is smokes from the automobiles, factory chimneys among others. These lead to atmospheric fouling. For example a gallon of petroleum consumed about three pounds of carbon (IV) Oxide and is discharged into the air. Most of these gasses remain as **acid rain** when dissolve by rain droplets. Hydrocarbon combustion of fuel oil (engine oil and petrol, cigarette smoke) is a cancer causing agent. When breath or taken by drinking water into the system will lead to certain problem. \

According to Chukwukere (2013) with biotechnology, roses are no longer crossed with just roses. They are mated with pigs, tomatoes with oak trees, butterfly with worms Chukwukere pointed out that technology that makes it possible is biolistics and if allowed to spread, fifty years ago, as few predicted that chemical pollution would cause so much vast environmental harm. She went on to assert that nearly one third of all species are threatened with extinction; again certain chemicals are used to improve certain plants genetically and are not sound for health. Chukwumere (2013) clearly pointed out that in 1996; the genes of Brazil nuts were genetically engineered with soybeans by a company called Pioneer Hi-Bred. Some individuals that ate these nuts developed severe anaphylactic shock that nearly leads to their deaths. Further in 1989, several Americans died after eating a genetically engineered version of food supplement called L-tryptophan. Others were severely impaired; the chemical company involved in the scandal according to Chukwukere (2013) was Showa Dnko (Mayeno and Gleich 1994) and they eventually agree to settle damages with two billion dollars. Therefore some chemicals used to improve certain supplements if not well modified may cause a serious harm.

In the world, food supplements pose a great change in the climate. Most people are no longer going green (using green sources) as a result of climate change (new technology). Individuals feel that it is a big deal going by supplements instead of natural sources. These pose a lot of health challenges. Most nutrients have been affected by chemicals that were used to improve the plant during production. They are no longer the same as when naturally produced (not improving with chemical). For example agricultural produce example apples are no longer what it supposes to be genetically; this is because chemicals use in producing them has taking part of it and are no longer 100% even when taken immediately. These generally affect individual health.

Climate change is a tremendous problem to individuals health especially with pregnancy outcomes example air pollution can lead to headache, dizziness, nausea, vomiting, loss of muscular control, mental dullness, decreased respiratory pulses, collapse, unconsciousness and often times death (Neel and Neel 2008).These have a serious pregnancy outcome these touched the writers to study on climate change; potential effects and controlling strategies on pregnancy outcomes. According to Rylander, Odland and Sandanger (2007) pregnant women, the developing foetus and young children are considered the most vulnerable and may have increased sensitivity to climate change. Further, published literature in climate change stated that human health, tropical diseases, and direct heat exposure are assessed through the regular search engines and it demonstrates that climate change will increase the risk of infant and maternal mortality, birth complications and poorer reproductive health especially in tropical developing countries. Rylander, Odland and Sandanger (2007) further, stated that effects of malnutrition, infectious diseases, environmental problems, and direct heat exposure on maternal health outcomes will lead to severe health risks for mothers and children. Further, Lancer commission in Rylander, Odland and Sandanger (2007) identified that climate change; lack of food and safe drinking water, poor sanitation, population migration, changing disease patterns and morbidity, more frequent extreme weather and lack of shelter influences health. Therefore, there is serious global problem which needed immediate strategic control which pregnancy outcome is the main, which is the target of this study. According to Micheel, Roses and Desal (2005) environmental perturbations in utero may permanently change organ structure and metabolism and alter homeostatic regulatory mechanism among offspring. Drought condition due to climate change can lead to famine and can affect a pregnant woman to deliver prematurely and the offspring may demonstrate low in birth weight which may demonstrate gender specific plasma hypernatremia, hyper toxicity and entrial hypertention (Rylander, Odland and Sandanger 2007).Therefore cause of climate change that affect pregnancy outcome needs to be controlled; therefore controlling strategies to prevent effects of climate change on pregnancy outcome will form the basics of this study thus, studying on the factors that affects climate change, Potential effects on pregnancy outcomes and its controlling strategies in south-east Nigeria

Purpose of the Study

The main purpose of this study is to determine climate change: potential effects on pregnancy outcome and its controlling strategies in southeast of Nigeria. Specifically the study intended to:

1. identify climate change in southeast of Nigeria

2. identify the potential effects of climate change on pregnancy outcome in southeast Nigeria.
3. identify the controlling strategies for climate change in Southeast of Nigeria.

This study sort answers to the following research questions:

1. What are the climate change in southeast of Nigeria?

2. What are the potential effects of climate change on pregnancy outcome in southeast Nigeria**?**
3. What are the controlling strategies for pregnancy outcome in Southeast of Nigeria?

Design of the study

The study utilized a survey design to collect relevant information for the study. It was focused on the people, their opinion, motivation, attitude and behaviour. This was to collect relevant information on analysis of the selected information on climate change; potential effects on pregnancy outcome and its controlling strategies in southeast of Nigeria. It was calculated from answers elicited from respondents through questionnaires.

Area of the Study

The study was carried out among the capital cities of the five states in the southeast Nigeria comprising of Anambra, Ebonyi, Enugu, Abia, and Imo state. These states have their local government areas that accommodate all tribes and communities in Nigeria. The capital cities in these states Southeast Nigeria remained the study area since relevant information used on the analysis of the study was obtained.

Population for the study

The population for the study comprises of three groups; health officers, the educated women and pregnant delivering women. Their actual population comprised a total number of three thousand, two hundred (3,200) respondents. The population of each of the state was collected from the different state capital (**source: personnel office of the state's education & state general hospitals)**.

Sample for the study:

The sample size was made up of three groups: the health officers, the educated women and the pregnancy delivery women. The sample size was determined using proportionate stratified random sampling. Where the capital of all the five states was sampled as well as the state's education and the general hospitals in these states were sampled thus:

State	**City**	**No of health officers**	**No. of Educated women**	**No. of pregnant delivery women**
Abia	Umuahia	10	240	35
Anambra	Awka	10	330	33
Ebonyi	Abakaliki	10	240	47
Enugu	Enugu	10	340	65
Imo	Owerri	10	290	30

Therefore the total sample size ```` used for the study was 1,700.

Instrument for data collection:

The instrument used for data collection was structured questionnaire. The questionnaire items were produced based on the information collected from the review of related literature. The questionnaire was made up of three sections 1 - 3 with fifty four (54) items on a five point scale of strongly agree, agree, undecided, disagree and strongly disagree with assigned scores of 5, 4, 3, 2 and 1 respectively. Research question 1-2 was administered to all the respondents, while research question 3 was administered to only health officers in the states capital. The instrument was subjected to face validation by producing draft copies of the questionnaire. This was given to three experts in the field of science education in Anambra state who critically examine the items included with the specific purpose of the study and made useful suggestions that improved the quality of the instrument. Their recommendations, advice, suggestion and observations were used to review the questionnaire items. To determine the reliability of the instrument, the questionnaire item was administered to five educated women and five pregnant delivering women in another different state Rivers state. This was to ensure that the respondents used in the reliability testing were excluded from the study sample. Their responses was subjected to reliability test using Cronbach alpha coefficient which result was 0.78 and was considered reliable for it to be used in collecting data for the study.

Data collection and analysis techniques:

One thousand, seven hundred (1,700) questionnaires were administered by hand to the respondents by the researcher with the help of research assistants in each state capital. However, one thousand five hundred (1,500) were returned. Frequency counts and mean were used to analyze the data collected. Any item with a mean score of 3.50 and above was regarded as agreed. Similarly, any item scored below 3.50 was regarded as disagreed.

FINDINGS

The following findings were made.

In Table one, there were sixteen items that was accepted as factors that affect climate change in southeast of Nigeria.

Table two has nineteen items accepted as potential effects of climate change on pregnancy outcome in southeast Nigeria.

Table 3 has also twenty items that were accepted as controlling strategies for **c**ontrolling pregnancy outcome of climate change in southeast Nigeria. See tables below:

Table 1. Mean Responses on factors that affect climate change in southeast Nigeria.

S/no.	factors that affect climate change in southeast of Nigeria include:	X	Remark
1	high intensity of the sun	4.38	Agreed
2.	constant rain	4.50	Agreed
3.	floods /drought condition	4.75	Agreed
4.	deforestation	4.45	Agreed
5	air pollution	5.01	Agreed
6	water pollution	4.85	Agreed
7	animal dropping	3.50	Agreed
8	hydrocarbons from automobile	3.54	Agreed
9	factory chimneys	4.20	Agreed
10	Chemicals (e.g. pesticide. lead, Dieldrin, D.D.T, Aldrin,)	4.75	Agreed
11	Greenhouse gases (e.g. water vapour precipitates, carbon dioxide, methane, nitrous oxide among others)	4.60	Agreed
12	fossil fuel	3.85	Agreed
13.	changes in land use,	4.20	Agreed
14.	Industries / technology	4.85	Agreed
15	atmospheric circulations across the equatorial pacific	3.85	Agreed

The respondents in table 1, strongly agreed that the above items are factors that affect climate change in southeast Nigeria. Since all the items are accepted.

Table2. Mean responses on potential effects of climate change on pregnancy outcome in southeast Nigeria.

S/no.	potential effects of climate change on pregnancy outcome in southeast Nigeria include:	X	Remark
16	hydrocarbon from automobiles can cause cancer	4.48	Agreed
17	delivering of low weight babies due to famine condition	4.22	Agreed
18	contaminated water due to acid rain cause diseases that affect the foetus	4.09	Agreed
19	fetal death/Stillbirth	4.03	Agreed
20	Preterm pre-eclampsia or eclampsia	4.02	Agreed
21	a clotting disorder (antiphospholipid antibody syndrome or a genetic thrombophilia)	4.32	Agreed
22	low birth weight as a result of lack of nutrient intake /famine condition	4.15	Agreed

23	alteration of homeostatic regulatory mechanism on the foetus due to disease of the mother	4.34	Agreed
24.	at times death of foetus / maternal due to disease condition	4.30	Agreed
25	Lack of micronutrient food sources intake due to flood	3.50	Agreed
26	Increase of diseases stimulate emotional and physical under development	4.45	Agreed
27	Deficiency of immunity due to low diet	3.75	Agreed
28	Stress leading to unhealthy condition due to high heat intensity	4.85	Agreed
29	Environmental toxicity causing diseases	3.75	Agreed
30	Gasses from acid rain causing cancer which may lead to death	3.65	Agreed
31	Breathing polluted air from automobiles affect foetal development	3.50	Agreed
32	Intake of polluted water causing diseases//infection.	3.85	Agreed
33	Poor reproductive health condition	3.65	Agreed
34	Maternal morbidity /mortality	4.15	Agreed

In table two above, the respondents accepted all the items. This is because all the items were above mean rating 3.50; above cutoff point of acceptance. This showed that they were all potential effects of pregnancy outcome in southeast Nigeria.

Table3. Mean responses on strategies for controlling pregnancy outcome of climate change in southeast Nigeria.

S/no.	strategies for controlling pregnancy outcome of climate change in southeast Nigeria include:	X	Remark
35	Constant antenatal visit**s**	4.55	Agreed
36	Counseling pregnant delivering mothers on climate change and their health principles	3.75	Agreed
37	Provision of safe drinking water	4.15	Agreed
38	Avoiding poor sanitation	4.02	Agreed
39	Sufficient availability of food nutrient sources	3.80	Agreed
40	Planting of trees to avoid direct heat /for shelter	3.75	Agreed
41	Good nutrition	4.03	Agreed
42	Careful cleanliness	3.54	Agreed
43	Micronutrient food sources intake (vitamins & minerals)	3.65	Agreed
44	Use of health healthy devices	4.85	Agreed
45	Education and services on effect of climate change	4.02	Agreed
46	Supplements food sources should be increased	4.32	Agreed
47	Constant use of vegetables/fruits	3.50	Agreed
48	Drugs therapy must supplement with micronutrient intake	4.25	Agreed
49	Careful planting of fruits/vegetables around the surrounding to encourage good intake	4.38	Agreed

50	Safe motherhood devices	4.15	Agreed
51	avoidance of acid rain to prevent cancer	3.75	Agreed
52	Constant report to hospital	3.50	Agreed
53	Reaching pregnant mothers in communities	4.85	Agreed
54	Healthy eating habits to build up immune functions	3.85	Agreed

Respondents in table three above also accepted all the items as strategies for controlling pregnancy outcome of climate change in southeast Nigeria. Since all the items accepted were above mean rating 3.50 which is above the cutoff point of acceptance.

DISCUSSION

The study climate change: potential effects on pregnancy delivery outcome and its controlling strategies in southeast of Nigeri*a* can be seen as source of information for women especially pregnant delivering mothers to avoid pregnancy outcomes for healthy delivery. The findings were in line with the views of Rylander, Odland and Sandanger (2007) who stated that effects of malnutrition, infectious diseases, environmental problems, and direct heat exposure on maternal health outcomes will lead to severe health risks for mothers and children. Further, Lancer commission in Rylander, Odland and Sandanger (2007) who also identified that climate change; lack of food and safe drinking water, poor sanitation, population migration, changing disease patterns and morbidity, more frequent extreme weather and lack of shelter influences health. Therefore, there is serious global problem which needed immediate strategic control like this study which pregnancy outcome is the main. Women especially pregnant delivering need good climate change controlling strategies to improve their skill, attitudes and knowledge of good pregnancy outcome due to climate change. According to Roses and Desal (2005) environmental perturbations in utero may permanently change organ structure and metabolism and alter homeostatic regulatory mechanism among offspring. Rylander, Odland and Sandanger further stated that drought condition due to climate change can lead to famine and can affect a pregnant woman to deliver prematurely and the offspring may demonstrate low in birth weight which may demonstrate gender specific plasma hypernatremia, hyper toxicity and entrial hypertention. The findings also identify the same result. These prove that there exist poor conditions of health on pregnant delivery mothers due to climate change in southeast Nigeria. This is due to the consequences which the main is human activity development in the environment. Controlling strategies for pregnancy delivery outcome is needed to equip individuals with good healthy condition. Therefore pregnant delivering mothers everywhere still face formidable obstacles to good health. This is due to lack of controlling strategies to climate change as well as pregnancy outcomes. That is why this study is highly important to pregnant delivering women. Women therefore needed factors that affect climate change, potential effects of climate change on pregnancy outcome as well as controlling strategies of this study. The findings revealed that women needed this study as a guide to enable them obtains knowledge, attitude and practices that will prevent them from ill health.

Therefore this study will reposition every individual especially the delivering women who were the target of this study.

CONCLUSION

The findings of this study revealed that women have been having delivery outcomes with their climate change conditions especially on drought and heat intensity condition which is one of the main climate change condition. They needed controlling strategies as well knowledge of factors that affect climate change and its potential effects on pregnancy delivery outcome in southeast of Nigeria. Therefore women will through this study correct their delivering outcomes and other ill practices of climate change.

RECOMMENDATIONS

From the findings of this study, the following recommendations were made. The Government of Southeast Nigeria should:

- Establish community education centers to improve knowledge, attitudes, skills and behaviours of women on pregnant outcome using this study.
- Women friendly services, women centers, entrepreneurship facility programs, private sector initiatives and social marketing can be linked with the findings from this study.

Market based programs about entrepreneurship education should be made available to

REFERENCES

Adekoya F (1991) Educational Training of Farm and extension managers in Nigeria. *Nigerian Journal of Management Foundations;2 (2), 15-21*

Chukwukere N.F. (2013). *The Green Pathway to Health & Recovery* Alphabet Nigerian Publishers Owerri Nigeria

Climate Change and Potential Effects on Maternal and Pregnancy Outcomes http://www.globalhealthaction.net/indexphp/gha/article/view/19538/html retrieved 25/6/2013

Enger E.D and Smith B.F (2004) *Enviromental Science; A Study of Interelationship* (19th edition). New York: MacGraw Hill Higher Education.

IPCC (2007) Fourth Assessment Report. **http://www.ipcc.ch/pdf/assessmentreport/ar4/syr/ar4_syr_spm.pdf**. retrieved 25/6/2013

Lean J. (2010) *Cycles and Trends in Solar Irradiance and Climate* "Wiley Interdisciplinary Reviews Climate Change," Vol. 1

Lockwood M, *"Solar Change and Climate: an update in the light of the current exceptional solar minimum*," Proceedings of the Royal Society A, 2 December 2009, doi 10.1098/rspa.2009.0519*;*

Micheel G. Roses, & Mina Desal (2005) *Effect of Drought American* Journal of Physiology, Regulatory Integrative and Comparative Psychology Vol. 208 No. R25.R33 Dol. 101152/a preg.004182004

Miller D. E.(1984) *Dimension of Community Health London; WMC; Brown Publishers.*

Naomi O (2004) *The Scientific Consensus on Climate Change.* Science 3: Vol. 306

Neel E. C . and Neel. R. H. (2008) Biology of Today. Ibadan Akunne Olaiya Fagbamigbe Ltd.

NRC (2008) *Understanding and Responding to climate change*.. Board on Atmospheric Sciences and Climate, US National Academy of Sciences. p. 2. Retrieved 9 November 2010.

NRC (2010) *Advancing the Science of Climate Change.* National Research Council, The National

Academies Press, DC. USA

O'Brien. K. (1985) *Why no one can say that pesticides are not dangerous. Forum for Development Action Groups; (96). 10-13.*

Rylande C., Odland J. and Sandager T. (2013). *Climate Change and Potential Effects on Maternal and Pregnancy Outcomes*: An Assessment of the most vulnerable, the mother, foetus and newborn

Taieba A. I. (2010) Solid waste Management; Potentials and Challenges http//enwikipediaorg.wiki. retrieved 10/5/2010.

The United Nations Envirommental protection (1992) http://unfccc.int/essential_background/convention/background/items/1349.php retrieved 25/6/2013

United States Global Change Research Program (2009) *Global Climate Change Impacts in the United States*, Cambridge University Press.

USGCRP (2009) *Global Climate Change Impacts in the United States.* Research program Cambridge University Press, New York NY. USA

Wikipedia, the free encyclopedia (2013) *climate change* http://ourworld.unu.edu/en/copis film festival retrieved 25/6/2013

An Attempt to Manage the Controversies between the Orthodox and Traditional Medical Practitioners Using Ontological Representations

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ABSTRACT

Several issues regarding the use of traditional medicine to limit/reduce critical health challenges are apparent. Despite orthodox medical practitioners' opposition to the use of traditional medicine with scientific reasons subject to training, a significant number of the general public believe in the efficacies of the treatments offered by traditional medicine. Previous attempts by modern-day doctors towards probing and elevating the standard of this type of medicine had seriously been resisted because traditional doctors see these efforts as threats to their means of livelihood. In a bid to correct the negative perspectives of these doctors, the use of information and communication technology (ICT) is required. Thus, this paper proposes the introduction of an ontological representation of sources of traditional medicine to the semantic web with the aim of promoting the indigenous knowledge in health and encouraging the traditional medical doctors. The roles of ICT for creating awareness as well as sharing knowledge amongst the general public are highlighted. Also, the challenges surrounding the adoption of the proposed model are equally observed in this paper. The existence of such representational model is expected to re-orientate the two seeming professional enemies on the dire need for open policies so as to come to terms as they avoid/reduce complications especially in critical circumstances. This platform can be used to drive advocacy and campaigns that discourage the cutting down of medicinal trees/plants, as well as initiate advocacy for policies that stops the cutting down of the medicinal plants. The promotion of planting and preservation of these trees will integrate into the larger global campaign to mitigate practices that intensify climate change. The sustainability of these medicinal plants would make them readily available for treatments and cure by both traditional and orthodox medical practitioners as well as improving the economic status of these doctors.

Keywords: Knowledge management, Indigenous knowledge, Critical health challenges, Situation awareness, effect on climate change

INTRODUCTION

Indigenous knowledge (IK), that which is natural or native to a particular region or community, has been seen to play an important role in the way communities interact with their climate, such as forecasting and the preservation of vital ecosystems (CDKN, 2013).

Highlights on the importance of IK towards the well-being of the community have become a matter of concern. This calls for collaborations between indigenous groups, scientists and the policy-makers to improve the understanding of how traditional medicines can be employed without any harmful effects on the community. Through these collaborations, uncovered threats can thereby draw the attention of other scientists within and outside our communities.

Recently in Nigeria, several traditional medical practitioners have emerged. Most of them have been involved in self-advertisement through trade fares and media to catch the attention of the general public. These sorts of advertisement lack reliability since there is no proof of the products' efficacy by the scientists. As rightly observed by the orthodox medical doctors, this may turn out to be more harmful rather than its intended usefulness to the community. The harmful effects may arise from errors in plant identification, poor manufacturing practices such as substitution or incorrect preparations/dosage, and lack of product standardization. Also, traditional medicinal products are likely to be affected by environmental factors such as light, temperature, soil quality, time of harvest, and age of plant. These factors complicate the processing of consistent products, and in sufficient quantities for use and testing.

These controversies still exist in our Nation, as the traditional medical practitioners remain resistant to the attempt by orthodox medical doctors to probe and raise the standard of their indigenous medicines. They rather see the orthodox medical doctors as threats to their traditional medicinal practices and means of livelihood. Several ways of managing these controversies have been recommended in the literature (Oberle et al., 2003; Omotosho et al., 2013). These include the use of ICT through available applications on the semantic web for awareness creation and knowledge sharing. The aim of this work is to propose and discuss the use of ontological representation for the sources of traditional medicines on the semantic web for the management of these unresolved controversies. This will promote the use of indigenous knowledge by both traditional and orthodox medical practitioners through the awareness creation offered by the proposed ontological representation, as well as protecting the climatic condition of the community whose practices are guided by known standards and policies.

The use of ontological representation/model is encouraged due to the flexibility of its schema that paves way for logical reasoning. Logic is the foundation for knowledge representation and this depends on the knowledge offered by the given ontology. An ontology is a piece of knowledge that can be used by a knowledge based application among other pieces of knowledge. Knowledge described by an ontology is on a schema level and can be shared and re-used in several domains. Different types of ontology foster different levels of knowledge re-use. According to Chen and Matthew (2007), ontology allows intelligent applications to exchange information by sharing a formal conceptualisation of an application domain.

With this representational model, it is believed that the two seeming professional enemies will have a re-orientation on the dire need for open policies and this will bring them to terms. Upon their coming to terms, better adaptive strategies will result in health and these will provide useful experiences that will attract the parties, other nations and create a positive impact on the climate. The implementation of this model will serve as a means of advertisement for the traditional medical practitioners and also legalise their right to practice. This will serve as a guide for the researchers and concerned authorities in pursuit of any indigenous product or partnership arrangement to know the right source.

INDIGENOUS KNOWLEDGE IN HEALTH

Researches that promote indigenous knowledge have recently become of great concern (Hausa et al., 2009). This is followed with the emergence of several findings from different fields of research around this domain, with the justification of the efficacy and safety of traditional plants medicine in health (Obomsawin, 2011). This has brought about the drive by the World Health Organisation (WHO) into African Traditional Medicine (TM) methods and institution, to work with researchers by promoting the use of TM for healthcare (WHO, 2002). However, this knowledge tends to decrease when practitioners of African Traditional Medicine decide not to explicitly share the knowledge for interested parties to learn and use from it.

Many of these traditional medicine practitioners exist in Nigeria, within which several categories of traditional healers have been highlighted (Adesina, 2013). Similarly, Richter (2003) has noted these traditional medicine practitioners in South Africa including traditional hears in the list of the traditionalists. However, the kind of partnership discussed here excludes traditional healers that attribute illness to witchcraft. Interestingly in this regard, policies were established in Nigeria to accredit and register traditional medicine practitioners and regulate the practice of traditional medicine in order to mainstream it into the public health, however, discrimination rate by the orthodox medicine practitioners is still very high in Nigeria (WHO, 2001).

In assuaging this protracted tension in Nigeria and as may be elsewhere, learning from the quest of Bolivia to preserve indigenous knowledge in imperative to the point of discussion here. Since some key lessons and recommendations by researchers, amongst were retained and put to effective practice, the proposal in this key into those lessons and recommendations, which were: encouragement of partnerships between scientists and indigenous knowledge holders; creation of policies that improve adaptive capacity and indigenous people's status; and promotion of the use of indigenous knowledge through international initiatives (CDKN, 2013).

Leaning on the Bolivia experience, government policies and programmes can support training in traditional practices for young people, provide funding for adaptation efforts, aim to preserve nomadic and semi-nomadic lifestyles, and promote diversity of domestic crops and animals (CDKN, 2013). The need for additional measures to a more effective protection technique of our forests and farmlands from threats by climate change was highlighted. The livelihood of our indigenous people and the world at large is said to depend on these forests and farmlands.

The controversies between the traditional medical practitioners and the orthodox medical doctors extend to the farmers and affiliated interest groups. In Bolivia, it seems the law will allow indigenous people to challenge large government-sponsored mining and energy projects, as their economy continues to depend heavily on extractive industries. The ban on genetically modified crops has raised concerns about the lack of consultation with indigenous farmers. Some farmers have fought against the ban because they depend heavily on genetically modified seeds, especially soya beans (CDKN, 2013). Notably, the efforts in that respect, is the development of a unique body of knowledge by the Bolivia's indigenous people, which is helping them adapt to the effects of climate change through weather predictions and coping practices; and the monitoring of the wind, clouds, frosts and other signals to predict the weather and improve agricultural practices by the Chipaya people.

Also of note, on the other hand, is the failure to recognise the value of indigenous knowledge by the climate scientists and if they do use it, they simply treat it as data. This has however, led to the inclusion of indigenous people as joint decision-makers in local and national adaptation initiatives and natural resource laws – from design through to implementation. This is to ensure that their valuable indigenous knowledge informs the projects.

Correspondingly, protection is needed to ensure that outsiders do not negatively impact indigenous rights, since indigenous communities are often fearful of outside intervention that aims to protect the environment (such as the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation) for fear of losing autonomy. Indigenous groups requested that regular sessions in which indigenous people could brief others on indigenous knowledge and its application to addressing climate change should be hosted. This further strengthens the use of participatory approach (Sieber and Wellen, 2008) which has been utilised to address the critiques that GIS is a totalizing technology transforming indigenous geo-spatial knowledge into meaningless bits and features (Rundstrom, 1995).

Dabra, who is also a Director for Association for the Promotion of Traditional Medicine (PROMETRA), reported that:

> *"Ghana has over 150,000 registered herbal practitioners with over 66 universities offering degrees up to PhD level in herbal medicine in China. It has over 200 patients. Similar progress is taking place in India." (The Nation, 2013).*

This development sees to the establishment of hospitals where both traditional and orthodox doctors work in collaboration. This is not the case in Nigeria.

Again, the coverage of orthodox medicine far outstrips that of traditional medicine both in terms of frequency of coverage and prominence accorded the issues. Though traditional medical issues are sparingly reported and covered by the print media in comparison to orthodox medical issues, the dismal coverage is consolably portrayed in positive light and given sufficient depth in terms of providing detail and appropriate attribution (Batta, 2012). This followed some recommendations that:

- The Nigerian print media should accord traditional medical issues the same importance and prominence given to orthodox medical issues.
- Traditional medical issues should not be relegated to the background in terms of the frequency of reports, the display of the reports, the variety of formats adopted in the presentation of the reports, and the depth of treatment given the issues reported.
- Newspapers should strive to use not only colour photographs, but also other useful illustrative devices such as diagrams and graphics to make traditional medical stories captivating, attractive, comprehensible, and meaningful;

Due to the highlighted setbacks on indigenous knowledge and their effects on climate change, tremendous efforts are made to manage these controversies. Some of which include: researches that has brought about the creation of a 'Traditional Medicines Database" called TRAMED III (Richter, 2003); and an internet based directory recording most of the researches that feature the use of traditional medicine in Africa (Fung, 2013).

Other attempts to build ontologies such as that which represents African indigenous medicine in the South-Western part of Nigeria (Omotosho et al., 2013) have been made. This paper discusses how the proposed representation of the indigenous knowledge in health (Bassey and Ntekop, n.d.) attempts to manage the controversies through the use of ontologies. This is to enhance a more flexible adaptation of stored concepts towards any reasoning process.

KNOWLEDGE REPRESENTATION AND ONTOLOGIES

The use of computers and smart devices today reveals the efforts of artificial intelligence (AI) researchers, as their work involve the development of methods for encoding computer systems with knowledge. This has brought about approaches which seek to discover and emulate the forms in which knowledge is represented in the human brain and those which take their inspiration from the external forms of representation used by humans to encode their knowledge, notably language, mathematics and formal logic (Galton, 2009).

Knowledge representation is said to be the study of how to put knowledge into a form that a computer can reason with (Russell and Norvig, 2003). Knowledge representation and reasoning depicted by Branchman and Levesque (2004) is concerned with how knowledge can be represented symbolically and manipulated in an automated way by reasoning programs. It is the convergence of artificial intelligence design techniques with techniques from other fields that has brought about advanced systems which perform tasks that require human intelligence (Sowa, 2000). An instance of this is the formal ontology, which is concerned with the systematic enumeration and classification of the various kinds of entity represented with a conceptualisation of the world, together with an account of their properties and relationships. Ontology translates into two directions:

- Conceptual ontology: that which focuses on the definition of terms in formal and logical but primarily human-readable form.
- Logical ontology: that which makes the formal vocabulary at the conceptual level logically rigorous and machine readable through the help of a reasoning piece of software to deduce new knowledge from the ontology.

The place of ontology in the semantic web layer from W3C in figure 1 shows the need for ontology towards monitoring, inferencing and verification of defined concepts which as further discussed in this research.

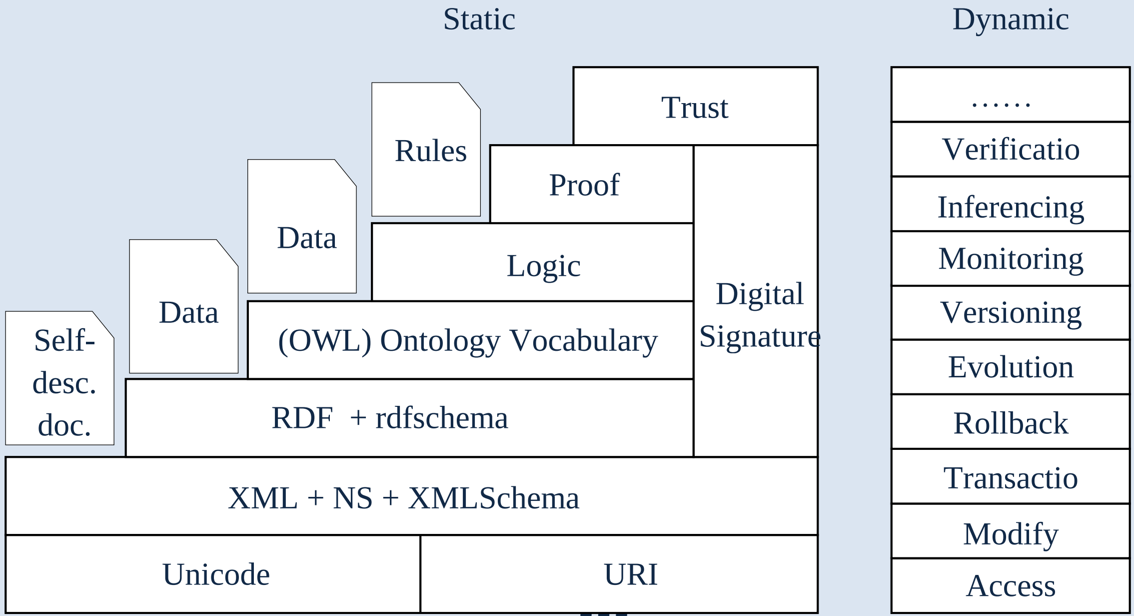

Figure 1: Static and Dynamic aspects of the semantic web layer cake
(Source: Oberle, Volz, Staab and Motik, 2003)

This paper's concentration is on illustrating how the proposed ontological representation (Bassey and Ntekop, n.d.) will combine all the concepts around indigenous knowledge in health with the special interest on the standard of the living of the indigenous people as affected by their climatic condition. Concepts that will encourage recommended policies which can manage some of the known controversies thereby controlling climate change are represented for knowledge sharing and re-use. Some of these concepts and their relationships with these policies as they adapt to climate change have been represented in the ontology.

ONTOLOGICAL REPRESENTATION OF INDIGENOUS KNOWLEDGE AND ITS EFFECT ON CLIMATE

Information that formed the basis for the proposed idea was obtained from literatures and through informal interactions with the traditional medicine practitioners, the users of their products, orthodox medical doctors and researchers. Several attempts to represent indigenous knowledge using ontologies have been made. Some of these ontologies have tried to model the critical health challenges (ailments) and the indigenous knowledge used for the ailments (Omotosho et al., 2013). Bassey and Ntekop (n.d.) have also designed a model of an ontology that extends the modelled concept to the name of the traditional medical practitioners, addresses, and witnesses to the efficacy of these products. The ontological model in figure 2 forms the basis for this paper's argument on how the highlighted controversies can be managed.

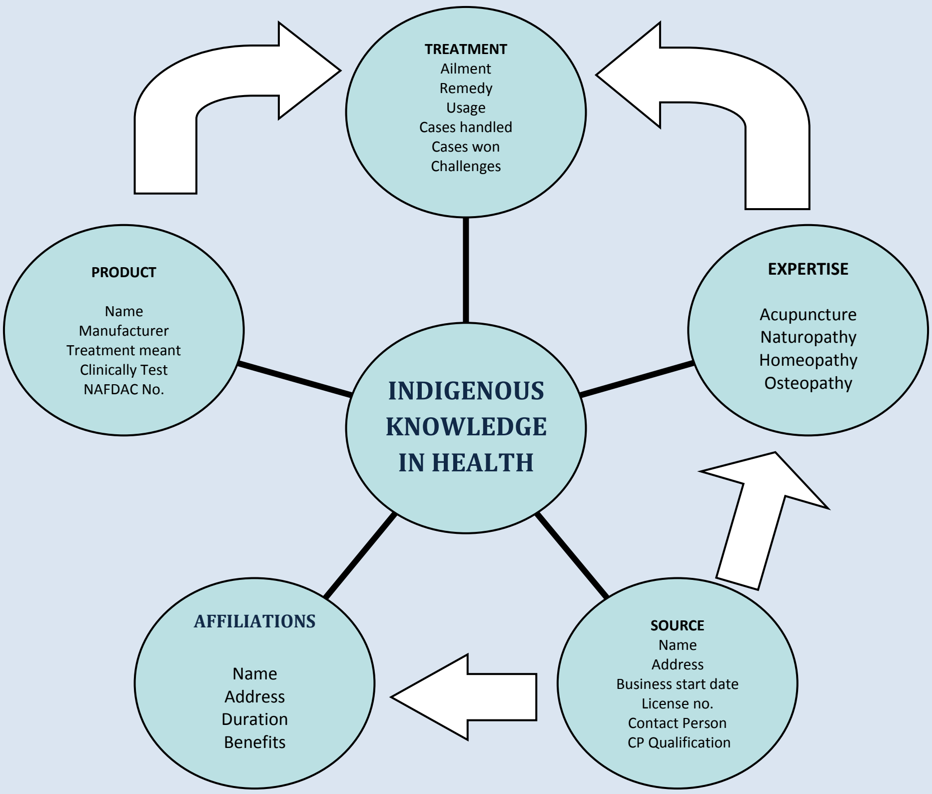

Figure 2: An ontological model of Indigenous Knowledge in health
(Source: Bassey and Ntekop, n.d.)

This ontological model represents as concepts, the treatment, the expertise, the source, the affiliations and the product which features the name of manufacturer, evidence of clinical test, and possible means for right to practice. This ontology builds in all the concepts and the relationships existing between them showing forth the recommended participatory approach where indigenous knowledge and the sources are recognised concepts brought into the Indigenous Knowledge Ontology in Health (IKONTOH). With the sources shared, the situation awareness is created, and the effect of the ontology reflecting in the list of affiliations, thereby serving as an encouragement to other indigenous people who might not have considered indigenous knowledge as an important thing to have. The number of encouraged indigenous people will increase the sources of traditional medical practitioners and other indigenous people that rise to protect the natural resources including medicinal plants required in health. The protection of these natural resources in-turn preserves our climate. Another thing may be that government, the supervisory body, will also enact policies that will help in this regard as well.

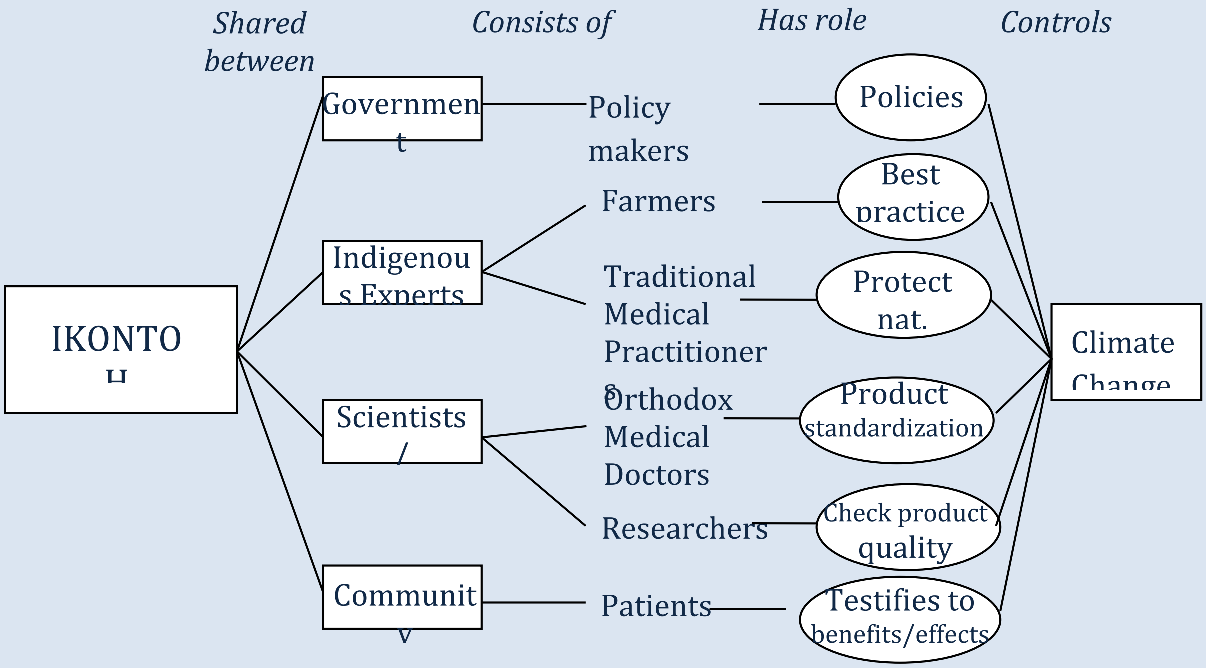

Figure 3: Effect of IKONTOH on climate change

From where the policies are retained, best practices maintained, farmers protect natural resources, orthodox medical doctors will not stop standardization, and researchers will keep examining the gap and the testimonies/benefits of their productions. All these derived features of the IKONTOH will assist in the control of climate change.

6. Conclusion

The implementation of the proposed ontological representation will serve as a useful drive towards the advocacy and campaigns that discourages the cutting down of medicinal trees/plants, as well as initiate advocacy for policies that stops the cutting down of the medicinal plants. The awareness creation through the use of ontological representation will promote good agricultural and collection practices. Farmers are encouraged to produce more of these crops and maintain them through improved practices.

The promotion of planting and preservation of these trees will integrate into the larger global campaign to mitigate practices that intensify climate change. This attempt will help to advocate the protection of natural resources (herbs/plants/trees), which are useful sources of these indigenous medicines as well as raw materials for the pharmaceutical industries from damage through climate change.

The sustainability of these medicinal plants would make them readily available for treatments and cure by both traditional and orthodox medical practitioners. This will help to protect the vulnerable population who through indigenous knowledge will contribute to the management of climate change. This will in turn improve the economic status of the indigenous people who have dedicated their farmlands for the cultivation of these medicinal plants

REFERENCES

Adesina, S. K. (2013). Traditional Medical Care in Nigeria. *Online Nigeria Daily News*. Saturday, July 13, 2013. http://www.onlinenigeria.com/health/?blurb=574

Bassey, P. C. and Ntekop, M. M. (*n.d.*). A Semantic Web Model for the Situational Awareness of Indigenous Knowledge in Health. *To appear in October 2013 series of Journal of Computer Science and Technology.*

Batta, H. E. (2012). Press Coverage of Traditional Medical Practice in Nigeria. *J Communication*, 3(2): 75-89. http://www.krepublishers.com/02-Journals/JC/JC-03-0-000-12-Web/JC-03-2-000-12-Abst-PDF/JC-03-2-075-12-047-Batta-H-E/JC-03-2-075-12-047-Batta-H-E-Tt.pdf

Branchman, R. J. and Levesque, H. J. (2004). Knowledge Representation and Reasoning. Morgan Kaufmann, San Francisco.

CDKN – Climate and Development Knowledge Network (2013). Building resilience to climate change through indigenous knowledge – the case of Bolivia. *INSIDE STORY March 25, 2013.* http://cdkn.org/2013/03/inside-story-building-resilience-to-climate-change-through-indigenous-knowledge-the-case-of-bolivia/

Chen, C. and Matthew, M. M. (2007). Extending description logic for reasoning about ontology evolution. USC CSE TR-2007-012. Department of Computer Science and Engineering. University of South Carolina, Columbia, Sc 29208.

Galton, A. P. (2009). Spatial and temporal knowledge representation. *Earth Sci. Inform.* 2:169-187. Springer-Verlag.

Hausa, V, Howlett, C. and Matthew, C. (2009). The place of indigenous knowledge in tertiary science education: a case study of Canadian practices in indigenising the curriculum. *The Australian Journal of Indigenous Education*. 38:46-58.

Karen Fung (2013). SUOLAIR: African Health & Medicine. © 1994-2013 The Board of Trustees of the Leland Stanford Junior University. All rights reserved. Retrieved on 13/07/2013 http://www-sul.stanford.edu/depts/ssrg/africa/health.html.

Oberle, D., Volz, R., Staab, S. and Motik, B. (2003). An extensible ontology software environment. (Technical Report and Handbook). Institute AIFB, University of Karlsruhe (TH). http://kaon.semanticweb.org/

Omotosho, L.O., Odejobi, O.A. & Akanbi C.O. (2013). A Framework For Knowledge-Based Ontology Model In African Traditional Medicine. *Afr J. of Comp & ICTs.* Vol 6, No. 1. Pp 43-48

Obomsawin, R. (2011). The Efficacy and Safety of Traditional Plant Medicines. http://pdf.amazingdiscoveries.org/Efficacy-Safety-Traditional-Plant-Medicines.pdf

Richter, M. (2003). Traditional Medicines and Traditional Healers in South Africa. *Discussion paper prepared for the Treatment Action Campaign and AIDS Law Project.* http://www.tac.org.za/Documents/ResearchPapers/Traditional_Medicine_briefing.pdf

Runstrom, P. (1995). GIS, indigenous peoples, and epistemological diversity. Cartography and Geographic Information Systems, 22 (1): 45-57.

Russell S. and Norvig, P. (2003). Artificial Intelligence: A Modern Approach. End ed. Pearson Education International, Upper Saddle River.

Sieber, R., & Wellen, C. (2008). Blending participatory GIS and Geo-spatial Ontologies for Indigenous Knowledge Preservation. http://www.emse.fr/site/SAGEO2007/CDROM/CQFD14.pdf

Sowa, J, F. (2000). Knowledge Representation: Logical, Philosophical, and Computational Foundations. Brooks/Cole, Pacific Grove.

The Nations, (2013) Nigeria, Ghana to collaborate in traditional medicine practice. The Nations. March 21, 2013. http://thenationonlineng.net/new/health/nigeria-ghana-to-collaborate-in-traditional-medicine-practice/

WHO (2001) Legal Status of Traditional Medicine and Complementary/Alternative Medicine. A Worldwide Review. World Health Organization. http://apps.who.int/medicinedocs/en/d/Jh2943e/4.32.html

WHO (2002). World Health Organization. "Traditional Medicine Strategy". Fact Sheet, World Health Organization, Geneva, Switzerland, 2002.

Development of artemether-loaded nanostructured lipid carrier formulation for topical application

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ABSTRACT

NLC topical formulation as an alternative to oral and parenteral (IM) delivery of artemether (ART), a poorly water-soluble drug was designed and tested. *Ab initio*, lipid-ART solubility was screened to select the best lipid composition for NLC formulation. ART thermal stability was confirmed by thermo gravimetric analysis (TGA) prior to formulation. Phospholipon 85G-modified Gelucire 43/01 based NLC formulations containing 75% Transcutol, a liquid lipid was chosen from DSC studies and loaded with gradient concentration of ART (100-750 mg). Photon correlation spectroscopy (particle size, polydispersity index and zeta potential), size distribution analysis by LM10 Nano Sight tracking analysis of particles under Brownian motion, thermal properties and storage stability study were carried out. Encapsulation efficiency was investigated by HPLC which also quantified the amount of ART on removed *SC* of the skin. The result shows that ART-loaded NLC systems were stable, polydisperse but within nanometer range as there was complete absence of microparticles upon storage. EE was concentration independent as lower drug loadings (250 mg) achieved higher ART entrapment of ~ 61 %. This optimized formulation was slight polydispersed (0.4) with particle d90 of 346 nm which existed well above -30 mV. DSC confirmed molecular dispersion of ART in less crystalline matrix (0.028 J/g) ascribed to high oil content (75%) which made recrystallization difficult. *Ex vivo* study showed detectable ART amounts up to the 10th stripped tape though without detection in living epidermis or dermis. Hence ART could not penetrate into the living epidermis as a positive signal for transdermal systemic delivery into the blood stream. Yet other penetration studies are underway to better understand the performance of ART at biological barriers.

Keywords: Artemether, Malaria, Nanostructured lipid carrier, topical delivery

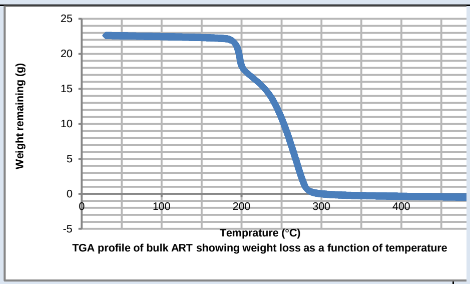
INTRODUCTION

Malaria due to *P. falciparum* is the most deadly and predominates in Africa Globally, an estimated 3.3 billion people were at risk of malaria in 2011, with populations in sub-Saharan Africa having the highest risk; ~80% of cases and 90% of deaths are estimated occur in the WHO African Region, with children <5 years and pregnant women most severely affected [1]. Antimalarial drug resistance is a major public health problem which hinders the control of malaria. Artemisinins treat uncomplicated malaria but the 5-7-day treatment result in poor compliance and partial clearance of parasites; hence promotes resistance [2]. The WHO recommendation of ACT for fast and reliable malaria treatment is the main stay, yet compliance remains an issue. Artemether (ART) is a rapidly-acting schizonticide, practically insoluble in water with oral bioavailability of ~45% and gives pain by injection. Reformulating a patient-friendly form would improve compliance and reduce side effects through active targeting of diseased tissues. As a result, the skin has been chosen as an application route to assess ART penetration into the living epidermis as a positive signal to hope for topical systemic delivery using nanostructured lipid carriers (NLC).

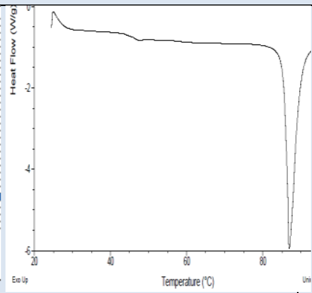
METHODS: NLC of ART was formulated using Gelucire® 43/01, a semi-solid block hard fat (HLB 1) and protective carrier for APIs (e.g. ART) sensitive to oxidation, humidity and light; phospholipid (15 % Phospholipon® 85G) and Transcutol® HP with Tween 80 as surfactant. Preformulation studies were done with DSC and TGA. Hot homogenization/ultrasonication of NLCs loaded with ART (0.75, 0.5, 0.25 and 0.1 %w/w) in 5 % lipid mixture at 90 ◦C yielded pre-emulsion further subjected to high speed mixing at 28,000 rpm with Ultra-Turrax T25 homogenizer (Polytron PT 2500 E, Kinematica, USA) for 15 min and later sonicated at 60 % amplitude for 15 min. After 48 h cooling at room temperature, lyophilization (Martin Christ, Osterode, Germany) was done. Particle characterization, encapsulation efficiency, DSC and *ex vivo* tape stripping study were done and results analyzed statistically using SPSS.

RESULTS AND DISCUSSION

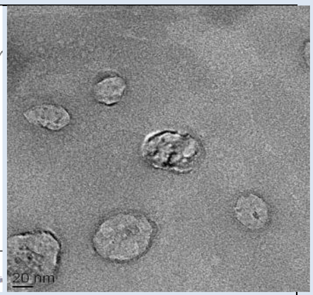
Fig. 1 (A and B) reveals thermal stability of ART at processing temperature of 90 °C. Thermal analysis revealed molecular dispersion of ART in lipid matrix such that recrystallization of amorphous supercooled melt was insignificant ($p<0.05$) due to high oil content (D).NLC particles were spherical (E), stable (>-30 mV), slightly polydisperse (0.4) but within nanometer range (d90 was 346 nm) and could load up to 250 mg of ART. Encapsulation efficiency was ~61 %. *Ex vivo* tape stripping study detected no drug within the living epidermis despite deep localization in the *Stratum corneum* (F). Yet other penetration studies are still underway to better understand the performance of ART at biological barriers.



A. TGA of ART



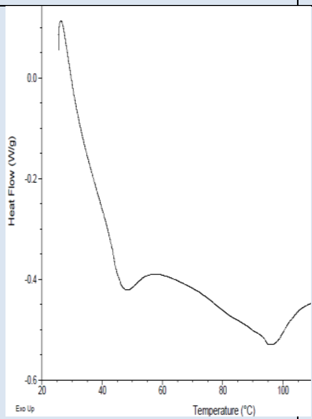
C. ART



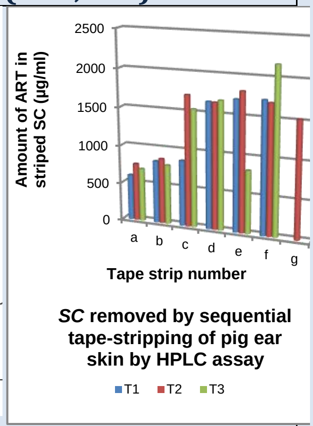
E. ART-NLC (X60,000)

Temperature range (°C)	ART percentage weight loss (%)	Inference
30-175	1.70	Possible water loss
175-200	18.20	First decomposition phase
200-280	80.09	Second decomposition phase

B. %weight loss of ART as a function of temperature



D. ART-NLC



F. Skin study

Fig. 1: Overall properties of artemether lipid carrier system

CONCLUSION

Results show NLC as promising topical delivery system for ART even though further experimental studies are still under way to understand the particular mechanism of ART entry into the blood circulation through the skin. This will provide a more patient friendly form of ART instead of the tablet (oral) dosage form and would improve compliance.

REFERENCE:

1. WHO Global malaria programme. Geneva, World Malaria Report, 2012.
2. P.O. Nnamani et al., J. Vector Borne Disease 48(4) (2011) 224-230

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Effective Communication Strategy and Sustainable Health Management in the Rural Environment of Akwa Ibom State, Nigeria

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ABSTRACT

Research works reveal that 70% of Nigerian Population lives in rural areas. In many cases, rural health sustainability and maintenance of environment variation due to climatic change remain largely untapped by reason of rural ignorance. Tree planting is unpracticed in rural areas. Again, all round rural defecation attitudes, manually dug shallow wells etc. turnout as water ponds which breed mosquitoes particularly during wet seasons. These place considerable strain on natural and material resources, impacting negatively on economic growth as well as health management. The researchers see effective communication strategy using media broadcast as a tool for awareness campaigns in communities on laudable government interventions on the maintenance of healthy lifestyles. Taking the above as a base, the study used a descriptive survey design to investigate the rural dwellers health habits under climatic changing conditions. The population comprised rural dwellers in Akwa Ibom State riverine areas. The sample also comprised 100 rural dwellers from the four local government areas that make up the riverine areas. The study was postulated on one research question and one hypothesis. A researcher designed 20 – item checklist tagged: Rural Dweller Healthy Living Habits under Climatic Changing Conditions (RDHLHUCCC) to elicit data from respondents. Data was analyzed through mean score rating and t-test statistical test. The result revealed that the mean score ratings for problem cases reported by the health workers indicated the cases of malaria and diarrhea as the highest. It further indicated that there was no significant difference between rural dwellers in most of their healthy living habits based on their exposure or lack of exposure to government's interventions on the creation of awareness. The study recommends the utilization of broadcast media to effectively create the required changes.

Key Words: Rural Dwellers, Health Management, Sustainability, Broadcast Media, Effective Communication

INTRODUCTION

Human activities at an increased tempo and encroachment on the physical environment have contributed gravely to climatic change. Population pressure denies us buffer frontiers such as large forest regions rich in resources and other antecedents for healthy living. Apart from deforestation/desertification, ozone layer depletion, drought, flooding and fire influence climatic change. In all these, human activities create unique health problems especially for children, being disproportionately vulnerable, suffering most of the effects Gracy (2003)

All round rural defecation attitudes for instance pose serious health challenges to rural people especially during the wet seasons. In some places good measures of human habitation occur on elevated terrains near running streams. Pit latrines and the so called ventilated improved pit latrines (VIPs) built within the periphery of the streams either crack or collapse, emptying some quantity of their contents into the surroundings. These find their way during the rains into the running streams which form one source of water supply to the whole of that community.

Industrial or exploration activities particularly in some rural areas in Akwa Ibom State generate increased energy production, resource extraction, air and environmental pollution. This could be seen in the mega activities of multinational companies prospecting for crude oil, petroleum related products and other minerals. Gas flaring activities in Ibeno and attendant gas emissions have taken their toll on rural health. Rain water being another major source of rural drinking water absorbs in the first place, the emitted harmful gases before dropping on contaminated rusted zinc sheets on the roofs of most buildings. This before is then consumed by rural humans, unchecked and untreated.

Writing on Air pollution and its possible health effects on rural dwellers in Rivers state, Nigeria. Several air borne disease through air pollution were responsible for over

13, 234 cases of sickness from which 29 deaths had been recorded "within the period of review" Nwanchukwu, and Ugwuanyi, (2010). Global warming generates direct health impacts of climatic change which include:

- Air pollution related sickness
- Water – borne diseases
- Vector – borne illness e.g malaria
- Cold related deaths etc, [Bunyavanich, S. et al (2003).]

"the relationship between climate change and child (human) health, has unfortunately not been well investigated." There is a broad scientific consensus that global climate is warming… and that human activities are very likely (>90% probability) the main cause and that children will experience both the direct/indirect effects of climate change. "it is against this background that a case is made for the intensification of environmental education especially among rural dwellers." The researchers see effective communication strategy using media (Radio) broadcast as a tool for awareness creation campaigns in communities particularly as laudable government interventions on the maintenance of healthy lifestyles in rural areas of Akwa Ibom State seem prioritized. The radio, from its beginning has proven to be a very feasible and apt instrument for science communication and is regarded as a very innovative way to connect people and promote education and health development and particularly so in the rural setting as opined by Shea, (2007) & Bunyavanich, et al (2003). Radio is identified as what "should be used more effectively to communicate science and technology in Africa." He stressed the need for setting up a rural development agendum with the radio as the main source of communication in Africa because according to him, science and technology developments affect rural population and activities Ben Ngubane (2002).

Awareness information dissemination and exchange of ideas towards preventing the resultant effects of air pollution, water pollution, which result in communicable diseases, poor hygiene and indiscriminate refuse disposal cannot be achieved without effective communication. Highly industrialized societies, especially in the societies of Western Europe and United States, communication at the grassroot may involve some of the Old Media (TV) and a variety of new interactive media but in Nigeria, the oral and radio are still in use. DFRRI in Tolorunleke, (2003). identified a number of channels for information diffusion to the rural areas. Those are

a. Formal information media – radio, television, newspapers, pamphlets, posters, etc.
b. Local communication channels – local leaders, town criers, market places, local musicians.
c. Development of associations and cooperatives
d. Traditional rulers and local institutions.
e. Adult education programs.
f. The urban elites

g. Local governments and other government agencies. Amongst the channels aforementioned for information diffusion to the rural areas, radio stands out to be an effective rural information dissemination Tolorunleke,(2003)..

The following are some of the advantages of radio in Education:

- ❖ Inexpensive: All of the audio/radio voice technologies are relatively inexpensive.
- ❖ Easily accessible: Almost every home in Nigeria has radio. In addition, most students have access to audio tape players, transistor radios, car-radios or cell phones with in-built radio in their homes, hostels, or in a car.
- ❖ Easy to use: Almost everyone is comfortable with the use of radio, with radio, audio or voice technologies. They are also easy to repair or maintain.
- ❖ Radio enables the rural dwellers to listen to experts, the historians, the author and the scientist.
- ❖ Reflects on – the – spot current events (like cut one tree and plant two), in the radio, the running commentary of some inauguration ceremony, lectures delivery on health care, at conference, workshops and so on have an attraction of its own. Omoniyi, (2005) &. Falade, (2010)

President Olusegun Obasanjo provides the National Economic Empowerment and Development Strategy (NEEDS) on Sustainable Health management in the rural environment. These include:

- ✓ *Community action, basic sanitation principles, offering farmers methods to improve irrigation, ways of improving significantly the lives of at least 100 million slum dwellers by 2020, ways to reduce maternal mortality by three-quarters and child survival interventions such as breastfeeding, vitamin A supplement, adequate use of insecticide-treated net (ITNs) and immunization NPC (2004)..*

Statement of the Problem

“Health is wealth” as they say it in Akwa Ibom State of Nigeria but health watch attitudes of the rural people, betray caution and discipline. Additionally, climatic and environmental variations are indices which impact more severely on the health of rural people. Apart from changing climatic conditions, high fertility rate and dependency ratio place considerable strain on natural and material resources, impacting negatively on economic growth as well as health development. The once vibrant and active sanitary inspectors that transversed rural areas to enforce hygienic health attitudes are no more hence sustained all round rural defecation habits continue to pose serious health challenges to rural health particularly during rainy seasons. Pit latrines and so called Ventilated Improved Pit (VIPs) latrines built within the periphery of nearby streams either crack of collapse emptying some quantity of their contents into the surroundings. These find their way during the rains into running streams, the major source of community water supply. The health outcome need not be debated. Amazingly, manually dug wells or pits are considered priced possessions of families as they catch up and store rainstorm water flowing into them on raw ground. They drink from those pits also. Therefore government has duty to remedy critical rural health situation through instructional radio awareness creation.

Purpose of the study: this study was designed specifically to determine the rural dwellers' awareness of healthy living habits under climatic variations.

Research Question: one research question was formulated for the study:

I. What are the health reports from rural dwellers in health centres from March 2011 to February 2012 as compared to March 2012 to February 2013?

Hypothesis: A null hypothesis was postulated and tested at 0.5 level of significance

H_0: there is no significant difference between rural dwellers living habits based on their awareness of healthy living habits through government interventions.

Method: The design for the study was a descriptive survey, aimed at soliciting the opinions of rural dwellers and also assessing records of Health Centres to determine the impact government's awareness of healthy living habits in the rural community.

Area of the Study: the study was carried out in the rural communities of four local government area of Akwa Ibom State: Oron, Ibeno, Eket, and Onna.

Population: The population for the study comprised all adult dwellers of these local government areas. The population of the four local governments put together would be estimated at about 183,508 (March 2006 census data)

Sample: A total of 200 rural dwellers were randomly selected from 200 rural households. This comprised of 50 rural dwellers from each of the local governments.

Instrument: The instrument tagged 'Rural Dwellers Healthy Living habits' had two section A and B. section A, sought for information on their exposure to governments awareness on healthy living habits while section B sought information on rural dwellers healthy living habits based on government's intervention for improved living conditions was designed using a five-point Likert scale format to obtain information from the subjects of this study. The responses scale and value point are: It's my habit (5 points), it was my habit (4 points), Undecided (3 points), it will be my habit (2 points) and it is not important to me (1 point).

Validity of the instrument: The instrument for this study was subjected to content validity by three experts. One of the experts was drawn from the department of the Health Inspectorate division of the Ministry of Health, Akwa Ibom State Secretariat. The other was drawn from the physical and Health Department of the University of Uyo. The third was drawn from the Department of Educational Foundations, a lecturer in Test and measurement.

Reliability of the instrument: the internal consistency of the instrument was established using 20 rural dwellers of two other rural communities that were not selected for the main study. The reliability index was found to be 0.75. The researchers adopted the split-half method to determine the reliability of the instrument by administering the structured interview schedule **(RDHLHUCCC)** to the respondents. The items were then split into even and odd groups and correlated using Kudar Richardson Formular 20 to obtain r = (-0.75) which shows that the instrument is adequately reliable.

Method of data Collection: six trained research assistants helped in the administration and collection of interview schedule. Considering the fact that the collection of data involved a one interaction with the respondents, the researchers took time to provide the research assistants with adequate information on how to carry out the interview.

Data Analysis: The responses from the questionnaire was analysed by computing the mean and standard deviation of each item, which was obtained from responses on the five point likert type scale. Each mean of an item was interpreted in relation to the real limits of the normal value of the scale used for data collection. A cut-off point of 3.50 was used to determine which item was accepted or rejected. Based on this cut-off, any item with a mean score equal to or greater than 3.50 were accepted as rural dwellers habits and any item with less than 3.50 were rejected. A t-test statistic (for independents samples) was used to test the null hypothesis at 0.05 α level of significance. The result of analysis of section A revealed that out of a total of 200 rural dwellers interviewed from 200 household, 113 respondents agreed that they were fully aware of government's healthy living conditions on the issues raised in the question while 87 indicated that they were not fully aware. The researchers also collected data from four health centres relating to the first 150 health related cases of school age children (3-10 years old).

RESULTS:

Research Question 1: What are the health reports from rural dwellers in health centres from March 2011 to February 2012 as compared to March 2012 to February 2013. Table 1 show that out of the first 150 of school age children health related cases reported in community centres in each of the rural areas of the four Local Government Areas of the state Malaria (39.00%) topped the list followed by Diarrhea (23.33%), Cough, Cold Related Complications, Measles, Snake bites and Burns. Then between the two seasons, the wet season had a greater number of Malaria cases, Diarrhea and Cold related complications. On the other hand, the dry season had the greater number of Snake bites and Cough. The issue is that the health conditions have not reduced significantly despite the governments' awareness on healthy living habits as can be seen in the difference between the total figure for both wet and dry seasons – 57(23+34) for 2011 and 60(19+41) for 2012 reported malaria cases with an overall mean score of 59(39.33%). Even for diarrhea the figure is almost the same 34 for 2011 and 36 for 2012, with an overall mean score of 35(23.33)

Hypothesis 1: Table 2 shows that the respondents, agreed that their rural living habits under varying climatic conditions included: clearing their environment of bushy shrubs and weeds(X=3.93*); filling pot holes to avoid ponds of water around their house during the rainy season (x=3.56*); sweeping and keeping their environment free from all refuse to rid it of bacteria and germs (x=4.13); sweeping all refuse into an open pit near your house (x= 4.45); out of 20 listed items, only 4 items were rated as the rural dwellers healthy living habits under varying climatic conditions.

Table 2 also revealed that most of the items ranging from 0.14 to -1.87 fell below the critical value of 1.96 indicating by the decision rule that the mean responses of the two groups of rural dwellers (who accepted and those who denied knowledge of governments awareness on healthy living habits) was therefore upheld for 16 out of 20 items. The calculated –t was greater than the critical –t. Thus, there was no significant difference between the responses of rural dwellers exposed and those not exposed to awareness on healthy living habits by government.

Discussions: the findings from the study reveal that the rural dwellers practices very few healthy living habits and only four items were significantly differed in terms of the healthy living habits between those who claimed that had exposure to government's awareness on healthy living habits and those who did not. This situation is further confirmed by the fact that reported cases of health related cases has not reduced significantly despite government awareness intervention. This is in line with Nwanchukwu,, and Ugwuanyi, (2010)., who submits that several air borne diseases through air pollution were responsible for over 13,243 cases of sickness from which 29 deaths had been recorded "within the period of review", in Rivers State. [9,2] Shea, (2007) & **B**unyavanich, et al (2003) agree with the fact that there is a broad scientific consensus that global climate is warming…and that human activities are very likely (> 90% probability) the main cause and that of children will experience both the direct/indirect effects of climate change. The finding is an indication that the government has to work hard communicate healthy living habits to the rural dwellers.

As Tolorunleke,(2003) observed that in highly industrialized societies, especially in the societies of Western Europe and United States, communication at the grassroot may involve some of the Old media (TV) and a variety of new interactive media but in Nigeria, the oral and radio are still in use. DFRRI in Tolorunleke,(2003) identified a number of channels for information diffusion to the rural areas. Those are:

a) Formal information media – radio, television, newspapers, pamphlets, poster, etc.
b) Local communication channels – local leaders, town criers, market places, local musicians.

As such this paper clearly recommends the use of the broadcast media towards where the programmes can be aired in the evening when the rural dwellers are done with the work and return home to rest for the day. The more the listen to the awareness on healthy living habits the more they can imbibe and practice the habits.

CONCLUSION:

The study has clearly shown that the rural dwellers need to be adequately educated on the impact of climatic variations particularly in the rural riverine areas. This situation will affect the children's education as their attendance in school could be hampered by climatic variations that would have been managed by the rural dwellers if they had knowledge of healthy living habits. It is based on this that the paper recommends the utilization of broadcast media considering the benefits that can be tapped by rural dwellers. It is not uncommon to see rural dwellers in their small communities and relaxation spots listening to radio progrmmes. The radio programmes can be intensified to create greater impact on healthy living habits.

RECOMMENDATION:

1. Government should supply functional radio equipment to Akwa Ibom Broadcasting Cooperation (AKBC) with the focus of making use of them to extend information on weather forecasts through structural radio programmes to rural areas to prepare them to face events that could harm their health and safety.
2. Awareness creation campaign should be heightened through special radio programmes to encourage rural dwellers to plant two trees for anyone cut down.
3. AKBC should run radio documentary jingles to alert rural populace on the damage of continuing poor hygiene and especially indiscriminate refuse disposal during wet seasons to avoid rain water carrying those refuse to their mainstreams where their drinking water comes from.
4. Return of monthly Sanitary Inspectors on basic sanitary capable of eliminating environmental pollution which results in communicable diseases and development of rural water schemes, should be intensified.

Table 1: Analysis of Weighted Mean Scores of Reported cases from Rural Dwellers among Children N = 150
Community Health Centres; in rural areas of Eket, Oron, Onna, Ibeno (June, 2013).

S/N	Health Related Cases	2011		2012		Mean Score
		Dry season	Wet Season	Dry season	Wet Season	TOTAL
1	Malaria	23	34	19	41	59(39.33)
2	Diarrhea	15	19	10	26	35(23.33)
3	Cough	18	11	12	9	25(33.33)
4	Cold related complication	9	24	7	21	31(20.00)
5	Measles	3	0	2	0	2(1.66)
6	Snake Bite	2	0	0	0	1(0.66)
8	Burns	1	0	2	1	2(1.66)
TOTAL		**62**	**89**	**52**	**97**	
N(PER SCORE)		**150**		**150**		

Table 2: Rural Dwellers Living Habits under Climatic `Variations Based on Governments Intensified Awareness on Healthy Living habits

S/N	ITEMS	$\bar{X}$	SD	Decision
1	You clear your environment of bushy shrubs and weeds	3.93*	0.08	1.98
2	You fill pot holes to avoid ponds of water around your house during the rainy season	3.56*	0.78	2.83*
3	You check and control bush burning round your house to avoid fire outbreak.	2.20	0.41	2.18*
4	You sweep and keep your environment free from all refuse to rid it of bacteria and germs	4.13*	0.52	2.46*
5	There maintain a distance between your farm and house	2.58	0.67	-0.87
6	You plant new trees as you uproot and trim the old ones.	3.34	0.87	-0.71
7	During rainy season you do not prepare your firewood furnace inside your houses.	3.47	0.39	-0.48
8	You rely on rain water during the rainy season.	3.19	0.43	-0..36
9	You boil the rain water before drinking.	3.32	0.43	-0.45
10	You depend on borehole water both in rainy and dry season.	3.45	0.36	-0.47
11	You have erected hygienic pit latrines which are kept covered and clean to avoid.	3.43	0.41	-0.36
12	You open your windows every day to allow fresh air into your houses.	3.65*	0.98	2.46*
13	You do not sweep all refuse into an open pit near you house.	3.45	0.51	-0.58
14	You maintain an open well water quite close to the house	3.36	0.40	-0.70
15	You use sterilizer nets to prevent mosquito bites	2.53	0.39	-0.47
16	You go for general checkups to prevent outbreak of fatal diseases.	3.14	0.98	-0.79
17	You filter your water before drinking.	3.41	0.40	-0.36
18	You do not depend on borehole water during rainy season.	3.30	0.49	-0.14
19	You fetch drinking water and wash your clothes in the same stream.	3.24	0.40	-0.69
20	You do not cut down all trees and plants to observe important traditional rites and ceremonies	3.06	0.28	-0.45
t-critical = 1.96; significant at 0.05 α level of significance.				

REFERENCES

Ben Ngubane (2002) Key to science communication in africa. http://www.scidev.neet/en/news/radio-key-to-scence-communication-in-africa.html.Retrieved19/06

Bunyavanich, S. et al (2003) Direct health impacts of global warming. In global climate change and child health. Children's Health and the Environment. WHO Training Package for the health sector, world health organization. www.who.int/cehpp.20.

Falade, A. A. (2010) Promoting radio/Audio (Brokkklkkadcast) media for effective teaching and learning in nigerian schools. nigeria association for educational media and technology (NAEMT) proceedings of the 31st Annual Convention and National Conference, Minna pp.36-37.

Global Climate Change & Child Health. WHO training package for the health sector, world health organization. www.who.int/ceh.pp.5.

Gracy, M. (2003) Child Health Implication of worldwide urbanization. environmental health, 8(1) pp. 51. www.who.int/ceh.

National Planning Commission (2004) National economic empowerment and development strategy (NEEDS) Abuja, Nigeria pp. 11-21.

Nwanchukwu, A. N., and Ugwuanyi, J. U. (2010). Air pollution and its possible health effects on rural dwellers in Rivers State, Nigeria. Afria Journal of Physics. Vol.(3) 217-240.

Omoniyi, T. (2005). Principles and applications of educational technology, Ibadan, Bash-Moses publishers, Nigeria.

Shea, K. (2007) American academy of pediatrics committee on environmental health. In global climate change & child health WHO training package. www.who.int/ceh. 120(5): 13, pp.59-67.

Tolorunleke, R. T. (2003). Rural development communication: A strategy for awareness creation and behavior change. In forty years of educational technology in Nigeria. A publication of nigeria Association for educational media and technology (NAEMT) Ilorin, Nigeria. Vol. (1) 94 -97.

Phytochemical and Antioxidant capacity of Cyphostemma glaucophilla Aqueous Leaves Extract

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ABSTRACT

Cyphostemma glaucophilla is used in the treatment of several degenerative diseases. Phytochemical analyses was carried out on aqueous leaves extract and the anti oxidant activity were investigated using albino rats, which were divided into five groups of five animals each. Group A received(0.85% NaCl; 5ml/kg)control while single daily oral doses of 10, 15, 20, 25mg/kg body weight of extract were administered to groups B, C, D and E for 21 days respectively. Animals were fasted overnight and sacrificed with ether anaesthesia and the liver homogenates were used for the assessment of protein, malondialdehyde and assay of glutathione peroxidase(GPx), superoxidedismutase(SOD), anti lipidperoxidation and 2, 2- diphenyl-1-piccrylhydrazylhydrate (DPPH) radical scavenging activities by standard methods. Results confirmed the presence of flavonoids, vitamin C, proteins, carbohydrates, steroids, O and C glycosides, traces of vitamin E and A. The extract induced significant ($p<0.05$) dose dependent increases in the concentration of proteins and inhibited significant ($p<0.05$) dose related decreases in the concentration of malondialdehyde. It produced significant ($p<0.05$) dose dependent increases in the concentration of glutathione peroxidase and SOD peaks at 25mg/kg(55 and 35%) relative to control, there was also a significant($p<0.05$) inhibition of lipid peroxidation by 18.80% in group B and 25.42% in E, the DPPH radical scavenging activity increased with increased concentration of extract by 14.31% and 37.23% in groups B and E respectively. Study has shown that extract contains phytochemicals of biological and pharmacological importance and has antioxidant capacity which can be utilized to alleviate the symptoms of chronic and degenerative diseases.

Key words: *Cyphostemma glaucophilla*, degenerative disease, 2, 2-Diphenyl-1-piccryhydrazyl hydrate(DPPH), anti-oxidant, phytochemical

INTRODUCTION

Cyphostemma glaucophilla is a flowering plant which belongs to the family of vitaceae. These species are caudiform and used to belong to the genus cissus. It is used in herbal medicine in Kogi and Kwara states of Nigeria for the treatment and management of diverse ailments ranging from malnutrition disorder, infertility and systemic disease in different locations. The Igalas, macerate the leaves in water and the aqueous extract is administered daily to malnourished children and hypertensive patients, Ebiras used the stem prepare in form of decoction as internal cleanser for new born babies while the Yorubas use the leaves for the treatment of infertility in women and stomach discomfort in children .

(Omale *et al., 2006)* had attributed its medicinal properties to the presence of bioactive compound in its leaves, root and stem . Result of acute toxicity recorded by (Ojogbane *et al., 2010)* indicated that extract has no adverse effect at the limit per oral dose of 5000mg/kg body weight administration to rats. The efficacy of Cyphostemma glaucophilla aqueous extracts in boosting protein synthesis and minerals has been investigated *(*Ojogbane and Nwodo 2010*;* Omale *et al.,* 2009) also, the potential of extract as an anti inflammatory agent has been examined and confirmed *(*Ojogbane *et al.,* 2011). Antioxidants are compounds that can delay or inhibit the oxidation of lipids or other molecules by inhibiting the initiation or propagation of oxidative chain reaction. The potential of the antioxidant constituent of plant material in the maintenance of health and protection from disease is also of raising interest among scientists and food manufacturers as consumer move toward functional foods with specific health effects (Al-Duais *et al.,* 2009). The antioxidants compounds present in edible plant have recently been promoted as food additives because they display little or no toxic effects (Han *et al.,* 2004). In this communication, the photochemical screening and antioxidants activity of the aqueous leaves extract of *Cyphostemma glaucophilla* were investigated.

MATERIALS AND METHOD

Plants Material: the leaves of *Cyphostemma glaucophilla* was collected in June 2012 from Egah in Idah local government of Kogi State Nigeria they were washed to remove dirts and pulverized with a milling machine into a coarse powder

Preparation of Ethanol and Chloroform Extracts: A 400g quantity of pulverized dried leaves of *Cyphostemma glaucophilla* was macerated twice in five volumes(w/v) of chloroform – ethanol mixture(2:1) for 18 hours with 2 changes of solvent the Whatman number 4 filtrate of the macerate was shaken with 0.2 volume water in a separating funnels. The two emerging layers: viz upper ethanol layer and lower chloroform layer were separated and dried in *vacuo*.

Preparation of Water Extract: An 80g quantity of pulverized leave were macerated in five volume (w/v) of water for 18 hours and then filter the filtrate was evaporated in a water baths to get the dried residue

Animals: Experimental animals used in this study were albino rats of either sex aged between seven and nine weeks and weighing 100-150g. They were purchased in June 2012 from the Faculty of Biological Sciences Animal House University of Nigeria Nsukka.

Experimental Design: five groups of six rats each weighing (110-120g) were fed with rat feed obtained from Top feeds and allowed drinkable water through out the period of experiment. Group A received daily oral doses of saline (0.85%NaCl:5ml;/kg) while groups B, C, D and E were administered 10, 15, 20,25mg/kgbody weight of extract using stomach tubes for 21 days respectively.

24hours after the last administration, animal were sacrificed. The livers were excised and homogenized and the liver homogenate were used for the assessment of total proteins by the method of Lowry *et al.,* (1951), malondialdehyde concentrations by the method of Wallen *et al., (*1993), activities of glutathione peroxidase (GPx) the method of Plagia and Valentine (1967), superoxide dismutase (SOD) activity by Wolliams *et al.,(*1983) and lipid peroxidation by the modified method of Nabasree and Bratati, (2002).

Reagents: the reagent kits used for the determination of proteins, malondialdehyde and the assay of SOD and GPx were obtained from Randox Laboratries Limited Antrim, United Kingdom

Anti-Lipid Peroxidation Assay: the anti – lipid peroxidation assay was determine using a modified thiobarbituric acid reactive species (TBARS) assay of (Nabasree and Bratati; 2002)

Principle: the end product of lipid peroxidation using liver homogenate as lipid-rich media was quantified by determining the formed malondialdehyde(MDA) which react with thiobarbituric acid (TBA) under acidic condition.

Procedure: To 0.5ml of a 0.1g/ml liver homogenate was added 0.1ml of varying concentration of the extract (5.0,2.5,1.25,0.625 and 0.3125mg/ml) in a test tube followed by the addition of 1.0ml of distilled water. Then 50ul of iron II tetraoxosulpahte (v) of 0.07M was added to the reaction mixture, vortexed and allowed to stand at room temperature for 30minutes. 1.5ml of 20% (w/v) acetic acid and 1.5ml of 0.8% (w/v) thiobarbituric acid in 1.1% (w/v) sodium dodecyl sulphate were added. The resulting mixture was then incubated in a water bath at 37^{0}C for 1 hour. After cooling, 4.0ml of butan -1-ol was added to each tube, shaken vigorously and centrifuged at 3000rmp for 10 minutes. The absorbance of the organic upper layer was measured at 532nm. Inhibition of lipid peroxidation (%) of the extract was calculated using the formula

$$1-\frac{E}{C} \times 100$$

Where C equal to absorbance value of fully oxidized control

Where E equal to absorbance in the present of extract

Determination of 2, 2 Diphenyl-1-Piccrlhydrazyl Hydrate (DPPH) Radical Scavenging Activity

The radical scavenging property of the extract was determined by the modified method of Brace (2001).

Principle: when DPPH reacts with an antioxidant compounds which can donate hydrogen it is reduce.

$DPPH^{+} + RH \longrightarrow DPPH_2 + R^{+}$

Note change in colour

Procedure: To 1.0ml of different concentrations (0.5, 0.25, 0.125, 0.0625, 0.03125mg/ml) of the extract was added 1.0ml of 0.3mm DPPH in methanol. The mixture was vortexed and incubated in a dark chamber for 30minute. The absorbance was measured at 517nm against DPPH control containing only 1.0ml of methanol in place of extract. The antioxidant activity (AA) was then calculated using the formula.

$$\frac{A0-AC}{A0} \times 100$$

Where A0 = absorbance without extract
AC is = absorbance with extract

Phytochemical Screening: Aqueous and chloroform extract were screened for the presence of bioactive components following the method of WHO (1998)

Data Analysis: The result were expressed as mean±SEM analysis of variance (ANOVA) was used to test for the difference among the group at $p<0.05$ regarded as significant

RESULTS

Table 1: Phytochemical screening

The bioactive compound are concentrated more in the aqueous extract than in the chloroform extract. The chloroform extract has only the fractions that are soluble in non-polar solution

Table 2: Extract induced concentration of liver proteins (mg/dL).

Table 2: shows that the extract produced a significant ($P<0.05$) dose dependent increase in the concentration of total proteins in rat plasma. It caused the total protein concentration to increase from a control value of 4.08 ± 0.02 by 1.94mg/dl in group B of rats which received the lowest dose of the extract and by 3.72mg/dL in group E that received four times group B dose. This treatment also affected the concentration of albumin in a scale manner. It induced an increase of 0.89mg/dL from a control value of 3.02 ± 0.04 in group B and 1.84mg/dL in group E.

Table 3: Extract induced inhibition of malondialdehyde (MDA; mg/ml).
The extract produced a significant (P<0.05) dose depended decrease in the concentration of MDA. There was a change of 0.25mg/dl from the control value of 0.38 ± 0.10mg/dl in group B and 0.34mg/ml in group E.

Table 4: Extract induced inhibition of lipid peroxidation
Doses of extract at 5, 10, 15 and 20mg/kg bw caused inhibition of lipid peroxidation by 41.49±1.31, 43.03±0.18, 48.82±0.51 and 51.50±1.00 respectively

Table 5: Extract induced increases in anti-oxidant activity

3.9.1 Effect of the extract treatment on DPPH radical scavenging activity

Table 20 shows that extract treatment induced dose dependent significant (p<0.05) increase in the antioxidant activity of DPPH radical from a value of 14.31% obtain for the control by 11.13% at the extract concentration of 0.5mg/ml, increasing doses of the extract at 0.75, 1.0 and 1.25mg/ml induced increases in antioxidant activity by 16.20, 19.56 and 23.92% respectively.

Table 6: Extract induced activity of Superoxidedismutase (SOD) and Glutathione peroxidase (GPx) µ/ml
There was a significant (p<0.05) dose dependent increase in the activities of SOD and GPx. Extract at the lowest dose of 10mg/kg effected a change of 1.11 ± 0.06 µ/ml in SOD and 0.60±0.10µ/ml in GPx. Scalar doses in group B and C cause a higher change in SOD and GPx. The effect of extract peak in group E with a change of 2.15±0.07u/ml in SOD and 6.74±0.03u/ml in GPx. However the effect of extract on GPx was more compared to SOD

DISCUSSION

In Table 1 the presence of proteins, vitamins, lipids and carbohydrates support its uses in providing energy: building up of worn out tissues and regulation of internal body temperature. flavonoids, vitamin C,E,A are antioxidant which are useful in free radical scavenging in living system. Vitamin C is also necessary for connective tissues and promote the healing of fracture and wounds These justified the use of extract in malnutrition and healing of bone fracture. However the aqueous extract will be more effective than chloroform extract. This result is in agreement with the report of (Omale *et al.,* 2006).
In table 2, the extract produced a significant (p<0.05) increase in the concentration of liver total proteins and a graded increase in albumin concentration. This result further confirm the result of earlier studies Ojogbane and Nwodo(2010). This extract induced concentration of plasma proteins can alleviate the protein deficiency in kwashiorkor(r, also the hallmark of kwashiorkor, oedema is caused by albumin deficiency (Cohen and Lehman, 2002) because albumin is used for the maintenance of colloid osmotic pressure at the capillary membrane to prevent plasma fluid from leaving into the interstitial cell. A decrease in albumin (less than 5g/dl) results in the lowering of plasma colloid osmotic

pressure in a way that it can no longer counteract the effect of the hydrostatic pressure of blood. This results in an increased outward movement of fluid from the capillary wall and decreased inward movement of fluid from the interstitial space causing oedema. The impaired immune response and high risk of infections which are consequent on reduced synthesis of protein (Heird, 2008) can be tampered with an increase in plasma protein concentrations.

The extract induced a significant ($p<0.05$) dose dependent inhibition of malondialdehyde in table 3. This observation is an indication of the inhibition of lipid peroxidation by the extract. This finding is a reflection on enhancement of antioxidant enzymes caused by the extract and is in accordance with earlier studies (Al-duais *et al.,*2009)

The increase in the activity of SOD and GPx in table 4 is of interest. SOD is an enzyme that repairs cells and reduce the damage done to them by superoxide, by catalyzing the dismutation of the superoxide radical (O_2) into hydrogen peroxide(H_2O_2) and elemental (O_2). Studies carried out by Muth 2004 have shown that SOD act as both antioxidant and anti inflammatory agent in the body neutralizing the free radicals that can lead to wrinkles and pre cancerous cell changes. It also helps the body to use Zinc, copper and manganese and a likely key to the production of healthy fibroblast; one of the deficiencies in protein energy malnutrition. The extract induce increase in SOD indicates the antioxidant and anti inflammatory potentials of *Cyphostemma glaucophilla* leaves.

GPx is the most abundant antioxidant that protects vision and boosts the immune system (Farmer, 2009). It also help in the detoxification of harmful compounds via the bile (Marnett, 1999). GPx keeps the red and white blood cell healthy to maximize the efficiency of the immune system. It has been shown by (Farmer, 2009) that low level of glutathione peroxidase makes the body more vulnerable to damage by free radicals. From the result in table 4, it is obvious that extract was able to enhance the activity of GPx which could explain the potency in treating various ailments which was also reported by (Hans *et al.,* 2004) .

There was a dose dependent percentage inhibition of peroxidation in table 5. Peroxidation of lipids as recorded by Languerre (2000) can disturb the assembly of the membrane, causing alteration of ion transport and inhibition of some metabolic processes. The observation in this study reveals that *Cyphostemma glaucophilla* leaf extract could be used to alleviate this challenges (Spector *et al.,* 2005) had also observed that inhibition of peroxidation is enhanced by phenolic anti oxidants, *Cyphostemma glaucophilla* could possess some natural antioxidant property which makes it exhibit this effect.. The DPPH scavenging activity in table 6 increased with increase in the concentration of extract. DPPH is a phenolic compound which inhibits lipooxygenase and scavenges free radicals (Hu *et al.,* 2005). DPPH scavenging activity as describe by Aruoma(2008) plays a role to inhibit reactive oxygen species that are responsible for various disease like neurodegenerative disorder, heart disease and inflammation hence *Cyphostemma glaucophilla* leave extract could be used to tamper these ailments. This result further confirms the studies of (Omale *et* al., 2009) which justify its use in herbal medicine.

The results of these studies provide scientific evidence for the use of *Cyphostemma glaucophilla* aqueous leaf extract in traditional medicine In conclusion, extract contain phytochemicals of biological and pharmacological importance and exhibits antioxidant activity which can be utilize to alleviate the symptom of chronic and degenerative disease consequently the leaf extract contains some bioactive agent that might account for this activity.

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REFERENCE

Al – Duias, mohammed, Larrs, Muller, Volker, Bohm and Gottfried Jetschke (2009) antioxidant capacity and total phenolic of *Cyphostemma digitatum* before and after processing: use of different assays. Eur food Res. Technol 228:813-821.

Aruoma .I. Okeziel (2008). Free radical in tropiocal diseases deepblue.lib.umich.edu/handle/2027.42/31905.

Brace J.L, Vander Weele D.J and Rudin C.M (2005). SVFL. Inhibits reactive oxygen species generation and promote survival under conditions of oxidation in *Saccharomyces cerevisiae*. Yeast 22 (8): 641-652.

Farmer, E.E (2009) reactive electrophile stress corri opin plant biology 10 (4): 380-6.

Cohen B.A and Lehman C.U (2002). Protein energy malnutrition, Derm Atlas. John Hopkins University Baltimore.

Han, Seong Soo; Choho.,Yong, wa Choi. Jin, Ho kim and Sevng, Hwa Back (2004) Antioxidant activity of crude extract and pure compounds of Acer ginnata max. Bull.Korean Chem Soc. 25 (3) : 389

Heird, W. C (2008) food insecurity, hunger and undernutrition Nelson Textbook of Pediatrics, 18th edition. Philadelphia, Saunders Elsevier. Chapter 43.

Hu, C., Chen, H.J and Kitts, DD (2002) studies on the antioxidant activity of *Ehinaceae* root extract. Journal of Agric.Food.Chem. 48: 1466.

Laguerre, M (2007). Lipid peroxidation. Progress in lipid research 36:244 – 282.

Lowry, O. H., Rosebrough, N.J., Farr, A. L and Randal, R.J (1951) protein measurement with folin phenol reagent. Journal of Biology and Chemistry 193:265-274.

Marnett (2009) lipid peroxidation DNA damage by malon dialdehyde mutation. Res. 412 (1-2): 83-95.

Muth, C.M (2004) Free radical research; 38(9) ; 927-932.

Nabasree, E and Brastati, T (2002) antioxidant activity of piper bitter leaf extract *in vivo* food chemistry 88: 214-224.

Ojogbane, Eleojo., Nwodo, Okwesili Fred Chiletugo and Musa, Achimugu Dickson (2010) Acute toxicity investigation and anti inflammatory potentials of *Cyphostemma glaucophilla* aqueous extract. TWOWS. Afric.J of Sc and Technol 1(1): 46-52.

Ojogbane, E., Musa, A.D and Nwodo, OFC (2011) Anti inflammatory effect of aqueous extract of *Cyphostemma glaucophilla* leaves. Niseb J. 11 (1): 67-73.

Ojogbane, Eleojo and Nwodo Okwesili Fred Chiletugo (2010). Effect of aqueous extract of *Cyphostemma glaucophilla* on protein synthesis in rattus Noirvegias . J.Chem and pharm. Res; 2(4) :16-23.

Omale,James., Okafor Polycarp Nnacheta and Ifeoma Ijeh (2009) chemical composition and effect of aqueous extract of *Cissus multistriata* on some biochemical parameter in Albino rats. Int.J of pharm Tech Research 1(3): 509-513.

Omale, James., Daikwo, Moses Alilu and Musa, Achimugu Dickson (2006) phytochemical characterization and biochemical studies of *Cissus multistriata* extract administered to *Rattus novergicus.* Animal Research International J. 3(2): 481-484.

Plagia, D.E and Valentine, W. N (1967). Journal of Laboratory and Clinical Medicine 70: 158.

Spector, L.G; Xie, Y; Robinson L.L; Heerema, N.A., Hilden, J.M and Lang B. (2005). Cancer epidemiol Biomarkers, Journal of experimental Biology and Medicine 14 (3): 651-655.

Wallin, B., Rosengren, B., Shetzer, H. G and Cameja, G (1993) lipid oxidation and measurement of thiobarbituric acid reactive substance(TBARS) formation in a single micro titre plates, its use for evaluation of antioxidants. Anal. Biochem, 208:10-15.

WHO (1998).quality control method for medicinal plant material. World Health Organization Monograph, Geneva pp 150.

Wolliams, J. A., Wiener, G., Anderson, P. H and Mc murray, C. H (1983). Resaech in Veterinary Science 34:253-256.

Table 1: Phytochemical Screening

Compounds	aqueous extract	Chloroform extract
Alkaloid	-	-
Anthraquinones	-	-
Carbohydrates	++	-
Flavonoids	+	–
Cardiac glycoside	++	-
Proteins	++	-
Lipids	+	++
Tannins	-	-
Saponins	++	–
Steroids	+	+
Vitamin E	-	++
Vitamin C	++	++
Vitamin A	-	+

- : absence of bioactive compound
++ : presence of bioactive compound in high concentration
+ : presence of bioactive compound in low concentration

Table 2: Extract induced concentration of liver proteins (mg/dL).

Group	Treatment (mg/kg)	Total Protein	Change in Total Protein	Albumin	Change in Albumin
A	Normal saline 5ml/kg	4.08 ± 0.02[a]		3.02 ±0.04 [a]	
B	5.0	6.02 ± 0.03 [b]	1.49[a]	3.89 ± 0.02 [b]	0.87 [a]
C	10.0	6.59 ± 0.01[c]	2.51 [b]	4.43 ± 0.02 [c]	1.41 [b]
D	15.0	7.17 ± 0.02 [d]	3.09 [c]	4.71 ± 0.03 [c]	1.69 [c]
E	20.0	7.80 ± 0.01 [e]	3.72 [d]	4.86 ± 0.02 [e]	1.84 [d]

Value with different superscripts in a column are statistically significant (P<0.05

Table 3: Extract induced inhibition of malondialdehyde (MDA; mg/ml).

Group	**Treatment (mg/kg)**	**MDA**	**Change in MDA**
A	Normal saline (5ml/kg)	0.38 ± 0.10	
B	5.0	0.13 ± 0.01	0.25
C	10.0	0.10 ± 0.01	0.28
D	15.0	0.08 ± 0.01	0.30
E	20.0	0.04 ± 0.01	0.34

Table 4: Extract induced inhibition of lipid peroxidation

Group	***Dose (mg/kg)***	***Absorbance at (532nm)***	***Change in absorbance***	***Iinhibition (%) wrt to A***
A	*Normal saline (5ml/kg)*	*0.90*		
B	*5*	*2.410*	*1.510*	*41.49±1.31*[b]
C	*10*	*2.323*	*1.423*	*43.03±0.18*[c]
D	*15*	*2.048*	*1.148*	*48.82±0.51*[d]
E	*20*	*1.942*	*1.042*	*51.50±1.00*[e]

values with different supercripts (a,b,c,d,e) in a column are statistically significant (p<0.05)

Table 5: Extract induced increases in anti-oxidant activity

Concentration of the extract (mg/ml)	***Antioxidant activity (%)***	***Change in antioxidant activity (%)***
Normal saline(5ml/kg)	*14.31*[a]	
0.5	*25.44*[b]	*11.13*[a]
0.75	*30.51*[c]	*16.20*[b]
1.0	*33.87*[d]	*19.56*[c]
1.25	*38.23*[e]	*23.92*[d]

values with different supercripts (a,b,c,d,e) in a column are statistically significant (p<0.05)

Table 6: Extract induced activity of Superoxidedismutase (SOD) and Glutathione peroxidase (GPx) µ/ml

Group	Dose of extract	SOD	change in SOD	GPx	change in GPx
A	Normal Saline 5ml/kg	10.0 ±0.28		11.80±0.41	
B	10.0	11.11 ±0.34	1.11±0.06	12.40±0.51	0.60±0.10
C	15.0	11.53 ±0.24	1.53± 0.04	14.78±0.55	2.90±0.14
D	20.0	11.95 ±0.22	1.95±0.06	15.35± 0.50	3.55±0.09
E	25.0	12.15 ±0.21	2.15±0.07	18.54 ±0.44	6.74±0.03

Parasitological Examination of Bile in Cattle Slaughtered at Jos Abattoir, Plateau State, Nigeria

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ABSTRACT

More studies exist on the prevalence of gastrointestinal helminth parasites in cattle than on bile of cattle in Nigeria. In this study, a survey of the parasitic infections occurring in bile of 515 cattle (402 cows and 113 bulls) was examined for prevalence of helminths' eggs in freshly slaughtered cattle at Jos Abattoir. Out of this number, 162 (31.46%) were found to be parasitized while 353 (68.54%) had no infection. Only eggs of two helminth genera were observed: *Fasciola gigantica* (Cobbold, 1855) Fascioliidae and *Dicrocoelium hospes* (Loss, 1899) Dicrocoeliidae; with prevalence rates of 20 (3.88%) and 115 (22.33%) respectively. Mixed infections of both helminth parasites occurred in 27 (5.24%). Majority, 93 (23.13%) of the cows were infected with *D. hospes* and only 15 (3.73%) were attacked by *F. gigantica.* Mixed infection of *D. hospes* and *F. gigantica* occurred in 20 (4.98%) with an overall infection of 128 (31.84%). Majority of the infestation in the bulls was with *D. hospes* 22 (19.47%), and 5 (4.43%) were found to be infected by *F. gigantica*. Mixed helminth infections occurred in 7 (6.20%) with an overall prevalence of 34 (30.09%). There was no significant difference in the infection rates between the younger and older cattle. In conclusion, climatic change in Nigeria primarily would distort rainfall patterns and this would have a concormitant effect on the availability of forage and foraging sites for cattle as well as impart on reproduction and resistance of helminths' eggs. A dry spell may lead to more incidence of helminth parasitization of cattle which are zoonotic to man as they graze on grasses, therefore, cattle slaughtered for human consumption should be thoroughly inspected so as to prevent infection in man.

KEY WORDS: Parasitic infection, helminths, *Fasciola gigantica, Dicrocoelium hospes,* Prevalence

INTRODUCTION

Parasitism is that condition of life which is normal and necessary for an organism that lives on, or in its host which is of different and usually larger species and nourishes itself at the expense of the host without rapidly destroying it as a predator does it prey, but often inflicting some degree of injury affecting its welfare (Cheng, 1964). Flukes generally belong to the phylum Platyhelminthes and class Trematoda. These include *Fasciola* spp., *Fascioloides magna*, *Schistosoma* spp., *Dicrocoelium* spp., etc. Parasitic platyhelminthes are among the oldest parasites known (Cheng, 1964). The first known trematode, the liver fluke, *Fasciola hepatica*, was reportedly found by Jehan de Brie in 1379 in the liver of sheep in France. The number of known species is well over 40,000 (Cheng, 1964). Brown and Neva (1983), reported that adult worms inhabit the proximal bile passages, gall bladder, and occasionally, ectopic sites of cattle, water buffalo, camels, wildhogs and other herbivora. *F. hepatica* is replaced by a similar but even larger species, *F. gigantica* in many parts of Africa and the Orient, including Hawaii (Chandler and Read, 1961; Ademola, 1989; Hall, 1994). Research carried out by Graber and Oumatie (1964), reported *D. hospes* as West African species of *Dicrocoelium*. In Nigeria, domesticated ruminants such as cattle, sheep and goats is numbering approximately 11, 7.6 and 22.4 million respectively, and form the major source of animal protein for the people. It was estimated that this group of livestock supplied about 241,000 tonnes of meat for human consumption in 1979 as against a demand of 339,000 tonnes (Chiejina, 1986). Although, these animals seem to be in abundance, the quality and quantity of meat gotten from them is far below demand (Chiejina, 1986). Pullan (1980) identified the causes of inadequacy due to poor productivity as numerous. Diseases caused by bacteria or viruses are best known (Akerejola *et al*., 1979). Studies carried out on fascioliasis in many parts of Nigeria showed that the disease is endemic in cattle slaughtered in large abattoirs and also constitute a serious obstacle to the efficient production of domesticated ruminants (Chiejina, 1986). Grove and Newell (1969) noted that when animals are infected with liver flukes the liver becomes seriously affected in structure, and its function are upset. It was reported that dicrocoeliasis is not very pathogenic since heavy infections do not cause gross pathological changes. In very heavy infections, the bile appear darkish-green and more viscous than normal and infection with both *F. gigantica* and *D. hospes* is more pathogenic than the effect of single infection (Odei, 1966). The pathological changes of dicrocoeliasis in animals can be a serious problem as they can accumulate large number of the parasites in their bile ducts, eventually leading to cirrhosis, fatty degeneration, hardening, and the appearance of dark spots and patches on the surface of the liver (Schillhorn Van Veen *et al*., 1980). Curca and Fotache (1985), noted that the ascorbic acid content in the liver tissue of cattle infected with *Dicrocoelium* decreased slightly while the adrenal gland content increased. The pathology due to *Fasciola* is based on the number of metacercariae ingested. There is no appreciable damage done during passage through the intestinal wall or the peritoneal cavity. The principal lesions occur in the liver, either in the parenchyma or the bile ducts. *Fasciola* infection though occurs in many species of mammals, is pathogenic only in sheep and cattle (Soulsby, 1982). Cameroon (1975) reported that where fluke is suspected as a herd problem, indications can be seen from diminished milk yield and quality, accompanied sometimes with weight loss, partial or complete anorexia commencing with refusal of concentrates and possible slight diarrhoea. Acute, sub-acute and chronic fascioliasis have been recognised (Boray, 1967). In Hawaii, humans are infected from eating watercress or other vegetables contaminated with metacercariae or by drinking water from streams containing floating metacercariae

(Brown and Neva, 1983). Hence, the effect of climatic change on rainfall pattern, drought and temperature will lead to higher incidence of fascioliasis and dicrocoeliasis in man and animal. Godsmid (1975), noted that there has been no report of human fascioliasis in Africa particularly in Nigeria even though some people drink bile believing it is of medicinal importance. However, 16 human cases of fascioliasis has been reported in Egypt (Ragab and Farag, 1981). Although, there have been various reports of fascioliasis in cattle found in Nigeria (Babalola and Schillhorn Van Veen, 1976) which are zoonotic. The present study was undertaken to provide information on the prevalence of the different genera of helminths found infesting the biliary tract of cattle in Plateau State whose eggs are evident in the bile.

MATERIALS AND METHOD

The research was carried out in Jos abattoir, the capital city of Plateau State, Nigeria. Jos in central Nigeria is a clearly defined highland lying about 1,800m above sea level and situated between latitude $10^{0}30'$ - $09^{0}00'$N and longitude $09^{0}30'$ - $08^{0}30'$E. Annual temperature average 21^{0}C – 24^{0}C especially at night. Very occasionally, atmospheric temperature drop to below freezing point. The area experiences three marked seasons in the year; cold dry (November – February), hot dry (March- May) and rainy (June-October). The vegetation is mostly savannah with grassland and the rocky and undulating nature of the soil provides good drainage. Extensive Tin mining and other mineral prospecting activities in the Jos area have given rise to characteristic depressions and excavations (Anyanwu and Iwuala, 1999).

A total of 515 livers and bile ducts from freshly slaughtered cattle were inspected and adult helminth parasites found were collected in McCartney bottles containing 10% formalin after they had been rinsed with 0.09% normal saline through duodenal or bile duct aspiration (Muller, 1975). The bile content was siphoned with the use of hypodermal needle from the gall bladder of the cattle and emptied into well labelled sample bottles for further study after preservation with few drops of 10% formalin. The bile was agitated vigorously to assume a random distribution of the eggs. A drop of the agitated bile was placed on the slide with cover slip and observed for the presence of parasites eggs under the X10 objective of the light microscope. The number of eggs found was counted to determine the intensity and prevalence of infestation. *F. gigantica* and *D. hospes* eggs were recovered. The identification was based on egg morphology. The eggs of *D. hospes* are oval, dark brown, typically operculate, small (38–45 μm x 22–30 μm), with two characteristic dark points ("eye spots") whereas the eggs of *F. gigantica* are thin shelled, indistinct operculum, yellow to light brown, large- broadly oval (160-190 μm x 70-90 μm) and unembryonated.

RESULTS

The majority of the cattle examined were the White Fulani breed. Adult helminths recovered from infected livers, bile ducts and portal veins of cattle were *F. gigantica* 210

(60.87%) and *D. hospes* 135 (39.13%). Of the 515 cattle examined, 162(31.46%) were parasitized. 20(3.88%) was infested with *F. gigantica*, 115(22.33%) had *D. hospes* infestation. There was mixed infestation of *F. gigantica* and *D. hospes* in 27(5.24%) gall bladders examined (Table1).

Prevalence of parasitic infection (eggs) in the bile of cattle in relation to sex (Table 2). Out of the 402 bile examined for the cows, 93(23.13%) were infected by *D. hospes*, 15(3.73%) had *F. gigantica*, 20(4.98%) were parasitized by *D. hospes* and *F. gigantica*. The overall prevalence for cows is 128(31.84%). A total number of 113 gall bladders of bulls were examined, out of which 22(19.47%) were infected by *D. hospes*, 5(4.43%) were parasitized by *F. gigantica*, 7(6.20%) had mixed infection and the overall prevalence for the bull is 34(30.09%). There was no statistical difference P>0.05) between infection rates in the cows and bulls examined.

Prevalence of parasitic infection (eggs) in bile of cattle in relation to age group (Table 3). The age groups range from 1-3 years, 4-6 years, 7-9 years, 10 years and above. From the total number of cattle examined, 269 were between the age group of 1-3 years out of which 211 were cows, of this number 78(36.97%) were infected by *D. hospes* and *F. gigantica*. 58 bulls were examined, 18(31.03%) were infected. From the age group of 4-6 years, a total of 222 cattle were examined, 175 cows were observed, out of which 45 (25.71%) were parasitized. From the 47 bulls examined, 15(31.91%) were infected. Among the age group of 7-9 years, a total of 19 cattle were examined. From this, 15 were cows and 5(33.33%) were infected. 4 bulls were observed but none of them had the infections. 5 cattle between the age group of 10 years and above were examined, a cow was observed with no infection, 4 bulls were examined with 1(25.00%) infection. There was no significant difference (P>0.05) between the prevalence of the infections of the age groups.

Table 1: Prevalence of parasitic infection (eggs) in bile of 515 examined cattle in Jos Abattoir.

Helminth Parasites	**No. infected (%)**
Dicrocoelium hospes	115 (22.33)
Fasciola gigantica	20 (3.88)
Mixed infection	
D. hospes / F. Gigantica	27 (5.24)
Overall prevalence	**162 (31.46)**

Table 2: Prevalence of parasitic infection (eggs) in bile of 113 bulls and 402 cows grouped by sex classes

Helminth Parasites	**Sex**	**No. infected (%)**
Dicrocoelium hospes	♀	93 (23.13)
	♂	22 (19.47)
Fasciola gigantica	♀	15 (3.73)
	♂	5 (4.43)
Mixed infection		
D. hospes / F. gigantica	♀	20 (4.98)
	♂	7 (6.20)
Overall prevalence	♀	**128 (31.84)**
	♂	**34 (30.09)**

Table 3: Prevalence of parasitic infection (eggs) in the bile of cattle in relation to age of cattle slaughtered in Jos Abattior, Plateau state, Nigeria.

Age group (Years)	**Sex**	**No. Examined**	**No. infected (%)**
1-3	♀	211	78 (36.97)
	♂	58	18 (31.03)
4-6	♀	175	45 (25.71)
	♂	47	15(31.91)
7-9	♀	15	5 (33.33)
	♂	4	0 (0.00)
10- Above	♀	1	0 (0.00)
	♂	4	1 (25.00)
Overall prevalence	♀	**402**	**128 (31.84)**
	♂	**113**	**34 (30.09)**

DISCUSSION

The result of this study shows a high prevalent rate 31.46% of infection in the 515 randomly sampled bovine gall bladders slaughtered at the Jos abattoir between May and June which is in the late hot dry season to the onset of rainy season. The chances of acquiring fluke infections were increased during the dry season. This might be as a result of climatic change in the distribution pattern and the amount of rainfall leading to high infection rate during the dry season because grazing pasture is scanty thereby exposing the cattle to the intake of metacercariae during foraging as they move from place to place. The parasites tend to be found in areas that favor the intermediate hosts, such as fields with dry, chalky and alkaline soils.

Babalola and Schillhorn Van Veen (1976) also reported a prevalence rate of 31.7% in 14,270 cattle from parts of north- eastern Nigeria between March, 1973 and February, 1974 in Bauchi abattoir. They noted that infection is acquired between early and mid-dry season and increases by late dry season with high prevalence in and immediately after the rainy season. It was estimated that 9.7% of 6,329 cattle slaughtered in Ibadan municipal abattoir from 1978-1980 were infected with *F. gigantica* (Ogunrinade, 1984). Reports also exist of high prevalence of fascioliasis at the beginning of the rainy season (Ogunrinade, 1984). In this study, 115 (22.33%) cattle had *D. hospes* infestation and 27 (5.24%) mixed infection of *D. hospes* and *F. gigantica*. Adeoye and Fashuyi (1986) reported a lower prevalence rate of 13.9% *D. hospes* and 4.4% for mixed infections of *D. hospes* and *F. gigantica* from 1,052 gall bladders of cattle slaughtered in Lagos metropolis between September, 1980 and August, 1982. The result of this study is at variance with the work carried out by Schillhorn Van Veen *et al*. (1980), in Soba, Zaria province in which the prevalence rate of *F. gigantica* and *D. hospes* infections was 65.4% and 56.0% respectively out of the 1,024 cattle examined. This disparity could probably be due to sample size and the geographical location of the cattle. The infection rate of *D. hospes* was quite higher in cows (23.13%) than in bulls (19.47%) out of the total number of cattle examined (Table 2). This difference could be because more cows were actually examined. However, there was no significant difference ($P > 0.05$) in the infection rate of the sexes as a result of the grazing pattern because cattle (cows and bulls) graze together on the same pasture and thereby exposed to approximately the same infection rate.

Younger cattle within the age groups of 1-3 years and 4-6 years were slaughtered more than older ones between the age groups of 7-9 years to 10 years and above. The reason might be that beef of younger cattle are tender and more palatable. Hence, the sample size of older cattle examined was relatively small compared to the younger ones and also leading to higher infection rates within these age groups. 27(5.24%) gall bladders were found to have a mixed infection of *F. gigantica* and *D. hospes* in this study which is in agreement with the findings of Adeoye and Fashuyi (1986) who found a mixed infection rate of 4.4% in Lagos metropolis. This implies that mixed infection of helminth parasites is always lower than single infection.

In conclusion, it is suggested that the general public and particularly the herdsmen should be educated on the effects of climatic change and the dangers of human activities like the introduction of snail intermediate host in water bodies, pollution of water, water conservation and irrigation schemes that favour fascioliasis and dicrocoeliasis. The habit of cattle spending much time in swampy areas which facilitate the completion of the parasites life cycles thereby increasing the chances of infection should be discouraged. Human infection can be controlled by eating properly cooked beef, thoroughly washed watercress and other vegetables, drinking of treated water and most importantly people should be discouraged from drinking the bile of cattle.

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REFERENCES

Ademola, O. S. (1989). *Tropical Zoology* 1st Edition, University Press Ibadan, Nigeria. 55-56pp

Adeoye, G.O. and Fashuyi, S.A. (1986). Incidence of Dicrocoeliasis in cattle slaughtered in Lagos metropolis; *Bull. Anim. Hlth. Prod. Afri* 34(1): 47-49pp

Akerejola, O. C.; Schillhorn Van Veen, T. W. and Njoku, C.O. (1979). O vine and Caprine Diseases in Nigeria, Review of Economic losses. *Bull. Anim. Hlth. Prod. Afr*. 27: 65-70pp

Anyanwu, G. I. and Iwuala, M. O. E. (1999). Mosquito breeding sites: Distribution and Relative Abundance of species in the Jos Plateau, Nigeria. Med. Entomol. Zool. 50(3): 243pp

Babalola, D. A. and Schillhorn VanVeen, T. W. (1976). Incidence of Fascioliasis in Cattle Slaughtered in Bauchi (Nigeria). *Trop. Anim. Hlth. and Prod*., 8:234-247 pp

Boray, J. C. (1967). Studies on Experimental Infection with *Fasciola hepatica* with particular referenceto acute fascioliasis in sheep. *Ann. Trop. Med. Parasitol.* 61:439-450pp

Brown, H. W. and Neva, F. A. (1983). *Basic Clinical Parasitology*. 5th Edition Norwalk, Appleton-Conn.:Century Crofts 225-228pp

Cameron, I. R. D. (1975). Fluke in Cattle (in UK) *Vet Record* 96 (13): 294-295pp

Chandler, A. C. and Read, C. P. (1961). *Introduction to Parasitology* 10th Edition. John Wiley and Sons, Inc., USA. 822pp

Cheng, T.C. (1964).The Biology of Animal Parasites 1st Edition, Henry Kimpton London. 727pp

Chiejina, S. N. (1986). The epizootiology and control of parasitic gastroenteritis of domesticated ruminants in Nigeria. *Helminth Abstr. Ser*. A55 (11): 413-429pp

Curca, D. and Fortache- Tanasescu, C. (1985). Ascorbic acid content in the liver and adrenal glands of cattle in parasitic liver disease. *Rev. Vet. Med*. 28:55-59pp

Goldsmid, J. M. (1975). Ecological and cultural aspects of human trematodes (excluding Schistosomiasis) in Africa. *Cent. Afr. Med Journal* 21: 49-53pp

Graber, M. and Oumatie, O. (1964). Existence en Afrique equatorale d'un impt. Foyer de dicrocoeliose bovine et ovine a *Dicrocoelium hospes, Rev. Elev. Med. Vet. Pays Trop,* 17(3), 523-533pp

Grove, A. J. and Nowell, G. E. (1969). *Animal Biology*. 8th Edition Cox and Wyman Ltd., London 192p

Hall, H. T. B. (1994). *Diseases and Parasites of Livestock in the Tropics*. Longman, London. 207-212pp

Muller,R.(1975). *Worms and Diseases; a manual of Medical Helminthology,* Hainemann. 161pp.

Odei, M. A. (1966). A note on dicrocoeliasis and *Fasciola gigantica* infection in livestock in northern Ghana with a record of spurious and of genuine *Dicrocoelium hospes* infection in man. *Ann. Trop. Med. Parasitol*., 60(2): 215-218pp

Ogunrinade, A. F. (1984). Bovine fascioliasis in Nigeria VI: Parasitological characteristics of field infections. *Rev. Elev. Med. Vet. Pay. Trop*. 37(3): 299-303pp

Pullan, N. B. (1980). Productivity of white Fulani Cattle on the Jos Plateau, Nigeria III. Disease and management factors. Trop. Anim. Hlth. Prod. 12: 77-84pp

Ragab, M. and Farag, H. F. (1981). Human fascioliasis in Egypt. *Journal of Egypt Med. Assoc.* 61(11/12):773-780pp

Schillhorn van veen, T.W; Folaranni, D.O.B; Usman, S and Ishaya, T (1980). Incidence of liverfluke infections (*Fasciola gigantica* and *Dicrocoelium hospes*) in ruminants in nothern Nigeria, *Trop. Anim. Hlth. Prod.* 12(2): 97-104pp

Soulsby, E. J. L. (1982). Helminths, Arthropods and Protozoa of Domesticated Animals. 7th Edition. John Wiley and Sons Ltd., Chichester, New York. 108-109pp

In Vitro Evaluation of Antifungal Properties of Solanium Incanum against Vaginal Isolates of Candida Albicans

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ABSTRACT

Medicinal plants are vastly becoming a source of therapy for many diseases worldwide and in Nigeria. Research has shown that the plant, *Solanum incanum* (garden egg leaves) is effective in the lowering of blood sugar, treatment of glaucoma, and has anti-ulcer, anti-inflammatory, antitumor, antimicrobial and hepatic protective effects. This study was carried out to evaluate the potency of the antifungal property of *S. incanum* leaves against *Candida albicans* isolates obtained from University of Port Harcourt Teaching Hospital, Rivers State Nigeria. The methanol and water extracts of *S. incanum* were extracted for their antifungal properties and also comparison was done with the standard drugs, fluconazole and nystatin to evaluate the effectiveness of the leaf extracts. The methods used were agar dilution and agar well diffusion. The methanol extract inhibited growth of 40 % of the *Candida* isolates with minimum inhibitory concentration of 100 mg/ml while the water extract had low inhibition of growth in about 24 % of the isolates at 100 mg/ml. Comparison of the antifungal activity using mean inhibition zone diameter showed methanol extract at 5.56 mm, water extract at 1.10 mm, fluconazole at 30.80 mm while nystatin at 13.44 mm. These organisms are probably not susceptible due to low activity of the antifungal property in *S. incanum* and the physiological state of the patients. The antifungal property of *S. incanum* may be attributed to the presence of secondary metabolites such as flavonoids, saponins and steroidal alkaloids.

Key words: *Solanum incanum* leaves, *Candida albicans* and antifungal activity

INTRODUCTION

Solanum incanum (garden egg leaves), a species of nightshade is native to Sub-Saharan African and also found from Middle East to India. *Solanum incanum* is invasive in parts of Kenya, Uganda and Tanzania (Henderson, 2002). The common name is Thorn Apple and Bitter Apple from family solanaceae (Germplasm, 2006). *Solanum* is a widespread plant genus of the family solanaceae which have over 1000 species worldwide with at least 100 indigenous species in Africa (Jaeger and Hepper 1986) such as *Solanum americanum*, *Solanum tuberosum* (potatoes) and *Solanum macrocapum* (Olaniyi, 2002). Locally, it is called '*Dauta*' in Hausa, '*afufa*' or '*anara'* in Ibo and '*Igbagba*' in Yoruba (Nigeria).

Solanum incanum is an herb or soft wooded shrub up to 1.8m in height with spines on the stem, stalks and calyces and with velvet hairs on the leaves. The leaves are alternate and flowers are often borne in the leaf axles, sometimes solitary or in few-flowered clusters. Fruits are yellow at the beginning; but later turn black (Dafni and Yaniv, 2004).*Solanum incanum* commonly known as garden eggs or African eggplants are constituents of Nigerian food and indigenous medicines. They are consumed on a daily basis by both rural and urban families (Tindal, 1965). *Solanum incanum* is traditionally used to ensure oral hygiene and treat people with venereal disease in developing countries where it is growing (Kambizi and Afolayan, 2001).

Vaginal Candidiasis is a major health problem worldwide in women especially in immunocompromised females and a major hospital acquired infection. Some of the problems that maybe encountered in the treatment of the candida infections include limited number of antifungal agents, ineffectiveness of the antifungal agents, resistance of the candida to the available agents, toxicity of the antifungal agents and relapse of the candida infections. Resistance to antifungal agents continues to be a significant problem in the fungal pathogen *Candida albicans* (Sanglard and Odds, 2002). Reports of resistance to commonly used antifungal agents such as fluconazole, miconazole abound including shift from *Candida albicans* to less sensitive species such as *Candida glabrata* and *Candida krusei*.

Several works have been carried out in the past to verify the use of *Solanum incanum* in the management of microbial infections. Earlier studies by the authors on the crude plant powder have established some significant antimicrobial properties by *Solanum incanum* with significant antimicrobial activity (Beaman and Muhammed 1976, Badiee *et al*, 2011, Bunalema, 2010, Mokua, 2011) The pharmacological properties of *Solanum incanum* have already been documented (Kokwaro, 2009). Hence, the present work is an effort geared towards assessing the in vitro anti-fungal activities of methanol & water leaf extracts of *Solanum incanum* on identified strains of *Candida albicans* with a view to isolating and characterizing the constituents responsible for the antifungal properties observed in the plant.

MATERIALS AND METHODS

Plant materials

Fresh leaves of *Solanum incanum* used for this study were purchased from the Market in Suleja, Niger state, Nigeria and authenticated by Dr. Jemilat Ibrahim of the National Institute of Pharmaceutical Research and Development (NIPRD), Abuja. Voucher specimens have been deposited at the herbarium of the institute. The leaves were air dried at room temperature to a constant weight, pulverized and passed through a 1mm sieve. The powdered material was stored in an air-tight container and kept in a refrigerator.

Microorganism used

The studies were performed with fifty (50) clinical vaginal isolates of *Candida albicans* obtained from The Medical Microbiology Laboratory, University of Port Harcourt Teaching Hospital, Nigeria. The identities of the isolates were confirmed using the Germ tube test (Cheesbrough, 2004). All the microorganisms were grown in Sabouraud dextrose agar (*Lab M,* UK) at 37^{o}C and maintained on nutrient agar (*Lab M,* UK) slants at 4^{o}C. The standardized cultures of the organism were used throughout the experiment.

Solvent and equipment

Methanol (*Sigma-Aldrich*, Germany), Buchner funnel, sensitive balance (HCK- by Dipse, Germany), Vacuum pump (TW-1, 1/A6 HP), Water bath (*Techmel and Techmel*, USA), Fridge (*LG* 131), incubator (*Memmert* 100-800, Germany), Oven (*Uniscope,* England), Microscope (PH50, China), Autoclave (LD2X-40B, China), Centrifuge (*Techmel & Techmel* USA). Other reagents used were freshly prepared in the laboratory according to official specifications.

Extraction of plant materials

-A portion (500mg) of the crude leaf powder was weighed using a sensitive balance and macerated n 98% methanol for 72 hours and the filtrate concentrated *in vacuo* to yield the crude methanol extract. The process was repeated using 100 g of leaf powder in 400 ml of water to obtain pure water extract of the garden egg leaves. Drying was done using a water bath at 40°C. The extracts were collected, stored in a universal bottle and preserved in a freezer (4 °C) until ready for use.

Phytochemical tests

Phytochemical tests were carried out to detect the presence of steroids, alkaloids, tannins, cardenolide, carbohydrates, flavonoids, saponins and anthraquinone. These were carried out according to the procedures outlined by Trease and Evans (1996).

Antifungal activity testing

The effect of methanolic extract and water extract of *Solanum incanum* against *Candida albicans* were tested by both agar dilution and agar well diffusion methods.

Agar dilution method involves obtaining different concentrations of the agar by diluting with sterile distilled water; the standardized inoculum is added to the dilutions (Mohammed *et al*., 2002). Different concentrations of the methanol and water extracts were made using sterile distilled water as solvent given an end concentration of 100 mg/ml, 80 mg/ml and 60 mg/ml. 1 ml of each was withdrawn and added to 19 ml molten Sabouraud Dextrose agar. This was mixed thoroughly and then poured into a sterile Petri dish aseptically and allowed to solidify. The isolates were streaked on the surface of the agar-extract medium and incubated 37 ºC. The presence or absence of growth was observed after 24 – 48 hours of incubation.

Agar well diffusion method

The inhibition zone diameters (IZDs) of the extracts and standard antibiotics (Fluconazole – *Parnax Lab*, India and nystatin - *DBH Pharma*, India) were determined by agar-well diffusion method. They were prepared in 100 mg/ml each by dissolving 1000 mg of fluconazole powder in 10 ml of sterile distilled water and 1000 mg of nystatin tablet in 10 ml of sterile distilled water. Then the highest concentration (100 mg/ml) of both water and methanol extracts were used for the agar diffusion as it inhibited more growth from the agar dilution. 0.1mL of the standardized broth culture of the appropriate microorganism was withdrawn using a sterile pipette and transferred into 20 ml of molten Sabouroud Dextrose agar and mixed gently. The mixture was then poured aseptically into a sterile Petri dish and allowed to solidify. Four wells (6mm) were bored into the agar equidistant from each other and not to close to the edge using a sterile cork borer. Two drops of each dilution were placed in each well using Pasteur pipettes, allowed to diffuse for about an hour and then incubated at 37 ^{0}C. The IZDs were recorded after 24 – 48 hours of incubation.

RESULTS

The results from the phytochemical screening of the both methanol and water extracts of the leaves of *Solanum incanum* showed that tannins, flavonoids, carbohydrates and saponins were present in both methanol and water extracts while alkaloids and steroids were present in methanol extract only. Anthraquinone and cardenolide were absent in both water and methanol extracts (Table 1).

Table 1: Phytochemical test on various extracts of *Solanum incanum* leaves

Constituents	Methanol extract	Water extract
Alkaloids	+	-
Tannins	+	+
Flavonoids	+	+
Anthraquinone	-	-
Steroids	+	-
Saponins	++	+
Carbohydrates	+	+
Cardenolide	-	-

+, ++ = Relative intensity of the Leave Constituents

The results from the antifungal test of *Solanum incanum* leaf extracts showed that they had some level of activity against the test fungi. The results of the agar dilution test obtained at different concentrations of the extracts of 100 mg/ml, 80 mg/ml and 60 mg/ml revealed that at concentration of 100 mg/ml, methanol extract showed more growth inhibition than water extract (Figs. 1 and 2). The growth of *Candida albicans* isolates were inhibited more by the methanol extract while the water extract inhibited few isolates. The 100 mg/ml was more active than other concentrations against the *Candida albicans* isolates.

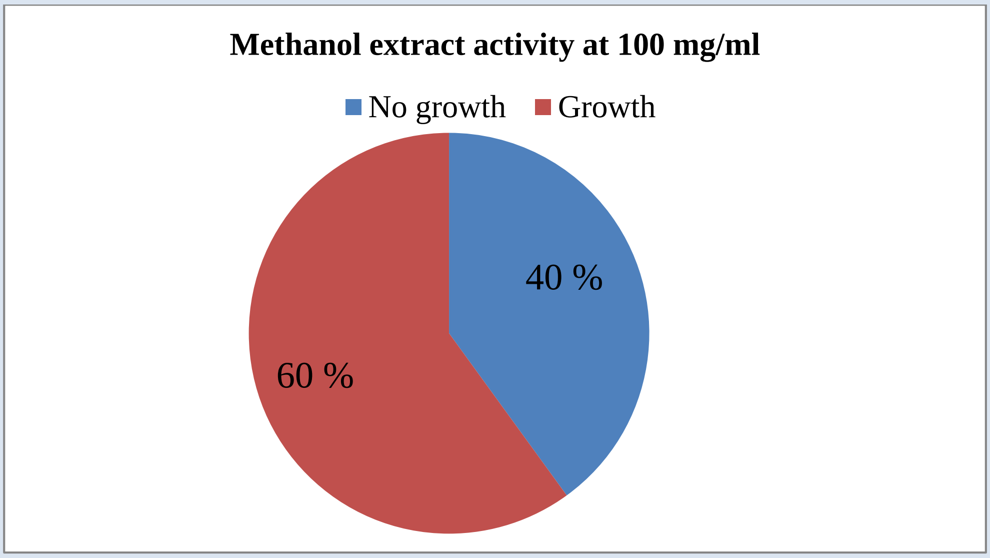

fig 1: methanol extract activity

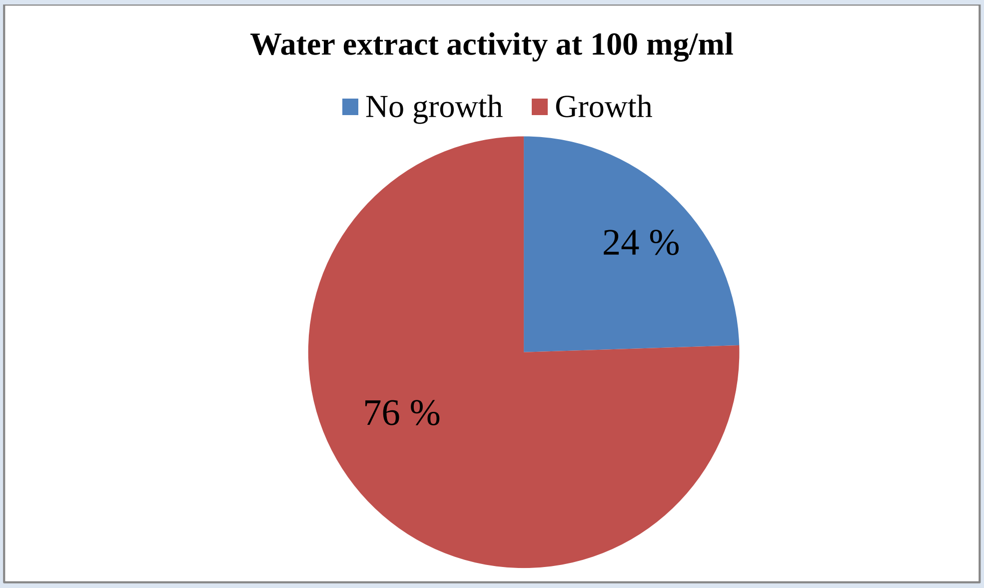

Fig 2: Water extract activity

The result of agar well diffusion method was obtained using the concentration that inhibited a number of growths in the isolates which is 100 mg/ml of both methanol and water extracts, with standard drugs, fluconazole and nystatin at 100 mg/ml. The mean inhibition zone diameters were calculated for methanol extract, water extract, fluconazole and nystatin and the results obtained are as follows: methanol extract: 5.56 mm, water extract: 1.10 mm, fluconazole: 30.80 mm and nystatin: 13.44 mm (Fig. 3).

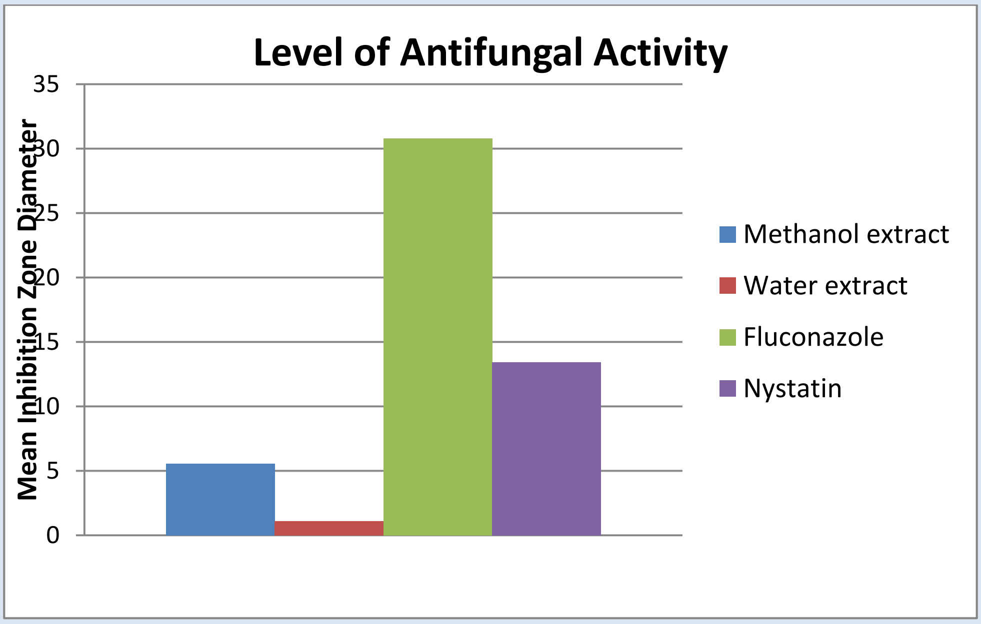

Fig 3: Level of antifungal activity of the extracts and standard drugs

DISCUSSION

An analysis of the phytochemical results suggests that the antifungal activity observed in *Solanum incanum* might be as a result of a number of the phytoconstituents present in the leaves. Flavonoids, alkaloids, saponins, steroids, carbohydrate and tannins were found present in the leaf extract of *Solanum incanum.* Among these constituents flavonoids have shown to have antimicrobial activity (Cushine and Lamb, 2005) while saponins appear to have the greatest impact on the activity under study. These deductions are in agreement with documented evidence about the medicinal potentials of secondary metabolites of the plant (Neuwinger, 2000; Cushine and Lamb, 2005; Burkill, 2000; Beaman and Mohammed, 1976). Steroids and alkaloids were present in methanol extract but absent in the water extract, this shows that the presence of steroidal alkaloids particularly glycoalkaloids may have added to the antifungal property observed in methanol extract. The saponins were present in both methanol and water extract but in varying intensity; the methanol extract had a higher intensity of saponins than in the water extract. Metabolites like flavonoids are known to be synthesized by plants in response to microbial infection, and thus have been found *in vitro* to be effective antimicrobial substances against a wide array of microorganisms (Dixon *et al*., 1983, Cowan, 1999; Himejima, *et al*., 1992). In the sensitivity testing using agar dilution method, 100 mg/ml concentration of the methanol extract effectively inhibited the growth of *Candida albicans* in about 40 % of isolates while water extract inhibited growth in 24 % of isolates. It shows that there is more antifungal property in the methanol extract than the water extract and this can be attributed to the presence of the high content of saponins, and possibly the presence of steroids and alkaloids.

The methanol extract showed intermediate susceptibility when compared to standard drug, nystatin. This implies that the isolates were intermediately susceptible to the leaf extract of *Solanum incanum* when compared to the activity of nystatin. The test thus confirms that the methanol extract is more effective than the water extract against *Candida albicans*; confirming the antifungal property. These findings suggest that the observed antifungal activity in *Solanum incanum* may be due to synergy among such constituents like tannins, flavonoids, alkaloids and/or saponins.

CONCLUSION

The present study has revealed that the crude methanol extract of the leaves of *Solanum incanum* had appreciable antifungal activity against *Candida albicans*, while the water extract exhibited a significantly reduced activity against the test fungi. The methanol extract of *Solanum incanum* leaves showed intermediate antifungal activity in comparison with standard drug, nystatin. The characterised secondary metabolites may explain in part some of the reported medicinal uses of *Solanum incanum.* Further works need to be carried out to isolate and characterise these secondary metabolites with the view of establishing their potentials as antifungal agents for drug discovery and development.

REFERENCES

Badiee P., Alborzi A., Shakiba E. and Japoni A., (2011). Susceptibility candida spp isolated from immunocompromised patients to antifungal agents. *Eastern Mediterranean health journal,* **17 (5)**: 425-30.

Beaman M.V. and Mohammed S.I. (1976). Antibiotic activities of *Solanum incanum*. *Antimicrobial agents and chemotherapy*, **1:** 920-924.

Bunalema L. (2010). Antimycobacterial activity and acute toxicity of *Erythrina abyssinica*, *Crptolepis sanguinolenta* and *Solanum incanum.* Theses submitted to department of zoology, Makerere University.

Burkill. H.N. (2000). The useful plants of West Tropical Africa. 2nd edition, Vol.5. Royal Botanic Gardens, Kew Richmond, United Kingdom. p686.

Cheesbrough M. (2004). District laboratory practice in Tropical countries. Low price edition 2000.

Cowan, M.M., *Clin Microbiol Rev* 1999, *12*, 564-582

Cushnie T.P. and Lamb A.J. (2005). Antimicrobial activity of flavanoids. *International Journal of Antimicrobial agents* **26 (5):** 343-35.

Dafni A. and Yanif Z. (2004). Solanaceae as a medicinal plant in Israel. *J Ethnopharmaol*.**44 (1):**11-18.

Dixon, R.A., Dey, P.M., Lamb, C.J., *Adv Enzymol* 1983, *55*, 1-69.

Germplasm resources information network. (2006). *Solanum incanum*. Department of Agriculture, United states. Pp01-14.

Henderson. L. (2002). Problem plants in Ngorongoro conservation Area. Final Report to the NCAA.

Himejima, M., Hobson, K. R., Otsuka, T., Wood, D.L., Kubo, I., *J Chem Ecol* 1992, *18*, 1809-1818.

Jaeger P.M and Hepper F.N. (1986). A review of the genius *Solanum* in Africa, *solanaceae biology and systematic* (New York, Columbia university press) **(3):** 41-55.

Kambizi L and Afolayan A.J, (2001). An ethnobotanical study of plants used for the treatment of sexually transmitted diseases in guruve district, Zimbabwe, *Journal of ethnopharmacology* **(77):** 5-9.

Kokwaro, J. O. (2009). Medicinal plants of East Africa: Third edition, Nairobi: University of Nairobi Press. p478 .

Mohammed J.M., Ching K.M., Tanja P, Robin S.W and Fred C. (2002). Antimicrobial susceptibility testing of *Bacillus anthracis*; Comparison of results obtained by using National committee for clinical laboratory standards broth micro dilution reference and agar gradient diffusion methods. *J clin microbial*, **40 (6):**1902-1907.

Olaniyi O.O. (2002). Medicinal Plants of Nigeria Volume 1. Academic Press. p21-22.

Sanglard D. and Odd F.C. (2002). Resistance of *Candida spp* to antifungal agents: *Molecular mechanism and clinical consequences*. **2**: 73-85.

Trease, G.E. and Evans, W.C. (1996). Trease & Evans' Pharmacognosy 4th edition, p820 - 835, WB Sunders, USA.

Tindal H.D (1965). Fruits and vegetables in West Africa. London Oxford University press 2nd edition, **(8):**105.

Effects of Vitamins A and C on Immune Response of Broilers Vaccinated Against Newcastle Disease

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ABSTRACT

The effects of vitamins A and C on humoral antibody response to NDV in broilers given Vitamin fortified feeds were tested at the Poultry Unit of the Kogi State University, Anyigba, Nigeria during the dry season of high ambient temperatures (March – April). Two hundred day-old broilers were grouped into four; T_1, T_2, T_3 and T_4 with 50 birds each. T_1 was fortified with Vitamin A, T_2 with Vitamin C, T_3 with Vitamins A+C while T_4 served as the control. Broilers in each group were vaccinated at 3 weeks with NDV (LaSota). Sera were collected from ten broilers in each group at 5, 6, 7 and 8 weeks and subjected to Haemagglutination Inhibition (HI) test. Six broilers from each group were isolated at 6 weeks and inoculated intramuscularly with 0.2ml of Virulent Viscerotropic NDV and observed for 20 days. Vitamin A, C, and A+C fortified groups enhanced the humoral immunity of ND vaccinated broilers better than the control group ($p<0.05$). Mean HI titres of T_1, T_2, T_3 and T_4 were 622.01, 882.70, 738.41 and 184.93. Only broilers in the control group showed clinical signs. This study shows that vitamins A and C in broiler feeds have the ability to enhance immunity of birds to ND vaccination during hot season.

INTRODUCTION

Broiler production plays a major role in food security for the rapidly increasing Nigeria population. Their short production cycle, high feed efficiency and high biomass per unit of agricultural land are particularly attractive for the Nigeria productive system (Ayo *et al*., 1996). However, compared to other domestic animals, broiler chickens are more susceptible to changing environmental condition (Nolan *et al*., 1999).

Broiler production in Nigeria is often faced with a viral condition of avian known as Newcastle Disease (ND) which is endemic in the country.

Newcastle disease is an acute, mild to severe highly infectious and pathogenic disease of domestic poultry, caged bird as well as wild birds caused by specified viruses of the Avian Paramyxovirus type 1 (APMV – 1) (Alexander, 2003). It is reported as the most important viral disease and a major threat to poultry production in the world including developing countries (Alder *et al*., 2001). Newcastle disease is very important because it is associated with high flock mortality and loss of edible and breeding eggs (Chansipipornchai and Sasipreeyajan, 2006). The disease was also reported to be more common during the dry harmattan (November – March), and cold stress has been known to worsen the outcome of the disease (Sonaiya, 2009). At present, the control of the disease without vaccination is unconceivable hence vaccination is the major measure of controlling ND (Senne *et al*., 2004). However, outbreaks have been reported in vaccinated populations despite the fact that vaccination is widely applied (Huang *et al*., 2004). Bourre and Galen (2006) reported that vitamins act as co-factors in several metabolic functions in immune reactions and that they are required for optimum health and normal physiological functions such as growth, development, maintenance or reproduction and that deficiencies of vitamins can cause impairment of immunity. Rama – Rao *et al*. (2004) remarked that generally higher levels of vitamins than the current recommendation for preventing deficiency syndromes would increase the immune response of poultry.

Vitamin A is necessary for increasing the immunity of vaccinated birds by the production of antibodies and its deficiency would reduce immune response and increase susceptibility to infection (Lin *et al*., 2001). Micronutrients like vitamins A and C have been shown to play vital role in host immune response (Karamouz *et al*., 2010).
Many vitamins are lost during processing, storage or when exposed to sunlight. So even if some quantities of these vitamins are added to the feeds by the commercial producers, they might have been lost ever before the poultry have access to the feed. It may therefore become necessary for the farmers to add these vitamins to the feeds on the farm at levels recommended for immunity. This work was undertaken to evaluate the immune responses to Newcastle disease vaccine (LaSota) in broilers given vitamins A and C fortified feeds.

MATERIALS AND METHODS

This study was conducted at the poultry unit of the Teaching and Research Farm of the Department of Animal Production, Kogi State University, Anyigba, Kogi State, which lies on Latitude 7^0 15^1 and 7^0 29^1 N of the equator and Longitude 7^0 11^1 and 7^0 32^1 E of the Greenwich Meridian (Ifatimehin and Ufuah, 2006).

A total of 200 day – old broiler chicks were purchased and randomly allocated into 4 treatments namely T_1, T_2, T_3 and T_4 with 50 birds in each group. After brooding for 3 weeks, the feed of broilers in group T_1 was fortified with 0.33mg of vitamin A per 25kg feed, that of T_2 was fortified per 25kg feed with 2.5g of vitamin C, and T_3 was fortified with 0.33mg vitamin A + 2.5g vitamin C in 25kg feed while T_4 served as the control with no supplement.

Vaccination:

Broilers in each group were vaccinated at the 3rd week of life with Newcastle Disease Vaccine Lasota Strain. The vaccine was reconstituted in 2 litres of drinking water and 500ml of the reconstituted vaccine was given to each group of broilers in their drinkards.

Blood collection:

Ten broilers from each group were marked and their blood collected via the jugular vein at 5, 6, 7 and 8 weeks of age. Sera was separated each time and stored at -20^0c until required for laboratory analysis.

Haemmagglutination Inhibition (HI) Test:

Sera obtained were subjected to Haemagglutination Inhibition (HI) test at the Veterinary Medicine Laboratory of the Veterinary Teaching Hospital, University of Nigeria (UNN), Nsukka, Nigeria.

Challenge Infection:

Six broilers from each group were picked at 6 weeks of age and isolated for experimental infection. The inoculum, a Virulent Viscerotropic Newcastle Disease Virus (VVNDV) was obtained from the National Veterinary Research Institute (NVRI), Vom, Plateau State, Nigeria, with a lethal dose – fifty (LD50) of $10^{8.7}$ per ml. Each broiler was inoculated intramuscularly with 0.2ml of the virulent NDV and observed for 20 days for clinical signs of ND as described by Ezema *et al*. (2009).

Data Analysis:

Data obtained from the HI tests were subjected to Analysis of variance (ANOVA) using the MINITAB Statistical Soft Ware (MINITAB, 1991).

RESULTS

Table 1: HI Titres of ND Vaccinated broilers fed with vitamin fortified feeds

	Mean HI Titres				
Age (in weeks)	**T_1**	**T_2**	**T_3**	**T_4**	**SEM**
5	800.00^a	624.00^c	757.30^b	421.30^d	57.85
6	61.33^b	250.67^a	53.33^c	48.00^d	47.23
7	1024.00^a	608.00^{ab}	1088.00^a	148.70^b	119.80
8	602.70^c	2048.00^a	1055.30^b	170.00^c	59.10

a, b, c, d superscripts on the same row show significant differences ($p<0.05$).
SEM: Standard Error of Means

Table 2: Virulent NDV challenge infection of broilers fortified with vitamins A and C Clinical Signs

Days post infection (PI)	T_1	T_2	T_3	T_4
4	-	-	-	Loss of appetite
5	-	-	-	Paralysis of the limbs and wings torticollis and weakness
8	-	-	-	Mortality
11	-	-	-	Mortality

At week 5 of life the HI titres of broilers in the various groups were very high and above the protective titre, 32.00. In addition there were significant differences ($p<0.05$) between the treatment groups, with the immunity of T_1 (800.00) being the highest, followed by T_3 (757.30), and T_2 (624.00) and the least being T_4, the control (421.30).

Week 6 revealed the highest immunity in T_2 (250.67) followed by T_1 (61.33) and T_3 (53.33) and the least in T_4 (48.00) at $p<0.05$.

In week 7 the immunity of T1 as revealed by the HI titre was the highest and was significantly higher ($p<0.05$) than the control, T_4 but there was no significant difference ($p>0.05$) between T_1, T_2 and T_3.

Furthermore, the HI titres in week 8 showed that broilers on vitamin C (T_2) had the highest (2048.00) titre followed by broilers on combine vitamins A + C (T_3) $p<0.03$ while T_1 (Vitamin A) and T_4 (control) were not significantly different ($p>0.05$) with HI titres 602.70 and 170.00 respectively.

The above results showed that broilers on vitamins A and C as single vitamins on in combination as A + C had consistently higher HI titres than the control broilers and in addition broilers supplemented with vitamin C had both high and long lasting HI titres even at the 8th week with HI titre of 2048 i.e. they sustained higher immunity longer than others.

Moreover, after inoculating the broilers in the different groups with the virulent NDV, only birds in the control group showed paralysis of limbs, wings and neck with 50% mortalities. On the contrary, broilers on fortified feeds were very active and showed no clinical signs of ND.

The high immunity to NDV in broilers fortified with vitamins A and C agrees with the findings of Swan *et al*. (2008) who reported that increase level of vitamins, increases mean cellular and humoral immunity in broiler.

The consistent high titres in the vitamin C group also agrees with the findings of Tuekam *et al*., (1994) and Aengwanich *et al*., (2003) who observed a positive correlation between antibody titre and vitamin C supplementation.

In conclusion this study has shown that vitamins A and C in broiler feeds have the ability to enhance the immunity of birds to Newcastle disease vaccination.

It is therefore recommended that broiler feeds be supplemented with vitamins A and C at levels recommended for immunity.

REFERENCES

1. Aengwanich W.P., Sridama Y., Phasuk T.E., Vongpralab P., Pakdee P., Katawatin S. and Simaraks S. (2003). Effects of ascorbic acid on cell mediated humoral immune response and pathophysiology of white blood cell in broilers under heat stress. *Song klanakarin J. Sci. Technol.* 25:297-300.
2. Alders, R.G., Costa R., Dias P., Fringe R., Fumo A., Lobo Q., Mata B.V., Silva A. and Young M.P. (2001). Investigations into the control of Newcastle disease in village chickens in Mozambique: Review of work done in Mozambique. Report on the ACIAR/INIVE Newcastle Disease Control Project Coordination Meeting, Tofo, Inhambane Province, Appendix 3.
3. Alexander, D.J. (2003). Newcastle disease. 11th Ed. Other Paramyxoviruses and Pneumovirus Infections. In: Saif, Y.M; Barnes H.J; Glisson J.R; Fadly A.M; McDougald D.J. and Swayne D.E. (Eds.) Diseases of Poultry. Iowa State Press, Ames, pp: 63-100.
4. Ayo J.O., Oladele S.B, Fayoni A. (1996). Effect of heat stress on livestock production. A review. *Nigerian Veterinary Journal, 58-68, special edition,* 1(1):58-68.
5. Bourre J. M. and Galea I.F. (2006). An important source of Omega 3 fatty acids, vitamin D and E, Carotenoids, Iodine, Selenium; A new nayural multi enriched egg. *Journal of Nutrition, Health and Aging.* 10:371-376.
6. Chansiripornchai N. and Sasipreeyajan J. (2006). Efficacy of Live B1 and Ulser 2C Newcastle Disease Vaccines simultaneously vaccinated with inactivated oil adjuvant vaccine for Newcastle Disease Virus in broiler chicken. *Vet. Scand;* 482.
7. Ezema W.S., Okoye G.O.A., Nwanta J.A. (2009). LaSota Vaccination may not protect against the lesions of Velogenic Newcastle Disease in Chickens. *Tropical Animal Health and Production.* 41:477-484.
8. Huang, Z., F. Subbaih, S.Y. Abdul and K. S. Siba. 2004. A recombinant Newcastle virus (NDV) expressing VP2 protein of infectious bursal disease virus (IBDV) protects against NDV and IBDV. *Journal of Virology.* 78:10054 -10063.
9. Ifatimehin, O.O. and Ufuah M.E., 2006. "The Effect of a Spatial Structure on Rural Economy: A Case of Kogi State University on Anyigba and its Environ", *Confluence Journal of Environmental Studies*, Volume 1(2):61-70.
10. Karamouz H., Shahriyar H.A, Gorbani A.N., Sis N.M and Jamshid G.G. (2010). Effect of vitamins, minerals and probiotics on production of antibody and live weight gain following vaccination with BCRDV in broiler birds. Bang. 1.2 *Vet. Med.* 6:31-36.
11. Lin, H; Jiao H.C; Buyse J. and Decuypere E. 2006. Strategies for preventing heat stress in poultry. *World Poultry Science Journal*, 62:71-86.
12. MINITAB Statistical Software (1991). V. 14.2. MINITAB Inc. P.A. USA.
13. Nolan J., Hinch G., Twaites J. and Walkden-Brown S. (1999). Constraints to animal production. Chapter 2: Climatic Constraints. Lecture Paper 12. Animal science Group Publisher, Australia.
14. Rama-Rao S.V, M.V.L.N Raju and D. Nagalakshmi, 2004 Nutritional modulation to enhance immunity in chickens. Poultry International April 2004 Watt Publishing Co. pp 24-29.
15. Senne D. A., King D.J. and Kapezynski D.R. (2004). Control of Newcastle Disease by vaccination. Development in Biological Science (Basel). 119:165-170.
16. Sonaiya E. B. (2009). Fifteen years of family poultry research and development at Obafemi Awolowo University, Nigeria. In Alders R.G., Spradbrow P.B. and Young M.P. (eds) 2009. Village

chickens poultry alleviation and the sustainable control of Newcastle Disease. Proceedings of an International Conference held in Dar es Salam, Tanzania. 5 – 7 October, 2005. ACIAR Proceedings no. 131 pp.235

17. Swain B.K., Johri T.S. and Majumdar. (2008). Effect of supplementation of vitamin E, C and Selenium and other different combinations on the performance and immune response of broilers. *Br. Poultry Science.* 47:287-292.
18. Tuekam, T.D., R.D. Miles and G.D. Butcher, 1994. Performance and humoral immune response in heat stressed broilers fed on ascorbic acid supplemented diet. *J. Appl. Anim. Res.,* 6(2): 121-130.

Effect of Route of Administration of Newcastle Disease Vaccine on Humoral Immunity of Broilers

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ABSTRACT

Newcastle disease (ND) vaccination failures have been rampant during extreme climatic conditions; this research was carried out to determine which route of vaccination administration is more immunogenic against ND during such season of the year. One hundred day old broiler chicks were grouped into 4 of 25 chicks each (A, B, C and D) at the Poultry Unit of the Kogi State University, Anyigba, Nigeria between March and April (dry season). On day 21 of life, the groups were vaccinated with LaSota intraocularly, intramuscularly and orally respectively while Group D served as the unvaccinated control group. Five chicks from each group were randomly selected and bled at 2, 3, 4 and 5 weeks post LaSota vaccination. Their sera were used for HI test. All the routes used produced high levels of HI antibody response two weeks post vaccination indicating that all routes were immunogenic. Immunity fell below protective level after 5 weeks post vaccination.

INTRODUCTION

Newcastle disease (ND), caused by Newcastle Disease Virus (NDV), is the most important viral disease of poultry, worldwide (Adene, 1990). It is a highly contagious viral disease affecting wild and domestic avian species (Seal *et al.*, 2000; Alexander, 2003).The impact of ND is most notable in domestic poultry due to the high susceptibility of poultry and the high morbidity and mortality rate that occur in outbreaks of virulent strains of NDV in commercial poultry (Alexander, 2003). It has been argued that ND may represent a bigger drain on the world economy than any other animal disease (Alexander, 2000).

There is a seasonal pattern to outbreaks of ND (Sharma *et al.,* 1986) influenced by changes in climatic conditions leading to stress, which predisposes birds to the disease and also hot, dry and windy periods which encourage air borne spread of the virus (Sonaiya and Swan, 2004). There is no specific treatment against ND and vaccination along with biosecurity measures are the major control methods against the disease. There are different live vaccines used in Nigeria to prevent the outbreak of ND.

Various routes are used for vaccinations against Newcastle disease in poultry. These include drinking water, spray, eye drop and intramuscular injection (Cargill and

Johnston, 2006). Weir and Hatch (2004) reported that it is very important to adhere to the route of administration of any vaccine as prescribed by the manufacturers.

Reasons for vaccination failure may include:

i. High levels of maternal antibodies in young chickens which may interfere with the multiplication of live vaccines, thus reducing the amount of immunity produced (Butcher and Miles, 2003).

ii. Stress which reduces the chickens' ability to mount immune response. Stress could include environmental extremes (temperature, relative humidity), inadequate nutrition, parasitism and other diseases (McDowell and Ward, 2009).

iii. Inactivation of live vaccines due to improper handling such as not maintaining cold chain (Yegani and Butcher, 2009).

iv. Use of vaccines that do not contain the proper strains or serotypes of organisms required to stimulate protective immunity.

v. Poor distribution of live vaccine in drinkers when administered by water or improper spray of vaccines such that chickens are 'missed' in parts of the house.

vi. Vaccination of chickens that are already incubating the disease.

vii. Immunosuppression due to infection with infectious bursal disease virus, Marek's disease virus or chick anaemia virus, consumption of feed with high levels of mycotoxins.

viii. Use of vaccines that are of poor quality (low vaccine titre or contaminated). McMullin (1985) explained that one major factor affecting vaccine efficiency is the vaccine itself – its titre, stability, serotype, quality, inactivation and adjuvants.

Different ND vaccines of various strains for different routes of administration are available in the market to prevent the outbreak of ND since there is no specific treatment for the condition.

Despite the ND vaccines and vaccination programs, ND outbreaks are still rampant in Nigeria and globally (Huang *et al.,* 2004; Oladele *et al.,* 2005; Oladele, 2008).

Some authors (McDowell and Ward, 2009) claimed that environmental extremes like high atmospheric temperature may be responsible for vaccination failure while others like Cargill and Johnston (2006) reported that poor methods of vaccination practice is the most common cause of vaccine failure in poultry.

This study was undertaken to evaluate the immune responses of broilers vaccinated with ND vaccine following different routes.

Materials and Methods

One hundred day old Ross broilers were used for this study at the Poultry Unit of the Kogi State University, Anyigba, Nigeria between March and April (dry season). On day 8 of life, the 100 chicks were given primary vaccination with Hitchner B1 strain intraocularly using the brand sourced from the National Veterinary Research Institute (NVRI), Vom, Nigeria. At age 20, they were randomly divided into 4 groups of 25 chicks each, the next day (age 21) the groups were vaccinated with NVRI brand of La Sota as follows:

- Group A received La Sota intraocularly (i/o)
- Group B received La Sota intramuscularly (i/m)
- Group C received La Sota in drinking water (orally)
- Group D served as the unvaccinated control.

Dosages were of 0.05 ml per eye for i/o, 0.2ml for i/m and 10ml per bird orally.

At 2 weeks post La Sota vaccination (PV), five birds from each group were bled and their sera used for HI test. This was repeated at 3, 4 and 5 weeks post vaccination. . Means of the HI titers results were transformed to $\log_{10}$ and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS 15.0).

RESULTS

Results are shown in table 1. From week 2 to 5 PV the different routes of vaccination; i/o, i/m, and oral produced significantly higher antibody titres than the control group ($p<0.05$). However, there was no significant difference ($p>0.05$) in the titres produced by the different routes.

Table 1: Mean Newcastle disease HI (log transformed) titres of broilers vaccinated with La Sota using different routes.

Weeks Post Vaccination	HI Titres			
	Group A i/o	Group B i/m	Group C oral	Group D Control
2	1.87 ± 0.11^{b}	1.99 ± 0.12^{b}	1.93 ± 0.34^{b}	0.96 ± 0.06^{a}
3	1.44 ± 0.18^{b}	1.63 ± 0.15^{b}	1.26 ± 0.39^{b}	0.24 ± 0.15^{a}
4	1.20 ± 0.20^{b}	1.44 ± 0.11^{b}	1.20 ± 0.34^{b}	0.00 ± 0.00^{a}
5	0.78 ± 0.20^{b}	1.02 ± 0.31^{b}	1.20 ± 0.32^{b}	0.00 ± 0.00^{a}
Mean	**1.32±0.23**	**1.52±0.20**	**1.40±0.18**	**0.78±0.23**

Different superscripts along a row indicate significant difference ($P < 0.05$)

DISCUSSION

Results of the experiment showed that NDV (La Sota) vaccination using either i/o, i/m or oral route produced high levels of immunity above protective antibody titre. Therefore, vaccination failure reports in Nigeria may not be due to the routes used.

McMullin (1985) explained that methods of administration (routes) may affect vaccine efficiency. However, in this study, the 3 routes employed gave high levels of immunity. Thaxton *et al.* (1974), Jen and Cho (1980) and McMullin (1985) reported that other factors such as the birds themselves not retaining immunity after vaccination due to stress or previous exposure to the disease may be responsible. The presence of maternally derived antibodies, immunosuppressive conditions and the presence of mycotoxins in their diet may also be responsible for vaccination failure among vaccinated flocks in the country.

CONCLUSION

All the routes (intraocular, oral and intramuscular) engendered high immunity in the vaccinated birds against ND.

REFERENCES

1. Adene, D.F. 1990. Country Report on the Management and Health Problems of Rural Poultry Stock in Nigeria. In: Proceedings of Seminar on Small Holder Rural Poultry Production. International Centre for Tropical Agriculture (CTA). Thessaloniki, Greece. 9-13th October, pp. 175-182.
2. Alexander, D.J. 2000. Newcastle disease and other avian paramyxoviruses. In: *Revue Scientifique et Technique de l' OIE,* pp. 443-462.
3. Alexander, D.J. 2003. Newcastle disease. 11th Ed. Other Paramyxoviruses and Pneumovirus Infections. In: Saif, Y.M; Barnes H.J; Glisson J.R; Fadly A.M; McDougald D.J. and Swayne D.E. (Eds.) Diseases of Poultry. Iowa State Press, Ames, pp: 63-100.
4. Anjum I., 2011 Vaccine Failure in Poultry. Accessed Online 22/2/2011. http://en.engormix.com/MA_Poultry_Industry/health/article/vaccine_failure_poultry/1531/165_po.htm.
5. Butcher, G.D. and Miles, R.D. 2003. Vaccine failure in poultry: Factors to consider. In: VM82 Institute of Food and Agricultural Sciences, University of Florida. http://edis.ifas.ufl.edu. March 2009. Accessed online. 06/10/2011.
6. Cargill, P. W. and Johnston J. 2006. Vaccine administration to poultry flocks. Merial, Gainesville, GA.
7. Jen, L. and Cho, B.R. 1980. Effects of infectious bursal disease on Marek's disease vaccination: suppression of antiviral immune response. *Avian Diseases,* 24(4):896-907.
8. McDowell, L.R. and Ward, N.E. 2009. Optimum vitamin nutrition for poultry. http://www.dsm.com/le/static/ovnrovimix/downloads/OVN_increased_meat_quality_and_productivity.pdf. Accessed online 12/11/2010.
9. McMullin, P. 1985. Factors which interfere with vaccine efficacy. Proceedings of the 1st Sta. Catarina Poultry Symposium. pp 10 – 20.

10. Oladele S.B. 2008. Clinico-pathological features of Newcastle disease in Japanese quails (Coturnix coturnix japonica) infected with Newcastle disease virus kudu 113 strain. *International Journal of Poultry Science,* 7(2):165-168.
11. Oladele, S.B; Nok A.J; Esievo, K.A.N; Abdu, P. and Useh N.M. 2005. Haemagglutination Inhibition antibodies, rectal temperature and total protein of chickens infected with a local Nigerian isolate of velogenic Newcastle disease virus. *Veterinary Research Communications,* 29:171-179.
12. Orajaka, L.J.E., D.F. Adene, B.M. Anene, E.A Onuoha. 1999. Seroprevalence of Newcastle disease in local chickens from Southeast derived Savannah zone of Nigeria. *Revue Élev. Méd. Vét Pays trop.* 52: (3-4): 185 – 188.
13. Seal, B.S; King D.J. and Meinersmann R.J. 2000. Molecular evolution of the Newcastle disease virus matrix protein gene and phylogenic relationships among the paramyxoviridae *Virus Research,* 66: 1-11.
14. Thaxton, J.P; Tung H.T. and Hamilton P.B. 1974. Immunosuppression in chickens by Aflatoxin. *Poultry Science,* 53: 721-725.
15. Weir, E. and Hatch, K. 2004. Preventing cold chain failure: vaccine storage and handling. *Journal of Canadian Medical Association,* (9)171:1050.
16. Yegani, M. and Butcher, G.D. 2009. Proper vaccination for healthy flocks. *World Poultry,* 25(7):1-4.

Assessment of Hand Hygiene Practice Among Primary School Children in Uli, IHIALA L.G.A. Anambra State

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ABSTRACT

A survey was designed to study the hand hygiene practice of Primary School Children in Uli, Ihiala Local Government Area, due to the observation that diarrhea associated childhood morbidity and mortality continued to be on the increase despite the Awareness on the oral dehydration therapy (ORT). Two hundred Primary School Children between the ages of 4-11years were randomly selected from four primary schools in Uli with the consent of their head teacher. Pre-tested questionnaires were distributed to them to collect information on hand washing practice, age and availability of hand washing facilities in the school environment. Each respondent was told to wash their hands in different bowls of water after submitting the questionnaires. The hand washed water samples collected were centrifuged and the deposit viewed microscopically in the laboratory using x10 and x40 objectives respectively. The results obtained showed that the major cause of infection was related to improper personal hygiene and inadequate hand washing facilities in the schools. About 132 (66.0%) pupils were infected with different types of micro-organisms ranging from *Staphylococcus aureus, Escherichia coli, Candida spp* and ova of *Ascaris lumbricoides.* The infection was highest (80.3%) in age group 6-7 years and lowest (42.5%) in age group 10-11 years. Males were more infected 80% than females 42.5%. In conclusion, climate variability/change exacerbate on specific sensitive diseases like bacterial pathogens, meningitis, plague, worm infestation, malaria which could be spread through improper hand hygiene. Therefore the knowledge, attitude and practice of good hand hygiene are highly recommended so as to prevent the transmission of pathogens into the body by hands among students.

Keyword: Hands, Hygiene, Pathogens, School Children, Uli, Anambra

INTRODUCTION

The high incidence of diarrhea disease and other communicable diseases among Primary School Children may be due to poor knowledge and practice of personal environmental hygiene (I). Hand hygiene is the act of cleaning the hands with or without the use of soap, for the purpose of removing soils, dirt and microorganisms.

Proper hand hygiene had been reported to reduce diarrhea morbidity and respiratory infection by 23% (2). Hands that have been in contact with human or animal faeces, bodily fluid like nasal excretions and contaminated foods or water can transport bacteria, viruses and parasites unwitting hosts. According to (2,8)transient microorganisms are bacteria, fungi, molds, viruses and parasites that can be found on the palms of hands, fingertips and under finger nails. Pathogens that may be present on the hand as transient types include *Escherichia coli*, Salmonella *spp, Clostridium difficle, Gardia lamblia* and Noro viruses. School Children contaminate their hands through various means this include money, toilet or playground (3).

Hand washing protects people against diseases transmitted through fecal -oral routes and direct physical contact such as impetigo (4). UNICEF and WHO is actively participating in the Global hand washing to prevent transmission of diseases (5). Centre of disease control (CDC) also recommends hand washing over hand sanitizers rubs particularly when hands are visibly dirty (6). The removal of microorganisms from the skin is enhanced by the addition of soap or detergents to water. Water is an inefficient skin cleanser because fats and proteins which are components of organic soil are not readily dissolved in water (7). However, warm soapy water is more effective than cold soapy water at removing the natural oils on the hands which holds soils and bacteria(8). Contrary to popular belief scientific studies showed that using warm water has no effect on reducing the microbial loads on hands (9). Solid soap may hold bacteria acquired from previous users if not properly rinsed off with water, liquid soap suspends transient microorganisms allowing them to be rinsed off with water effectively (I0). Hand sanitizers are most effective against bacteria and less effective against some viruses (11)

Conventionally, soap and warm running water is the best method for hand washing because it washes all the surfaces thoroughly including under fingernails (12). Hand washing is considered to be one of the most important ways to stop spread of germs. It is the most effective method of preventing the transmission of infections. Remembering to wash hands at the right time reduces the chances of picking up germs. The right time to wash hands include.

- After going to the toilet or changing napkin
- Before handling or eating food
- Immediately after touching raw food (e.g poultry, meats and vegetables).
- After touching animals or their feeding equipment
- After coughing, Sneezing or blowing the nose
- After contact with body fluids (e.g blood, faeces, vomit)
- After touching a dirty surface (e.g rubbish bin)
- Before and after giving first aid, applying contact lenses or handling any medicines and.
- If they look or feel dirty, Source(1)

MATERIALS AND METHODS

Study Area and Population

The study was carried out in Uli town, Ihiala Local Government Area of Anambra State, Nigeria. It is made up of four notable wards, Umuoma, Umubazu, Eziama and Ubahudara. It lies approximately between latitude $5^{0}58^{1}$- $5^{0}60^{1}$N and longitude $6^{0}47$ –

$6^{0}57^{1}$E of the equator. The major occupation of the people is farming and trading, in addition to other occupational groups such as civil and public servants, and artisans. Water sources for domestic and agricultural uses are streams, rivers, bore-holes and open wells. The vegetation is of two distinct season, the wet season lasting from April – September and a short dry season from October to March. The annual rainfall ranges from 27 to 33^{0}C and relative humidity of 70 – 80% (7)

Collection of Hand Washed Water Samples and Analysis

Prior to the collection of hand washed water samples, consent was obtained from the head teachers of the selected Primary Schools as well as from the volunteers' parents. Interactive sessions were held with the School Children stating clearly the objectives of the study, what would be involved and its significance.

Pre-tested questionnaires which indicated their bio-data on age, sex, name, behavioural characteristics on hand washing practices and availability of hand washing facilities in the school environment were also distributed. The hand washed water samples of the volunteers were collected during their break period. The samples collected were dispensed into labeled sterile specimen bottles and thereafter taken to the laboratory for microscopic examination. Water samples not examined within the same day of collection were preserved in the refrigerator at 4^{0}C and later examined to avoid possible disintegration of the microorganisms.

On reaching the laboratory, each hand washed water samples was inoculated into Mac-conkey and blood agar plates and incubated at 37^{0}C for 24hrs(13). After that each samples were put into centrifuge bottles and spined at 121 rpm and supernatant decanted and deposit viewed under x10 and x40 objective, cells, casts, bacteria, debris were noted.

Statistical Analysis

Chi-square $(x)^2$ statistical distribution was used to check for the prevalence of micro-organisms on the hands of the selected primary school children with respect to age and sex

RESULTS

Four Primary Schools were studied for hand hygiene practices in the study area. Of the 200 students sampled, 132 (66.0%) were found to be infected (Table 1). The infection was recorded in all the primary schools with St. John Primary School 40 (80.0%) having the highest.Prevalence followed by Ndiumereku 35 (70.0%) while Ihite primary school with 25 (50.0%) had the least prevalence. A Chi-square analysis showed significant variation in prevalence among the Primary Schools (x^2 =0.352, df=3; p>0.05).

Table 1: Prevalence of Microorganisms infection on the hands of selected Primary School Children in Uli town.

Primary School Examined	No of students examined	No of students infected with microbes	Prevalence of infected (%)
Ihite Primary School	50	25	50.0%
Ndiumereaku Primary School	50	35	70.0%
St. John Primary School	50	40	80.0%
Ubahudara Community Primary School	50	32	64.0%
Total	200	132	66.0%

Age related prevalence data are summarized in Table 2. Out of a total 200 students with the age range 4-11 years old respectively. Infection prevalence was highest in the age group 6 – 7 years 45 (80.3%) while age group 10-11 years had the least prevalence rate of 27 (42.8%) respectively.

Table 2: Age related prevalence among students examined in the selected Primary School.

Ages group examined (years)	No of students examined	No (%) infected with microbes
4-5	35	25 (71.4)
6-7	56	45 (80.3)
8-9	46	35 (76.1)
10-11	63	27 (42.8)
Total	200	132 (66.0)

X^2=0.352; df=3; p=0.05

Table 3 shows the sex-related prevalence of hand hygiene among the primary schools randomly selected. Of the 200 students examined (100 males and 100 females); 80 (80%) males and 52 (52%) females were infected. There was however, no significant difference in the prevalence of infection in relation to sex.

Table 3: Sex related prevalence among students examined in the selected primary schools.

	Males		Females	
Schools	No examined	No infected (%)	No examined	No infected (%)
Ihite Primary School	25	17 (68.0)	25	10 (40.0)
Ndiumereaku Primary School	25	18 (72.0)	25	14 (56.0)
St. John Primary School	25	23 (92.0)	25	15 (60.0)
Ubahudara Community Primary School	25	22 (88.0)	25	13 (52.0)
Total	100	80 (80.0)	100	52 (52.0)

Table 4 shows the prevalence of microbes on the hands of the student examined in the four selected primary schools. Results obtained recorded *Staphylococcus aureus* as the highest prevalence with 54 (27.0%) followed by *Escherichia coli* 47 (23.5%) while the ova of *Ascaris lumbricoides* had the least prevalence rate of 6 (3.0%)

Table 4: Prevalence of Microorganisms found on the hands of the students in the four selected Primary Schools.

Microbes	Ihite Primary School No =50	Ndiumereaku Primary School No=50	St. John Primary School No=50	Ubahudara Primary School No=50	Total No = 200
Staphylococcus aureus	10 (20.0%)	14 (28.0%)	18 (36.0%)	12 (24.0%)	54 (27.0%)
Escherichia coli	8 (16.0%)	13 (26.0%)	12 (24.0%)	14 (28.0%)	47 (23.5%)
Candida spp	5 (10.0%)	7 (14.0%)	7 (14.0%)	6 (12.0%)	25 (12.5%)
Ova of *Ascaris lumbricoides*	2 (4.0%)	1 (2.0%)	3 (6.0%)	0 (0.0%)	6 (3.0%)

The attitude and practice of children towards hand hygiene were assessed in the four primary schools (Table 5). The number who do not comply to washing of hands after toilet, picking of dirt, before eating were greater than those who wash their hands.

Table 5: Assessment of various hand washing practices amongst the primary school children sampled

Risk Factors (No=200)	No (%)	Response
Hand washing after toilet	65 (32.5) 135 (67.5)	Yes No
Hand washing with soap after toilet	104 (52.0) 96 (48.0)	No Yes
Hand washing before eating	103 (51.5) 97 (48.5)	No Yes
Hand washing with soap after playing	106 (53.0) 94 (47.0)	No Yes
Availability of hand washing facilities (Soap, water and sinks)	133 (66.5) 67 (33.5)	No Yes
Hand washing with soap after picking papers from the school compound	109 (54.5) 91 (45.5)	No Yes

DISCUSSION

A hand hygiene prevalence of 66% was observed in this study. This result confirms the presence of poor hand hygiene practices in Uli town, Ihiala Local Government Area Anambra State. The poor hand hygiene poses a major public health problem in the communities especially among children. The prevalence reported in this study is however higher than those reported by other researchers (11,14). This calls for the attention of the state health authorities as well as that of the Local Government in the provision of hand washing facilities in schools and other public places. There is a noticeable disparity in infection prevalence among the various Schools Studied. This disparity can be attributed to varying degrees of acquisition of hand hygiene facilities such as adequate water supply, adequate toilet facilities, supply of soap and hand towels.

The hand hygiene practices in this study vary with age as similarly described elsewhere (8, 12) . Pupils with age group 6-7 years had the highest prevalence (80.3%) (Table 2), while those in the age group of 10-11years had the least (42.8%). As noted (3) variations in use of hand hygiene practices and playing habits of children influences distribution of microorganisms.

Consequently, the observed variations in age prevalence in the study, may therefore be attributed to excessive playing habits of the children within that age group, their lack of non compliance to hand hygiene practices, knowledge and carelessness (8). The observation in this study that males had higher prevalence rate than females might result from the fact that males are more rough and this effects their playing habits. This finding agrees with those of other workers (10, 8).

There was a variety of bacteria species found on the hand washed water of these students. The observation that Candida spp was recorded in the study is in contrasts to (4), but still confirms the poor hand hygiene practices of the study population. Climatic changes also encourages or favours some bacteria to thrive more than others. Consequent upon this,some bacteria are commonly spread through hand shake, soiling hands with sand, by extension spreading diseases through poor hand hygienepractise(9). Pathogens observed in the study include *Staphylococcus aureus, Escherichia coli,* ova of *Ascaris lumbricoides,* these were in agreement with reports from other parts of the country. School Children are the most heavily infected group with geohelminths. The high prevalence of these infections in school children is closely correlated with poor hand hygiene practice or poor sanitary conditions coupled with their voracious eating habits(3,6). Non-compliance to hand hygiene practice leads to intestinal discomfort coupled with other adverse health effect which may result in anaemia (9). Control of these worms and pathogens is of great importance, especially in children. So it is advocated that children hand hygiene practices should be properly monitored.

The knowledge, attitude and practice of school children towards hand hygiene practices observed in the study area were poor. Greater number of students examined do not observed proper hand hygiene practices possibly because the facilities are unavailable.

Schools in the study area lack hand washing facilities. Some school children have the knowledge about hand washing but does not always translate it into practice.

This study has shown that poor hand hygiene practices is endemic in Uli town. This observed prevalence is of public health significance and could be a threat to important socio economic activities in the area if not quickly checked, since poor hand hygiene practices leads to diseases like diarrhea, dysentery, HIN Influenza, gastro-intestinal and respiratory infections. There is urgent need therefore for Government in corroboration with health and Education section to organize an enlightenment programmes in schools and communities in the State. Also to provide hand hygiene facilities in schools and public places in order to improve their immediate environment as well as their personal hygiene level. Finally Government are advocated to enforce laws on "human-induced climate change" because some diseases are more advantaged which trigger out-breaks of emerging and re-emerging diseases(15).

REFERENCES

1.Hogne, B.A. (2003). Hand washing practices and challenges in Bangladesh. *International Journal of Environmental Health* 13(1); Pp 81-87

2.UNICEF (2008). The State of the World's Children survival children as Agents of change. Lessons from UNICEF

3.Heenan, C.B. (2001). Washing away your sins. Threatened morality and physical cleansing. *Journal of Science* 313 (5792). Pp 2-1451.

4.Stern (1998). Hand washing among school children in Bogata, Colombia, *American Journal of Public Health* 99 (1); Pp44-101

5.Larson, E.A. (1998). Hand washing, its essential effect when you use gloves. *American Journal for the Nurses* (88); Pp934-939

6.Scott, B.V; Curtis, T.V. and Rabie, T.C. (2003). Protecting Children from diarrhea and acute respiratory infection. The role of hand washing promotion in water and sanitation programmes. *British Journal of Infection Diseases* 7(1); Pp42-47.

7. Kretzer, J.S. (2002). Diarrhea and School toilet hygiene in Cali Columbia. *American Journal of Epidemiology.* 107(5); Pp412-420

8.Tanbekar, D.H.; Shirsat, S.D; Suradkar, S.B. (2007). Prevention of transmission of infectious disease. Studies on hand hygiene in health care among students. *Continental Journal of Biochemical Sciences* 3(1); Pp6-10.

9.Lastedius, J.G; Dimbery, L.O. (2005). Hot water for hand washing, where is the proof? *Journal of Occupational Environmental Medicine*. 47(4); Pp5-434.

10.McBride, M.E (1984). Microbial flora on in-use soap products. *Applied Environmental Microbiology* 48 (2); Pp 41-338.

11.Michaels, B.G.; Gangar, V.A.; Arenas, M.D. and Paulson, P.A. (2002). Water temperature as a factor in hand hygiene efficacy. *Food Service Technology* 2(3); Pp 139-149.

12. Hibbard, J.S.(2005). Analysis comparing the antimicrobial activity and safety of antiseptic agents*. A Review of nursing Journal 28(3):*Pp 194-207.

13.Cheesbrough, M.N.(2005). Culture Examination for Microorganism. *District Laboratory Practice in Tropical Countries Part* 1. Cambridge Low-price Edition: Pp239-258.

14Tambekar,D.H.,Shirsat,S.D.,Suradkar,S.B.(2007).Prevention of transmission of infectious disease. Studies on hand hygiene in health care among students. *Continental Journal of Biochemical Sciences.3(1):*Pp6-10

15.Nwoke,B.E.B.,Nwoke,E.A.,Ukaga,C.N.Anosike,J.C.,Dozie,I.N.S.andAjero,C.M.U. (2007).The impact of changing human environment and climate change on emerging and re-emerging parasitic diseases*. Nigeria Journal of Parasitology 28(2).*Pp135-145.

Phytochimic and pharmacological studies of some Central African medicinal plants with antidiabetic properties

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ABSTRACT

For thirty years, diabetes is a real public health problem worldwide. It results in abnormally high blood sugar measured in the blood several months apart, at a concentration greater than 1.4 gr. per liter at fasting and it affects all age groups. It is a chronic metabolic disease that occurs when the pancreas does not secrete insulin, insulin-dependent (type I) usually affects young individuals age 30 or when the pancreas does not produce enough insulin secretion and that it is in deficit; form of diabetes found in adults and obese: diabetes non-insulin-dependent (type II). Besides these two forms of diabetes are primitive, there are diabetes secondary to other diseases, diabetes and gestational diabetes Mady. Indeed, given the dissatisfaction found in modern medicine, traditional herbal tracks seem to reinforce potential interest, including the process of development, from plant to phytomedicine through appropriate scientific methods, could offer a credible alternative, for communities.

Keywords: phytochemical, pharmacological, medicinal plants, antidiabetic

INTRODUCTION

Nowadays, endemic diseases such as onchocerciasis, hepatitis, malaria, diabetes or AIDS are among the evils against which, the Third World in general and African countries in particular are faced with resources, especially financial, limités.Les the consequences include:

• increasing costs of certain drugs that are not accessible to the majority of people often far from health centers.

• the event, for sociocultural reasons, a certain distrust of the people living in rural areas particularly in relation to modern medicine, preferring to turn to traditional healers who do not speak very often such concepts as the determination of remedies to administer to their patients.

The corollary of this is an increasing morbidity and mortality that slow the development of the countries concerned and thereby exacerbate the poverty of their populations

To solve these specific problems of public health in Central Africa, in particular, one way seems to be the use and exploitation of medicinal plants that abound in our forests and wealth that have already proven their effectiveness. As part of our research project to obtain a doctorate and PhD to make our modest contribution to solving public health problems, we focused our attention on one of these scourges, diabetes, which been recognized by the World Health Organization (WHO) as an urgent priority at national and international [1, 2].
Indeed, the prevalence of diabetes worldwide, according to predictions by experts [3] was 4% or 135 million people in 1995, this rate would reach 5.4% or 300 million people in 2025 . Movers & Shakers of this insidious disease will be rampant and observed in developing countries: we will indeed have a 17% increase is an increase from 84 to 228 million patients between 1995 and 2025. During the same period in Central progression rate of diabetes will be among the most important, going from 72,000 to 210,000 people with diabetes [4].
In Central Africa, a good part of diabetes is currently aged between 40-65 years [5], which has the backlash to question our policy development, insofar as this category of patients are workers who play an important role in building the nation. Instead, they will, during the many years they are supposed to produce, deal with the complications of chronic disease, which involve the use of medical resources for their constant, often very expensive for the state and their families [6, 7]. It should be emphasized that the goal of the program African Traditional Medicine and Pharmacopoeia of CAMS is to make available to African populations Improved Traditional Medicines (MTA) to solve the crucial problem of drugs, and gradually create the conditions for implantation of the future African pharmaceutical industry.
The objectives were not met since the development of this program, led the 13th Symposium on Traditional Medicine and Pharmacopoeia African (Apay) held in Brazzaville (Congo) from December 6 to 10, 2004, responding to criticism by the Steering Committee (Audit AUF), and suggest the creation within the program, a purpose of streamlining the three geographical areas with each of them target diseases in addition to HIV / AIDS:

- West Africa: Malaria;
- Central Africa: Hypertensive disease and metabolic;
- East Africa and Madagascar: diarrheal diseases.

To continue the program, it was necessary for the identification of Research Projects - Development plans in each sub-region and taking into account the concerns targeted by the Secretariat General of the CAMS taking care of the financial resources necessary to carry out the activities. Network Apay Central Africa, established in December 2005 and coordinated by Professor Jean-Maurille Ouamba, participates in the diarrheal diseases by collecting data from the sub-region on the issue through research projects and thesis, including this one .

OBJECTIVES OF THE STUDY

General Objective

This research protocol is designed to contribute to better knowledge of plants used in the pharmacopoeia and traditional medicine in Central Africa, specifically those used by traditional healers for treatment of diabetes.

Specific Objectives

The study intends to achieve the following objectives:
* Inventory and identify medicinal plants used in traditional treatments of diabetes.
• verify and prove by ethno-medical procedures, the effectiveness of key plants to retain.
• extract the active ingredients and medicinal properties for the development of herbal medicines.
• highlight the main chemical groups in plant extracts.
• evaluate the pharmacological activities.
• isolate the active fractions after selective extraction.
• purify the active fractions to isolate the active principles.
• contribute to finding solutions to health problems of the population of Central Africa in general and particularly in the context of diabetes improved quality of life there of.

These are the reasons that lead us to conduct this study in view to make our modest contribution to the research undertaken in this particular sector in Central and / or Congo - Brazzaville under development, rational management and sustainable use of GR renewable, conservation of biodiversity and cultural heritage of scientific and indigenous knowledge.

MATERIALS AND METHODS

Plant material

Usually five (5) medicinal species have been identified and inventoried in Bangui and its surroundings during the treatment of diabetes by traditional healers (see table)
The plant material consists of leaves, roots, barks harvested in the area of Bangui and its surroundings. These plants are also used traditionally to treat many diseases. Their botanical identification was carried out at the Faculty of Science Department of Materials Science at the University of Bangui. The samples are dried at room temperature in the laboratory of direct sunlight and then ground and extracted.

III.2. Methods

Scientific name (Family)	**Bodies used**	**Vernacular names + Vulgar names (Issongo)**	**Medical**
Morinda Lucida Bth. (Rubiaceae)	Leaves, Bark	Mokekele	The decoction of bark and foliage is used for toilet diabetic
Persea americana Mill. (Lauraceae)	Leaves	Avocado	Two small wrists cut leaves into small pieces, infuse a liter of water to drink during the day
Ocimum gratissimum L. (Lamiaceae)	Leaves	Ngbanda	The disease diabetes consume the macerated leaves as a beverage
Citrus aurantifolia L. (Rutaceae)	Leaves	Moguembeg uembe Citronnier	Against diabetes, the decoction of fresh leaves mixed with honey
Paullinia pinnata L. (Sapindaceae)	Leaves	Gagambolo	The leaves mixed with lightly toasted sesame is consumed by the patient three times

The following methodology is adopted :

- Ethnobotanical Survey :
  - Identification of traditional healers;
  - The collection of botanical specimens of plants designated by the study team by traditional healers;
  - Documentary research on the pharmacological properties of these plants harvested and their various uses in traditional medicine in African pharmacopoeia (Congolese, Cameroonian, Senegalese and Central we have).
- Study phytochemical :

Many solvents will be used for the extraction of plant material. The different parts of the herbal substance are selected from the therapeutic uses of traditional healers as the solvent used. The extraction can be cold (maceration) or hot (Soxhlet).
Subsequently, these different extractions will be performed in the laboratory of chemistry, a chemical screening will be performed on crude extracts of different samples to highlight the family of alkaloids, triterpenes, flavonoids, sterols, tannins, saponins, etc.., D According to the method described by Abayomi (1996).
Finally, we will end the isolation, purification and structure determination of active principles: to achieve, it is necessary to use analytical techniques for separation and / or characterization. The technique most commonly used is the High Performance Liquid Chromatography (HPLC) in order to isolate the active extracts to fractionate and purify

them. The use of infrared (IR), Mass Spectrometry (MS), etc.. Allows us to identify the molecular structure of compounds.

- Evaluation of pharmacological activities:

This task boils down to evaluating the toxicity and anti-hyperglycemic with the assistance of biologists network Apay Central Africa.

- Literature:

It will be put to therapeutic uses to compare species identified through our work in the plants studied in other pharmacopoeias including the Congo, Senegal and the ethnobotany of the expedition conducted by the Central Empire.

EXPECTED

1. Establishment of a database on plants antiglycémiantes potential (chemical screening of extracts, evaluation of the biological activity of fractions, isolation of active principles, correlation "structure - activity);
2. Confirmation or denial of the application areas of these plants and their pharmaceutical interest;
3. Publication of results (annual reports, scientific papers, patents, and possibly work).
4. Defending a doctoral thesis at the University Ngouabi;
5. In the medium term, the formulation of improved traditional medicines.

RESOURCES

At the plateau technique, we will benefit from the technical platform of the University of Bangui University Ngouabi which have been operating for 6-7 years, doctoral studies, and particularly, we will build the skills and materials scientist Doctoral Enhancement of aromatic plants, medicinal and food-medicament, the Regional Centre of Excellence AUF "Training and Research on Pharmacopoeia and African Traditional Medicine" and the Network of Central Africa Apay CAMS headquartered Ngouabi University of Brazzaville and placed under the coordination of Professor Jean-Maurille Ouamba.

REFERENCES

1. World Health Organization: Non Communicable Disease Prevention and Control: Report bye the Director General EB 101/**14**. **Geneva, W.H.O**, 1997.
2. World Health Organization: World Health Report: Conquering Suffering, Enriching Humanity. **Geneva, W.H.O**, 1997, 152-156
3. H. King, R.E. Aubert et W.H. Herman, Global Burden of Diabetes, 1995-2025. **Diabetes Care**, 1998, **21**, 1414 – 31.
4. R. Cooper, C. Rotimi, J. Kaufman, E. Owoaje, H. Fraser, T. Forrester, R. Wilks, L. Riste et J.K. Cruikshank, Prevalence of NIDDM among population of the African diaspora. **Diabetes Care**, 1997, **20**, 343 -348.
5. H. King et M. Rewers, WHO Ad Hoc Diabetes reporting Group, Global estimates and impaired glucose tolerance in adults. **Diabetes Care**, 1993, **16**, 157 -177.
6. Kerarho J. Adam J.G.(1974), pharmacopée Sénégalaise traditionnelle, plantes médicinales et toxiques, **Edition Vigot et frère**, Paris
7. Adjanohoum E. 1988, Contribution aux études ethnobotaniques et floristiques en République Populaire du Congo. **ACCT**. Paris 605 P.

THEME 7: CLIMATE CHANGE AND LEGISLATION AND POLICY FOR SUSTAINABLE DEVELOPMENT

Effective Adaptation to Climate Change in Nigeria: Who's Responsibility?

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ABSTRACT

With increasing greenhouse gas emissions, the earth is facing global warming which has resulted to persistent climate change. There is not yet an agreed path to emission reduction internationally. The need to initiate adaptive measures to climate change is not only recognized but has become a necessity. This study determined the role of government, private sector and individuals in providing adaptive measures to climate change in Nigeria. The study was carried out in Nigeria after the flood disaster last year that laid waste billion naira worth of property in the country. Three research questions guided the study and a questionnaire was used to collect data from the study namely: To what extent is government responsible for leading on adaptation to climate change in Nigeria? How can individuals be responsible to adaptation to climate change in Nigeria? What is the role of private sector in adaptation to climate change in Nigeria? Based on survey data from 600 respondents randomly selected from the six geopolitical zones in Nigeria, substantial proportion of the respondent strongly agreed that since there was no market failure in adapting to climate change, it was up to individuals, communities and private companies to consider the potential impact of climate change and take action accordingly. Furthermore, the findings indicated that government should provide information and flexible economy that ensures good environment for adaptation; that generating options for adapting to climate change was best done as a shared process between researchers and the society and government; that investment to research was a critical response to building capacity to cope with climate change and its related natural disaster. Government, individuals and private sectors have primary role to adaptation to climate change in their different levels and these roles when combined with research reports will enhance the capacity to cope with climate change by the general public.

INTRODUCTION

With the increasing greenhouse emission, the earth is facing global warming which has resulted to climate change. Climate change is altering long standing patterns of temperature and precipitation. Air pollutants are being found in the most remote valleys and in the highest peaks. Thus climate change is having dramatic effects on forests, natural resources and people's livelihood and health. In Nigeria, the worst floods in 50 years killed 140 people, left hundreds of thousands homeless, tens of thousands of hectares of farmlands destroyed and raised fear of flood crisis, (Chonoko,2012). Nigeria gets heavy tropical rains from May to September, usually suffers from seasonal flash flood. According to Sidi (2012) the 2012 Nigeria floods killed over 363 people, over 2100000 displaced as of 5th November. Nigeria is not the only country that experienced flood disaster. BBC news reported that in the global scene, the world experienced flood disaster 2011 in Sindh, 2010 China, 2010 Pakistan floods and 2005 Kashmir earthquake.

Climate change is altering the face of disaster risks not only through rises in sea level and temperature but also through increased socio-economic vulnerability resulting from water stress, impacts on agriculture, ecosystem and health (UNISDR, 2012). According to UNISDR (2011) climate change will worsen the impact of disasters because weather and climate related disasters are already a major and costly concern and climate change will make matters worse. With no clear internationally agreed path to emission reduction the need for adaptation is recognised at the different levels in the world and Nigeria in particular.

Adaptation involves changing the way we do things to prepare for the potential impacts of climate change. This means we will be better protected against negative impacts like flooding. It also means we will be better prepared for new opportunities like the chance to grow different crops. Adaptation and disaster risk reduction are closely linked. Thus adapting to impact of climate change and reducing risk to disaster are priorities that are best addressed in an integrated manner. Both build resilience and reduce the vulnerability of communities. Thus IPCCSREX (2012) made it clear that reducing the risks to disaster is an effective approach to climate change adaptation which required integration with regard to policy setting and capacities and knowledge. The problem of this study if put into question is: Adaptation to climate change in Nigeria, who's responsibility?

Garnaut (2012) argued that there is no real failure in adapting to climate change and that it is primarily up to individuals, communities or private companies to consider potential impacts of climate change and take action accordingly. He pointed out that government has some responsibility to provide information, look after its own assets and provide for a strong and flexible economy that provides the best environment for adaptation. According to Sidi (2012) the 2012 Nigeria floods brought all stakeholders together as never before to address the consequences of the flood, plan to reduce the vulnerability of our people and increase their resilience. Sidi (2012) further pointed out that he would want to see participation of the people at local level in addressing the effects of climate change and said that inclusion of conflicts resolution as major area of risk reduction. He said that participation of women and children will be critical to the successful implementation of any disaster risk reduction beyond 2015. From reviewed literature, climate change requires adaptation to cope with the weather related change. It involves general responsibility. Every sector has responsibility to adaptation to climate change government, individuals and private. In Nigeria, what are the roles of government, individuals and private companies to adaptation to climate change in Nigeria?

Research Questions:

Three research questions guided the study.

- To what extent is government responsible for adaptation to climate change in Nigeria?
- How can individuals be responsible to adaptation to climate change in Nigeria?
- What is the role of private sectors in adaptation to climate change in Nigeria?

Method:

After the menace of 2012 Nigeria floods and the consciousness it generated among the Nigerian populace, the researchers randomly selected 600peoples across the six geopolitical zones in the country to sensitise the people on the roles of government, individuals and private sectors on adaptation to climate change in Nigeria. A questionnaire: Climate Change Adaptation (CCA) was developed by the researchers in which each respondent is to indicate the extent he/she agrees to the items in the questionnaire. Percentage was used for data analysis and any mean percentage below 2.50 is rejected while mean percentage above and equal to 2.50 is accepted. The study is a survey research. Six research assistants were used for the study. CCA has three sections and each section is used to answer corresponding research question.

Result

Table 1: Percentage Mean Responses to Climate Change

SN	ITEM	SA	A	DA	SD	X %
	SECTION A: Government Responsibility					
1	Establish National Adaptation Programme	300	230	30	20	3.2
2	Established local sustainable development plan	220	315	40	25	3.2
3	i Assessment-disaster loss data in both local nd state level	310	120	100	70	3.1
4	y o An environmental protection	321	110	97	72	3.1
5	Devises early warning system	410	150	25	15	3.7
6	Provides insurance scheme for natural disaster	220	315	40	25	3.2
7	Establishes research centres for NAP	115	312	30	43	2.5
8	Engages on enlightenment campaign	500	45	21	34	3.7
9	Give warning notice to the public	312	132	56	100	3.1
10	Trained Personnel for emergency management	312	120	92	76	3.1

11	Evacuation centres in each state Government has responsibility to climate change adaptation	272 423	202 99	171 30	55 48	3.1 87
	SECTION B: Individual Responsibility					
12	Changed farming periods and system	486	45	25	34	3.3
13	Provide water ways	115	312	30	43	2.5
14	Engage on various preservation devises	220	315	40	25	3.2
15	Engage on tree planting	300	230	30	20	3.2
16	Reduce cutting of trees	410	150	25	15	3.7
17	Preserve local ecosystems	220	315	40	25	3.2
18	Maintain clean environment	321	110	97	72	3.1
19	Build escape points for emergency	115	312	30	43	2.5
20	Reduce environmental pollution	223	132	84	161	2.7
21	Buy energy saving appliances	210	197	150	43	2.95
22	Individuals have responsibility to adaptation to climate change	403	89	40	68	82
	SECTION C: PRIVATE COMPANY					
23	Support the development of carbon foot print product	115	312	30	43	2.5
24	Reduce GHGs emission from transport and service	410	150	25	15	3.7
25	Provide low emission products	220	315	40	25	3.2
26	Use energy saving light bulbs	223	132	84	161	2.7
27	Sell A-rated electrical appliances	210	197	150	43	2.95
28	Offer services and products that reduce customers GHGs emission	410	70	51	69	3.4
29	Educate consumers through product labelling	210	197	150	43	2.95
30	Provide guidance to customers to reduce their carbon footprints	276	192	50	77	3.1
31	Private sectors have responsibility to climate change adaptation	400	68	41	91	78

Table 1 showed in percentage, the respondents' reaction to the items in the questionnaire showing the extent they agreed or disagreed with each item. Based on the survey data, substantial proportion of the respondents 62% agreed that both government, individuals and private sectors have primary responsibility to adaptation to climate change in their different levels in the country.

DISCUSSIONS

Based on the survey data from the respondents, substantial proportion of the respondents strongly agreed that it is up to individuals, government and companies to consider the impact of climate change and act accordingly. These combined with research reports will enhance the capacity to cope with the vulnerable situations a result of climate change. Government in both national and local level should use the institutions to provide information and flexible economy that ensures good environment for adaptation. The establishment of National Adaptation Programme in the different levels of government will help in the formulation of informed policy decision for effective planning and prioritising of adaptation actions. Providing information on current and future climate hazards (Garnaut, 2012) NAP will:

- Raise awareness of the need for climate change adaptation
- Increase resilience to current climate extremes
- Take timely action for long-lead time measures
- Address major evidence gaps.

Generating options for adapting to climate change was best done as a shared process between researchers and practitioner (Johnston, 2012). According to Lauterjung (2004) research study helped to develop early tsumani warning system in Japan. Government should involve institutions with expertise and functioning mechanisms to address the risk of natural hazards in development planning, promote the integration of climate change adaptation and disaster risk reduction practices and ensure that methodologies offered by disaster risk reduction practices address the negative impacts of climate change.

Companies or private sectors should implement processes to manage climate change risks if they are to avoid future legal liabilities. The major role of companies to climate change is to reduce carbon emissions. Sullivan and Gouldson (2011) pointed out that the responsibility of the companies is to influence the suppliers, customers and other parties to reduce carbon emission by working direct with suppliers to help reduce their greenhouse gas emissions, support the development of products carbon footprint and reduce greenhouse gas emissions from transport and logistics, providing low emission products and services and educating consumers through product labelling and provide guidance on the actions that customers can take to reduce their carbon footprints. The experience to date suggests that these actions can make a material contribution to reducing greenhouse gas emissions.

Individuals and society have had a long history of adapting to climate variability and change. There are few systematic barriers to adaptation. Indigenous Nigerians hold a significant body of traditional knowledge that is potentially valuable in helping us adapt to the variable and changing climates. In addition tree planting, clearing of water ways as well as clean environment should be intensified to reduce greenhouse gas emission in the environment. With increased awareness on adaptation by the government low carbon emitting household appliances will replace old ones thus bring about reduction in greenhouse gas emission.

CONCLUSION

An informed society is very essential for effective adaptation to the effects of climate change. Adaptation to climate change will be a continually evolving process requiring new approaches and tools. There is need for continuous sensitisation of Nigerian citizens on climate change, its impacts worldwide on economy and human life to enable them cope with it as other people are doing.

REFERENCES

BBC (2012). Nigeria deadly flooding in Jos Plateau State, **News Report. July, 24. 201**

Chonoko, I. (2012. Nigeria flooding called natural disaster. **Reuters. November 5, 2012. Retrieved November 26, 2012**

Garnaut, R. (2010). Adapting to climate change: More questions to answer. **Climate Change Review: http:chimalaya.org2012/06/30adapting-to-climate-c**hange

IPCCSREX (2012) The UN global assessment report on disaster risk reduction. http://ipcc-wg?-gov/SREX.

Lauterjung, J. (2004). Lost in Japan: How to defend against tsumanis. **German Research Centre for Geo-science.**

Sidi, S. (2012). Nigeria lost N2.6tn to 2012 flood disaster. **African-Al Jazeera Englishhttp://www.aljazeera.com/news/africa/2012/10/2012**10128342196987...

Sullivan, R and Gouldson, A. (2011). Whose responsibility is it to reduce carbon emission? **Guardian Sustainable Business**

The Concept of Carbon Neutrality: An Independent Critique on the Carbon Offsetting Approach

INTRODUCTION

Climate Change is a major threat to sustainable development. It is a long-term shift in the statistics of the weather (including its averages) (NOAA, 2007). Human activities is the major cause of climate change and they result in emissions of four principal greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the halocarbons (a group of gases containing fluorine, chlorine and bromine) which accumulate in the atmosphere to cause concentrations that increase with time (IPCC, 2007). After a dip in 2009 due to global financial crisis, carbon emissions are estimated to have climbed to a record 30.6 Gigatonnes (Gt), a 5% jump from the previous record (IAE, 2011).

Several discussions and conferences (held in Rio, Kyoto, Copenhagen and Durban) have created awareness about climate change, and more individuals, governments, communities and business organisations are begining to accept responsibility. As a result they are adopting different approaches, formulating policies, setting targets and organising programmes on Greenhouse Gas (GHG) emissions. One of such ways used in cutting down emissions is the quest to become carbon neutral. Carbon Neutrality can be said to be achieved when emissions from a product, activity or a whole organisation are netted off either through the purchase of equivalent number of offset or through a combination of emissions reduction and offseting (Carbon Trust, 2006). It can also be defined as a transparent process of calculating emissions, reducing those emissions and offseting residual emissions to achieve net carbon emissions equal to zero (DECC, 2009). Carbon Neutrality simply means, taking away from the atmostphere the same amount of emission that you produce, to have a total emission of zero. This is achieved following the necessary procedures. These procedures involve knowing the sources and quantity of emissions and the approach to adopt to reduce or eliminate these emissions.

Carbon Footprinting and Setting of Boundaries

There is need for business organisations, individuals, governments or anybody who wants to achieve carbon neutrality to know how much emissions they are directly and indirectly responsible for, before deciding what to net out, what cannot be netted out and what to do with the residue emissions. A carbon footprint includes activities that result in direct and indirect emissions in relationship to where the boundaries for particular activities are drawn (Carbon Trust, 2006). According to Energetics (2007), the acceptable method of carbon footprinting based on the International Standard AS ISO 14064 is conducting Life-Cycle Assessment to ensure that all sources of the carbon emissions that are material to your organisation are captured and to enable you answer the following questions:

- What is the service that I offer?
- Would the emissions related to this service have occurred if I was not offering the service?

This involves inventory covering wide range of emissions sources from direct use of fuels to indirect impacts such as employee travel or emissions from other organisations up and down the supply chain (CarbonTrust, 2007). This will include calculating and quantifying as full as possible a range of emissions sources in order to provide a complete picture of the organisation's impact. According to CarbonTrust (2007), the major steps for a systematic approach, suitable for producing an accurate carbon footprint are:

- Define the methodology - a consistent approach/method ensures for accuracy and makes it easier for issues to be dealt with systematically anytime they arise. The commonly used methodology is the GHG Protocol produced by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) and International Standard AS ISO 14064.
- Specify the boundary and scope of coverage – there is need to be clear about which set of emissions that will be quantified. This is usually done by including emissions from wholly or partially owned subsidiaries and emissions from leased assets (vans leased from a hire company). These decisions are about determining what will contribute enough to your inventory to merit inclusion in your footprint, and whether the emissions would occur even if you were not providing your service or product. Every decision taken to include, and exclude, emissions from your footprint, must be justifiable in the public domain. After defining the boundary, what types of emissions to be included is considered, by deciding whether to include - CO_2 only or all greenhouse gases; direct emissions from fuel use onsite and from transport; direct emissions from manufacturing processes onsite; emissions from the electricity the organisation purchased; and emissions from the organisation's supply chain and other activities for which the operation is indirectly responsible, such as outsourced activities or manufacture and transport of raw materials, by another company, which your organisation then uses.
- Collect emissions data and calculate the footprint - the accuracy of the footprint relies on correct data and may include collecting information on onsite fuel consumption, owned transport utilisation, emissions from chemical reactions in manufacturing processes or from land use or agricultural activities, electricity consumption, employee travel by air, rail and in vehicles not owned by the organisation and Suppliers' emissions. These data can be collected in the following units MWh, kWh, MJ, Litres of fuel, total fuel consumption based on the mileage of the vehicles. Energy consumption data can be converted into equivalent CO_2 emissions using standard emissions factors, while emissions of other greenhouse gases must be converted into equivalent emissions in tCO_2e, using the global warming potential factors published by DEFRA.

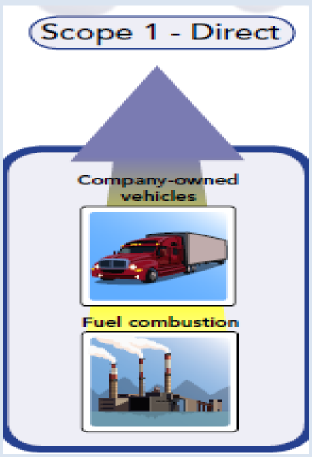
Calculating Carbon Emissions

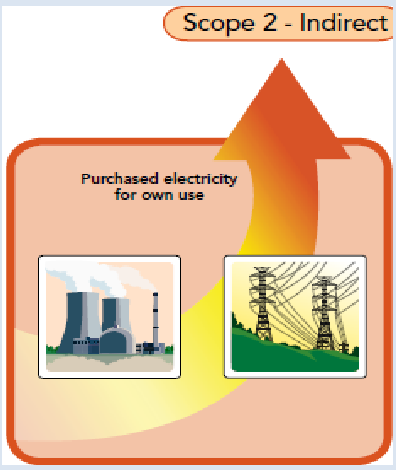
According to DECC (2009), the validity of any carbon neutrality claim is based on how accurate, consistent and transparent its emissions calculation is. Calculating total emissions from the relevant sources is started once the boundaries have been set for a given period. Applying documented emissions factors to known activity data (e.g. bills, invoices and receipts) from the organisation is the most common approach used (DECC, 2009). Activity data is information used to calculate GHG emissions from combustion and other processes e.g. the litres of fuel consumed by a car or electricity use in kilowatt hours. Carbon emissions are accounted for on three scopes, therefore organisations need to categorise their emissions based on these scopes by using the most internationally accepted approach; the Greenhouse Gas Protocol (GHG Protocol) (DECC, 2009).

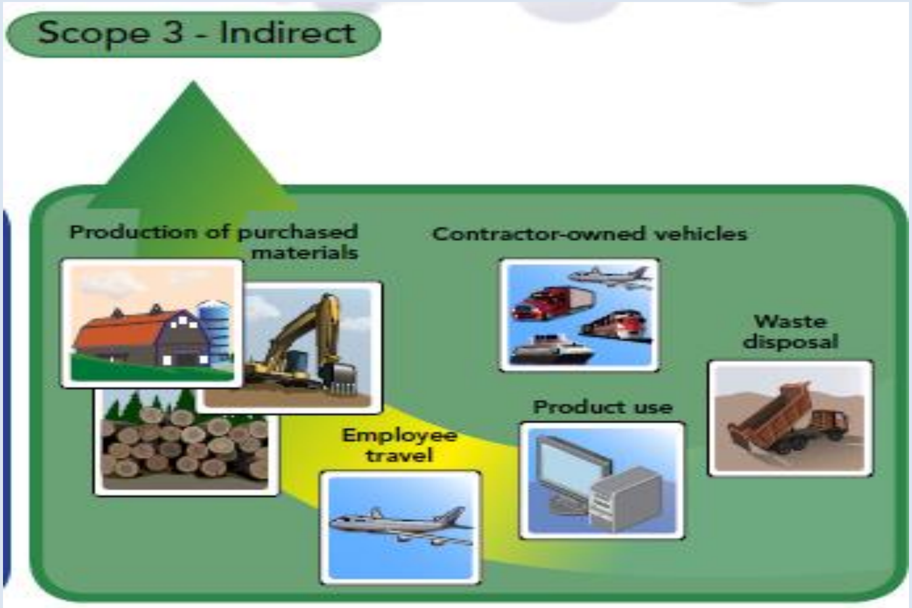
Scope 1: This scope covers those activities that an organisation ownes or controlles which release emissions straight into the atmosphere and they are called direct emissions. Examples of scope 1 emissions include emissions from combustion in owned or controlled boilers, furnaces, vehicles owned or controlled; emissions from chemical production in owned or controlled process equipment.

Scope 2: This covers emissions released into the atmosphere associated with consumption of purchased electricity, heat, steam and cooling. These are indirect emissions that are a consequence of activities which occur at sources not owned or controlled.

Scope 3: All other activities that release emissions into the atmosphere as a consequence of actions taken, which occur at sources that are not owned or controlled and which are not classed as scope 2 emissions are under scope 3. Examples of scope 3 emissions are business travel by means which are not owned or controlled, waste disposal, use of sold products or services, purchased products, product distribution and commuting, leased assets, franchises and outsourcing.







APPROACHES TO BECOME CARBON NEUTRAL

The approaches to become carbon neutral are usually divided in internal and external. The internal involves the use of carbon emission reduction techniques (e.g. energy efficiency and green energy technologies) while external approach is all about carbon offsetting.

Carbon Reduction Techniques

Reducing emissions internally is a vital part of achieving carbon neutrality. According to DECC (2009), internal reduction of emissions is a continuous process, because innovation is likely to increase the ways in which you will be able to make internal emissions reductions over time. The approaches usually adopted to achieve reduction are; completion of projects such as energy efficiency measures, behaviour change programmes, supplier engagement strategies, installation of on-site renewable, generation and consumption of electricity from renewable sources backed by Renewable Energy Guarantees of Origin (REGOs) certificates and purchasing green tariffs which comply with OFGEM's Independent Certification Scheme (DECC, 2009).

Energy Efficiency Technologies

Most organisations can cut 10-15% of their energy use (which inturn cuts greenhouse gas emissions) through a consistent energy management program and implementing projects (replacing non-energy efficient lighting, office equipment and air handling appliances with energy efficient ones) which pay back in less than 3 years (Energetics, 2007). This approach also includes installation of small scale electricity and heat production systems such as Combined Heating Power (CHP) systems and Under Ground Heat Pumps. Using this approach as a pathway to carbon neutrality is good and it includes the following types of tasks:

- Audit energy use from a Level 1 audit (overview) to a Level 2 audit (preliminary cost and

savings assessment) to a Level 3 audit (a robust estimate of savings and costs); and
- Benchmarking energy use against comparable locations or processes. For example, commercial buildings can be benchmarked through the Australian Building Greenhouse Rating (ABGR) scheme.

Increasing energy efficiency will not only reduce direct energy costs, but also reduce the cost of becoming carbon neutral, as with each implemented energy efficiency project, the potential cost of purchasing carbon offsets will also drop.

Green Energy Technologies

Renewable energy, does not rely upon the use of fossil fuels and thus does not increase greenhouse gases in the atmosphere. An organisation can use renewable energy as an on-site power generation or as purchased power. Renewable energy devices are available in all sizes and apart from reducing your carbon footprint, they provide a visual symbol to demonstrate a company commitment to reducing climate change impacts.

Carbon Offsetting

This involves voluntary offseting of residual emissions on a tonne-per-tonne basis. The role of carbon offsetting in relation to carbon neutrality is to compensate for residual emissions after calculating and reducing emissions. Therefore, it involves, first, calculating emissions from a particular activity and then purchasing “carbon credits” from emissions reduction projects that have prevented or removed emissions of an equivalent amount of carbon dioxide elsewhere (normally internationally) (DECC, 2009). According to DECC (2009), offsetting can lessen the impact of an individual’s or organisation’s actions, however, it does not reduce the overall emissions contributing to climate change.

There are two main types of carbon credits:

i. Kyoto-compliant credits (i.e. credits that are covered by one of the flexibility mechanisms under the Kyoto Protocol and they are are primarily Certified Emission Reductions (CERs), but they also include other credits), and
ii. Non Kyoto-compliant credits (known as Voluntary Emissions Reductions (VERs) and they emanate from the non-regulated sector) (Carbon Trust, 2006). Kyoto-compliant credits can be used by countries with binding targets under the Kyoto Protocol to meet those targets. CERs are produced by projects that take place under the UN Clean Development Mechanism (CDM). The UK Government believes that the purchasers of the offsets should be able to choose what type of offsets they wish to buy.

The quality criteria carbon credits must meet before they can be used as part of efforts to become carbon neutral as stated in the DECC Carbon Neutrality Guidance (2009) are:

- Additionality: Projects must demonstrate that they have produced a saving in carbon that would not have happened without the carbon finance from selling credits.
- Avoiding leakage**:** The project must demonstrate that it has not caused an increase in carbon emissions elsewhere.

- Permanence: Impermanent projects, (e.g. forestry projects are at risk of disease or fire) must be periodically independently reviewed and, if necessary, credits must be replaced when they expire or cease to be valid.
- Validation and verification: The project must be verified by an accredited and recognised independent third party and purchasers of credits should also ensure that robust, independent validation and verification procedures were in place to check projects were implemented according to the methodology and subsequently monitored to ensure that emission reductions were properly measured.
- Timing: Carbon credits should be ex-post, that is, they must only have been issued from the project after the emissions reduction has taken place.
- Avoiding double counting: A registry must be used to register, track and permanently cancel credits to avoid double counting or double selling.
- Transparency: Credits should be supported by publically available project documentation on a registry to set out the underlying projects (when they were considered approved and implemented), the quantification methodology applied and independent validation and verification procedures and reports for project and credits.

Emissions Reduction Measurement

Measuring emission reductions should be conducted along the same lines as those used for calculating the original carbon footprint of the organisation or product in question. Therefore only the scope used in calculating the carbon footprint should be used to measure emission reductions in line with the carbon neutrality target. This means that if the target is to achieve carbon neutral in both scope 1 and scope 2, emission reductions have to be measured based on the available data under scopes 1 and 2 and not otherwise.

Barriers to Emission Reduction Measurement

Oftentimes, measuring emission reductions is unseccessful due to some barriers and most of these barriers are:

- Lack of transparency in the process
- Lack of accuracy in the calculation
- Inconsistency in methodology
- Lack of timing or non-stating of period covered in achiving reduction
- Corruption during carbon offsetting

CRITICISM OF CARBON OFFSETTING AS A CARBON NEUTRALITY APPROACH

Some approaches adopted by companies in their quest to become carbon neutral no doubt will help towards achieving the global goal of making sure energy-related emissions in 2020 is not greater than 32 Gt as set in the IEA's 2010 World Energy Outlook, but some of them, seem not. The transparency issues surrounding most organisation's claims, boundary settings and strategies towards becoming carbon neutral make their so called carbon neutrality success a difficult thing to ascertain. Most of them do not make public a detailed carbon footprint and some fail to justify why they would buy offset instead of investing in reduction techniques. It will be difficult to limit emissions to 32 Gt carbon in 2020 if we continue to allow the adoption of the term unavoidable emission.

Continuity and improvement in the adoption of green energy (either through on-site generation or out sourcing from energy suppliers), energy efficient measures and behavioral change, scientifically reduces global carbon emissions; however, carbon offsetting seems not. While an organisation can practically show how much carbon it has cut from the overal emissions of the country where it is located with the adoption of green energy, energy efficiency and change of behaviour; carbon offsetting seems to support business as usual.

The Problem with Offsetting

Carbon offsetting seems too good to be true. It is like saying that, if you can really pay a third party to offset the consequences of driving you car and burning fossil fuel, while you don't have to worry about climate change instead you can continue behaving exactly as you like. According to Martin (2008), closer examination of the offset emissions frequently described as 'unavoidable' suggests that this usually meant 'costly', 'inconvenient', 'calculated by our offset provider' or, more fundamentally, 'would involve changing our business model'. Although these organizations could implement change in their home country by sponsoring emission reduction projects locally, the economic benefits of deploying an equivalent emissions reduction scheme in the developing world for a fraction of the cost is what drives the international trade in 'carbon offsets'. This means that organisations see carbon offsetting as cheaper and convenient than investing in low carbon technologies, changing behaviour and changing business models. Carbon offsetting seems like a way people can pretend to deal with climate change while they still maintain their levels of energy consumption. In fact, it encourages people to believe that with offset schemes they can continue their emission as long as they pay money to absolve themselves of their responsibility to the climate.

In The Guardian of Saturday October 7, 2006, Kevin Anderson, a scientist with the Tyndall Centre for Climate Change Research said "Offsetting is a dangerous delaying technique because it helps us to avoid tackling the task (of dealing with climate change)". Continuing he said "It helps us to sleep well at night when we shouldn't. A Carbon Trade Watch report, authored by Kevin Smith and published in February, 2007, stated that offset schemes assign a financial value to people's impetus to take climate action, neatly absorbing it into the prevailing logic of the market. This simply means that once somebody can click and pay the assigned price for 'experts' to take cost-effective action on his/her behalf, there remains little need to ask question about what happens to the climate.

Most offset vendors are more interested in selling offsets than in helping their customers to reduce emissions under the pretence that their paying for offsets would focus corporate attention on reducing costs and thus on reducing emissions (Martin, 2008). Also, the processes of carbon markets encourage a kind of colonialism in which wealthy nations avoid action by investing in developing countries for their own purposes (Williams, 2006). The carbon-fixing projects according to Centre for Science and the Environment, India are in reality opening the door to a new form of colonialism, using climate policies to bring about a variation on the traditional means by which the global South is dominated.

In my opinion, I would say that carbon offsetting cannot change the consumption attitude which drives the fossil fuel economy rather it provides a form of insurance cover to continue in it.

RECOMMENDATIONS

Having raised concerns about carbon offsetting, the following are recommendated as profitable Carbon Nuetrality approaches:

1. In adopting their carbon neutrality approaches, organisations should prioritize avoiding emissions as possible as they can, reducing emission through energy efficiency measures, and replacing high-carbon energy sources with low- or zero-carbon alternatives (e.g. green energy and Combined Heating and Power (CHP) systems), instead of making offsetting their pririoty. This will practically cut their emission, cut their energy bills and gain them better reputation in the fight against climate change.
2. Companies should develope climate-friendly value chains to internalize the most significant negative impacts. This can be done by undertaking due diligence on materials specifications, giving preference to low-emissions suppliers, reducing product miles, designing low-emissions products and services, linking existing products to restoration, labeling products better and providing buyers and users guidiance. This will help the company reduce embedded and product use carbon emissions.
3. Organisations should try to shape external systems by engaging policymakers, individuals and other organizations to multiply positive externalities; this can be achieved through:
   i. supporting collaborative solutions
   ii. furthering science-based and equity-oriented policy frameworks
   iii. advancing market-based initiatives
   iv. building informational networks
   v. developing operational partnerships
4. Carbon Neutrality should be treated as a long-term commitment, as an ongoing and as a dynamic challenge so that organisations do not take the fastest and cheapest approaches or even cut corners to achieve it.

CONCLUSION

Slowing down emission is everybody's responsibility and if we must achieve it, everybody must be carbon neutral. To become Carbon Neutral is not a race and it is not a competition, rather it is our commitment to ensuring that no more additional emissions are released into the atmosphere. Therefore companies, businesses, governments, communities and individuals should be transparent and sincere about it. Lets not encourage any behaviour or allow any business interest or gains that will maintain the status quo.

REFERENCES

Adam D. (environment correspondent, The Guardian, 2006), *Can planting trees really give you a clear carbon conscience?* The Guardian, Saturday 7 October 2006. Available at: http://www.guardian.co.uk/environment/2006/oct/07/climatechange.climatechangeenvironment accessed on 6/12/2011.

Bachram H. (2004), *Climate Fraud and Carbon Colonialism: The New Trade in Greenhouse Gases*. Capitalism nature socialism, Volume 15, Number 4 (December 2004). ISSN 1045-5752 print/ISSN 1548-3290. Available at: http://www.carbontradewatch.org/durban/cns.pdf. Accessed on 2/12/2011.

BRS (2007), *Beyond Neutrality: Moving Your Company Toward Climate Leadership*. October, 2007. Available at: http://www.bsr.org/reports/BSR_Beyond-Neutrality.pdf. Accessed on 6/12/2011.

BSR (2007), *Getting Carbon Offsets Right: A Business Brief on Engaging Offset Providers*. July 2007. Available at:*www.bsr.org/reports/BSR_Getting-Carbon-Offsets-Right.pdf. Accessed on 7/12/2011.*

Clean Air-Cool Planet and Forum for the Future (2008), Getting to Zero: Defining Corporate Carbon Neutrality. Available at: www.cleanair-coolplanet.org/documents/zero.pdf.Accessed on 28/11/2011

DECC (2009), Guidance on carbon neutrality.30 September, 2009. Available at: http://www.decc.gov.uk/en/content/cms/guidance/. Accessed on 29/11/2011

DECC (2009), Consultation on The Term 'Carbon Neutral': Its Definition and Recommendations for Good Practice, 26 February, 2009. http://www.decc.gov.uk/en/content/cms/consultations/. Accessed on 29/11/2011

Energetics Pty Ltd (2007), The Reality of Carbon Neutrality. Available at: www.energetics.com.au/file?node_id=21228. Accessed on 28/11/2011

IEA, (2011) Prospect of Limiting the Global Increase in Temperature to 2ºC is Getting Bleaker. 30 May 2011. Available at: http://www.iea.org/index_info.asp?id=1959. Accessed on 2/12/2011

IPCC (2007), *The IPCC Explains Human and Natural Causes of Climate Change*. Available at: http://co2now.org/Know-the-Changing-Climate/Climate-System/ipcc-faq-human-natural-causes-climate-change.html . Accessed 8/10/2011

Martin P. (2008) *Beyond carbon neutral*. CarbonSense, Highleigh House, Teignmouth TQ14 8TL United Kingdom, May 2008 Available at: www.carbonsense.com. Accessed on 30/11/2011

NOAA National Weather Service, October 2007 Issue. Availabe at: http://www.nws.noaa.gov/om/brochures/climate/Climatechange.pdf. Accessed 6/10/2011

Smith K. (2007), *Carbon Neutral Myth: Offset Indulgences for your Sins*. February, 2007.ISBN 9789071007187. Available at*: www.carbontradewatch.org/pubs/carbon_neutral_myth.pdf. Accessed on 30/11/2011*

Standard Life Investment (2007), Carbon Management and Carbon Neutrality in the FTSE All-Share. Available at: http://canadafr.standardlifeinvestments.com/content/pdf/sli/CO_%20Carbon_Management_Report.pdf?show=true. Accessed on 5/12/2011

The Carbon Trust (2007), Carbon Footprinting: An Introduction for Organisations. August, 2007. CTV033. Available at: www.carbontrust.co.uk/publications/.../publicationdetail.aspx?...CTV. Accessed on 28/11/2011

The Carbon Trust (2006), Three Stage Approach to Developing a Robust Offsetting Strategy. Publication: CTC621. Available at: www.carbontrust.co.uk/publications/.../publicationdetail.aspx?...CTC. Accessed on 28/11/2011

Williams A. (2006) *Down with carbon colonialism.* Spiked, 28 September 2006. Available at: http://www.spiked-online.com/index.php?/site/article/1724/ . Accessed on 5/12/2011

What is Carbon Credit? Available at http://www.carbon-futures.org/index.php/carbon-credits-explained.html Accessed on 14/08/2013

Impact of Palm Oil Mill Effluent on Physico-Chemical Parameters of a Southwestern River, Ekiti State, Nigeria

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ABSTRACT

The physico-chemical parameters of water and palm oil mill effluent (POME) samples of Ayanyan River was investigated between August 2009 and July 2010 to assess the impact of the POME on the water quality. The parameters tested were pH, temperature, alkalinity, total suspended solids, dissolved oxygen, biochemical oxygen demand, nitrate, phosphate, potassium, magnesium, lead, oil and grease. Standard methods of water and waste water analysis were used and compared with WHO permissible limit. The results showed that all the samples had values above the WHO standards which makes the river water unsafe to both human and aquatic life. As there is rising concern globally regarding POME as one of the sources of greenhouse gases, legislative measures are necessary to enforce laws and rules on land-use and waste regulation to control the location and management of palm oil mills, especially when cited near water bodies close to residential areas.

Key Words: Physico-chemical parameters, POME, Ayanyan River, Pollution, Remediation

INTRODUCTION

Nigeria is the most populous country in Africa, with a population of about 160 million people. The country is endowed with generous resources of water bodies. The span of water bodies within the country is estimated at 900km^2. This water provides resources for fisheries, transportation, irrigation, recreation and domestic uses (Ekiye *et al.,* 2010). However, about 60 percent of the Nigeria populace both rural and some urban dwellers still source for domestic water and sometimes drinking water from ponds, streams, and shallow wells justifying the concern for increase in the level of pollutants in surface and groundwater, thus making water monitoring even more vital (Adelegan, 2004; Water Aid, 2007; Morenikeji, 2010). Regulations put in place by the world health organization (WHO) and the federal environmental protection agency (FEPA) to protect the aquatic environment have not been so effective in Nigeria. Hence, indiscriminate dumping of refuse into water bodies and effluents from solid waste dumpsites is on the increase. These effluents range from chlorides, nitrates, oil and grease, heavy metals, e.t.c. One of the common pollutants in aquatic ecosystems in Nigeria, particularly in the south western parts of the country is the palm oil mill effluents (POME). During palm oil processing, large quantities of water is used in mills where oil is extracted from the fresh fruits of African oil palm, *Elaeis guineesis*. About 50% of the water results in palm oil mill effluent. It is estimated that for 1 ton of crude palm oil produced, 5-7.5 tonnes of water ends up as POME (Ahmad, *et al.,* 2003).

Palm oil mill effluent is the voluminous liquid waste that comes from the sterilization and clarification sections of the oil palm milling process. The raw effluent contains 90-95% water and includes residual oil, soil particles and suspended solids. Palm oil mill effluent is a highly polluting material and much research has been dedicated to means of alleviating its threat to the environment (Ho *et al.,* 1984; Perez, 1997; Chavalparit, 2006). POME is a highly polluting material due to its high BOD, low pH and colloidal nature. It was estimated that a processing plant with a capacity of 10 tons fresh fruit per hour would need a water treatment plant comparable to that required by a population of half a million inhabitants (Brezing, 1986). A more serious environmental impact of POME is that anaerobic ponds release greenhouse gases (methane and carbon dioxide) that contribute to global warming. Communities located near oil mills may also suffer from odor emissions and lack of access to good water caused by poorly managed effluent treatment systems (Chavalparit, 2006).

In Nigeria, POME are discharged directly and untreated into the nearby agricultural lands and surface waters in its raw form especially by small scale processors. Though wastes generated by these operators may be minimal because majority of the wastewater are reused and oftentimes, the receiving water bodies has the ability for self-purification. But in many cases, palm oil milling operations are on a continual basis, thus creating a lot of stress on these water bodies and breaking their capacity for self-purification. Also, large and medium scale mills produce copious volumes of POME from the processing lines which are sometimes treated before been discharged. However effective the system of oil recaptured from sludge may be, POME discharged from oil mill is objectionable and could pollute streams and rivers and surrounding lands (Hartley, 1988).

Ayanyan River is the main water supply to some parts of Ado-Ekiti (especially Omisanjana areas), the capital city of Ekiti State. The river was dammed at the Ajilosun area of the town to form the Ado-Ekiti Water Reservoir, which is the major supply to the town and its environs. Although Ayanyan river is not noted for fishery activities because of its size, residents around the area do fish from it and carry out a lot of other domestic activities around it, such as farming, laundry and it's a source of water for household chores especially during dry seasons. The river also receives effluents from small scale agricultural and palm oil production activities. As a result of these activities, the river usually has a brownish coloration and a greasy surface. Though the effluents could be a source of food for the fishes, it may also contribute significantly to the pollutional load of the river and affect the quality of the river for other uses. In the light of this, this study was designed to assess the physicochemical parameters of water and palm oil mill effluent samples discharged into the Ayanyan River.

MATERIALS AND METHOD

Study Area

The study area Ayanyan River is located in Ado-Ekiti metropolis, the state capital of Ekiti State, Nigeria. Human activities around the river have led to the reduction in size of the river. Geographically, Ayanyan is at an altitude of 433 meters above sea level and Ado – Ekiti lies within the tropical rainforest zone of southwestern Nigeria between 7^{o} 35'N and longitude 5^{o} 12'E . A stretch of grass covers the banks of the river and among these are sparsely distributed trees incuding *Parkia biglossa*, *Elaeis guineesis*, Raffia Palm, *Desmodium Sp, Andropogon Sp.* etc. Notable herbs along the banks are elephant grass (*Pennisetum purpureum*) giant star grass (*Cynodon plectostachyum*), rhodes grass (*Chloris guyanana*), siam weed (*Eupatorium odorantum*).

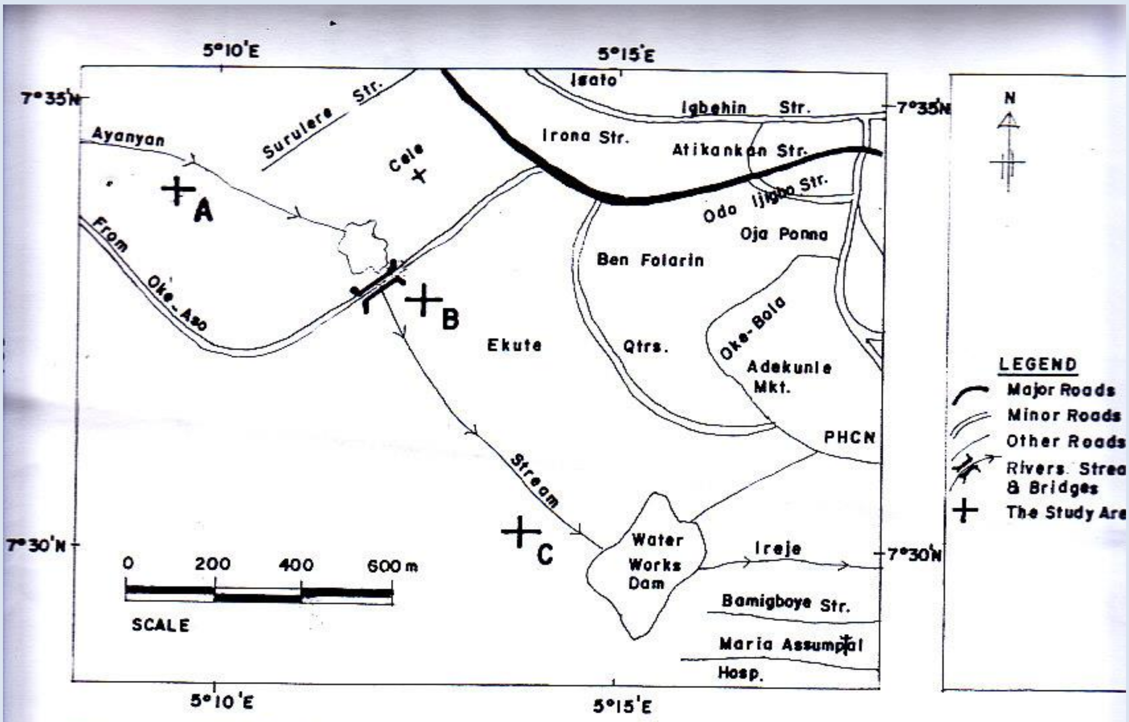

FIG. 1·2 : THE STUDY AREA WITHIN ADO-EKITI: AYANYAN STREAM.

Source: Ministry of Lands Urban & Regional Planning, State Secretariat, Ado-Ekiti, Ekiti State, Nigeria.

Sampling for Determination of Physicochemical Parameters of Water and POME.

Three sampling stations (coded A, B and C) were selected along the length of the river. Bimonthly sampling was carried out from August, 2009 to March, 2010. On each occasion, water and POME samples were collected between 6:00 am and 8:00 am. The laboratory procedures were carried out using the water and effluents analysis method of Ademoroti (1996) at the Institute for Agricultural Research and Training (IART), Ibadan, Nigeria. The parameters determined were temperature, hydrogen ion concentration (pH) alkalinity, TSS, dissolved oxygen (DO_2), BOD, COD, nutrients including nitrate and phosphate, and metals including potassium, magnesium, and lead. The oil and grease content of both water and POME samples were also determined.

RESULTS

The means of physicochemical parameters of water and POME samples of Ayanyan River are presented in Tables 1 and 2.

Table 1: **Means of Physicochemical Parameters of water samples of Ayanyan River**

Physicochemical Parameters	Mean±Std	Range	WHO Standard	NESREA 2011
pH	6.6 ±0.46	6.00 – 8.8	6.5 – 8.5	6.5-8.5
Temp (^{0}C)	28.8 ± 0.65	26.0 – 30.0	30 – 32	-
Alkalinity (mg$CaCO_3$)/L	152.08 ± 6.84	140.0 - 160.0	-	-
TSS (mg/L)	16.06 ± 1.61	11.00 – 19.00	5	0.25
DO_2 (mgO_2/L)	10.64 ± 0.74	8.00 – 12.45	4.00	6.00
BOD (mg/L)	18.50 ± 2.43	14.50 – 25.05	3.00	-
COD (mg/L)	40.40± 1.77	35.00 – 45.00	-	≤10
NO_3 (mg/L)	60.30 ± 2.36	49.00 – 71.50	10.00	9.10
PO_4 (mg/L)	45.60 ± 1.58	28.50 – 54.80	3.50	5.00
K (mg/L)	82.50 ± 10.08	43.80– 123.20	-	-
Mg (mg/L)	78.00 ± 7.96	42.60– 125.70	0.50	0.50
Pb (mg/L)	0.35 ± 0.21	0.02 - 2.29	0.05	-
OLG (mg/L)	0.56 ± 0.07	0.01- 1.18	-	-

Table 2: **Means of Physicochemical Parameters of POME samples of Ayanyan River Compared with WHO and NESREA Standards**

Physicochemical Parameters	Mean ± Std	Range	WHO Standard (1993)	NESREA 2011
Ph	3.85 ±0.21	3.5 – 4.5	6.5 – 8.5	6.5-8.5
Temp (^{0}C)	35.1 ± 0.57	21.0 – 35.0	30 – 32	-
Alkalinity (mg$CaCO_3$)/L	175.0 ± 8.40	128.0 - 275.0	-	-
TSS (mg/L)	35.00 ± 4.10	29.00 – 42.00	5	0.25
DO_2 (mgO_2/L)	14.50 ± 0.07	3.00 – 15.25	4.00	6.00
BOD (mg/L)	30.83 ± 1.63	25.00 – 35.52	3.00	-
COD (mg/L)	41.80± 0.87	33.70 – 55.00	-	≤10
NO_3 (mg/L)	95.50 ± 5.36	56.00– 126.50	10.00	9.10
PO_4 (mg/L)	69.00 ± 4.51	53.00 – 84.80	3.50	5.00
K (mg/L)	98.50 ±	35.80– 125.20	-	-
Mg (mg/L)	10.12	32.60 – 98.00	0.50	0.50
Pb (mg/L)	58.00 ± 2.83	0.00 - 0.56	0.05	-
OLG (mg/L)	0.27 ± 0.10	1.10 – 4.35	-	-
	2.84 ± 0.26			

A neutral pH was recorded during the rainy season months of August – October and the lowest (6.0) was recorded during the dry season months. The water samples were generally slightly acidic with a mean value of 6.6 ± 0.46 while the POME samples were acidic with a mean value of 3.85 ± 0.21.The pH values for both the water samples and

POME were within the WHO recommended limits for drinking water. The temperature of water samples ranged between 26.0^{0}C – 30.0^{0}C with a mean of 28.8^{0}C ± 0.65 during the period of study, while that of the POME samples ranged from 21.0^{0}C to 35.0^{0}C with a mean value of 35.1 ± 0.57. Temperature of the water samples were within the WHO standard while that of POME samples was found to exceed the WHO recommended limits of 30-32. Alkalinity values of the water samples ranged from 140.0 – 160.0 mg$CaCO_3$/L with a mean of 152 ± 6.84mg$CaCO_3$/L. The highest value of 160.0 mg$CaCO_3$/L was recorded during the rainy season month of September. For the POME samples, alkalinity ranged from 128.0- 275.0mg/$CaCO_3$/L, having a mean value of 175.0 ± 8.40 mg$CaCO_3$/L. Total suspended solids of the water samples had a mean of 16.06 ± 1.61mg/L and ranged between 11.0 – 19.0mg/L. The highest value was recorded during the rainy season between August – October. TSS values for the POME samples ranged from 29.0 – 42.0mg/L, with a mean value of 35.00 ± 4.10mg/L. Both the water samples and POME had mean values greater than the WHO recommended limits of ≤ 5mg/L. Dissolved oxygen content of the water samples had a mean value of 10.64 ± 0.74 mgO_2/L and ranged from 8.00 – 12.45 mgO_2/L, while that of the POME samples ranged from 3.00 – 15.25 mgO_2/L and had a mean value of 14.5± 0.07 mgO_2/L. Both samples were observed to have mean values higher than the WHO recommended standards for drinking water. The biochemical oxygen demand of water samples had a mean value of 30.83 ± 1.63mg/L and ranged between 25.00 – 35.52mg/L during the period of study. Mean values of BOD for the POME samples were lesser than observed for water samples (18.50 ± 2.43mg/L). However, both recorded values greater than the WHO recommended standard. The chemical oxygen demand of POME samples were also observed to be higher than that of water samples, having a mean value of 41.80± 0.87mg/L with a range of 33.70mg/L to 55.00mg/L. While for the water samples, COD had a mean value of 40.40± 1.77mg/L and ranged between 35.00 – 45.00mg/L.

For the nutrients, both the nitrate and phosphate contents of the POME samples had values greater than that observed in the water samples. Nitrate ranged from 49.00 – 71.50mg/L with a mean value of 60.30 ± 2.36mg/L in the water samples, while in the POME samples, it ranged from 56.00 mg/L to 126.50mg/L with a mean of 95.50 ± 5.36mg/L. Both the water and POME samples had mean values that were above the recommended standard of ≥ 10mg/L. Phosphate in the water samples ranged between 28.50mg/L and 54.80mg/L with a mean of 45.60 ± 1.58 mg/L. While for the POME sample, phosphate had a mean value of 69.00 ± 4.51mg/L and ranged from 53.00mg/L – 84.80mg/L. Only the POME samples recorded a higher value (84.80mg/L) than the WHO standard of ≤ 75mg/L during the beginning of the dry in November.

Potassium had a higher mean value in the POME samples (98.5 ± 10.12mg/L) than what was observed for the water samples (82.50 ± 10.08mg/L). Magnesium and lead were however higher in the water samples than in POME samples (See Tables 1& 2). Oil & grease recorded a higher value in the POME sample (2.84) and a much lower value (0.56) in the water samples.

DISCUSSION

Physicochemical parameters such as those evaluated in this study have been known to have effect on water quality and the general well-being of the aquatic ecosystems (Maybeck, *et al*., 1989; Aderinola, *et al.,* 2009; Adewuyi and Opasina, 2010; Adeyemi, 2011 and Adeogun *et al.,* 2012). The pH of water samples was alkaline throughout the period of sampling. This indicates that the water can support adequate fish production as recommended by Boyd (1979) and as well be a source of good drinking water after treatment. However, the pH of the POME samples was generally more acidic. This observation was in agreement with that of other previous researchers such as Ideriah *et al.* (2007); Awotoye *et al.* (2011); Ibrahim *et al.* (2012); and Akinsorotan, (2013) to mention a few. This implies that the acidity of the POME if not treated before being discharged will affect that of the water and if discharge continues unabated, the productivity of such receiving river may be reduced. pH has profound effect on water quality by affecting solubility, alkalinity and hardness of the water. Aquatic organisms are also affected by pH because most of their metabolic activities are pH dependent (Chen and Lin, 1995; Aiyesanmi and Ipinmoroti, 1997 and Wang *et al.,* 2002).

Dissolved oxygen was lower in the water samples than in POME. This may be as a result of high level of nutrients and total solid content of the POME. DO gives an indication of the degree of freshness of a river and it's very important for the survival of aquatic organisms. The DO content of the water sample which ranges between 8.5 -12.5mg/L could sustain aquatic lives. The BOD content of both the water and POME samples were high indicating that they contain high amount of polluting organic matter. The COD was equally high in both the water and POME samples. High COD indicates recalcitrance of chemicals that have escaped biodegradation. These chemicals may be persistence in nature and may cause severe environmental problems like bioaccumulation (Kanu and Ochi, 2011). The high COD recorded in this study may also be attributed to the observed high total suspended solids. The high levels of BOD and COD recorded for the POME samples had been observed to result in rapid consumption of DO in the water leading to a phenomenon known as oxygen sag (Akinsorotan, 2013).

The level of nutrients, nitrate and phosphate in both the water and POME samples were fairly high. Nitrates in both samples exceeded the 10mg/L value for good drinking water as specified by NESREA and WHO. Phosphate also had values far above the NESREA and WHO standards of 3.50-5.00mg/L in both water and POME samples. The metals assayed in this study equally recorded higher values above the recommended standards for good drinking water. This indicates high pollution arising from the palm oil milling operations and may have been further enhanced from other sources including land-use around the river, local runoffs from nearby surface soils, interactions between the water and sediments from dead plants and animal remains at the bottom of rivers (Adeyemo, *et al.* 2008), laundry activities of surrounding residents and runoff of house hold effluents into the river (Fakayode, 2008).

CONCLUSION AND RECOMMENDATIONS

The physicochemical parameters of water and POME samples of Ayanyan River, Ado-Ekiti, Nigeria, was assessed to determine the impact of the palm oil mill effluent originating from a local oil mill plant located close to the river. The results showed that all the samples had values above the recommended standards of NESREA and WHO, thus making the river water unsafe to both human and aquatic life. There is the need for continuous regulation and quality control monitoring to prevent and control pollution in order to safeguard human health and to facilitate Nigerian attainment of millinieum development goal (MDG) and sanitation. Also, utilization of the entire waste biomass including the empty fruit bunch (EFB) and POME for power generation and other uses should be encouraged, as done in Malaysia and other developed countries. Use of the waste biomass as feedstock in the production of renewable energy, cellulosic ethanol, biogas, bio-hydrogen and bio-plastic could also increase the feasibility of the industry. These will also most importantly reduce the carbon dioxide emissions into the environment. Climate change studies, especially in relation to water quality and ecology, are at fairly early stage in Nigeria. It is therefore pertinent to develop and fully implement strategies aimed at understanding the processes and mechanisms controlling water quality and ecology of Nigerian rivers, and also understand how these may combine and interact to sustain our potable water supplies and conserve the river systems.

REFERENCES

1. Ademoroti, C.M.A. (1996). *Environmental Chemistry and Toxicology*. Foludex Press Limited, Ibadan. 121p.
2. Adeogun, A.O., Babtunde, T.A. and Chukwuma, A.V. (2012). Spatial and temporal variations in water and sediment quality of Ona River, Ibadan, Southwest Nigeria. *European Journal of Scientific Research* Vol. 74(2): 186-204.
3. Aderinola, O.J., Clark, E.O., Olarinmoye, O.M., Kusemiju, V. and Anatekhai, M.A. (2009). Heavy metals in surface water, sediments, fish and periwinkles of Lagos Lagoon. *American – Eurasian Journal of Agric & Environmental Science* 5(5): 609-617.
4. Adewuyi, G.O. and Opasina, M.A. (2010). Physicochemical and heavy metals assessment of leachates from Aperin abandoned dumpsites in Ibadan city, Nigeria. *E-Journal of Chemistry*, 7(4): 1278-1283.
5. Adeyemo, O.K., Adedokun, O.A., Yusuf, R.K. and Adeyeye, E.A. (2008). Seasonal changes in physicochemical parameters and nutrient load of river sediments in Ibadan city, Nigeria. *Global NEST Journal* Vol. 10 (3): 326-336.
6. Ahmad, A.L., Ismail, S., Bhatia, S. (2003). Water recycling from palm oil mill effluent (POME) using membrane technology. *Desalination* 157: 87-95.
7. Akinsorotan, A.M. (2013). Histopathological effects of acutely toxic levels of palm oil mill effluents on gill and liver of Nile Tilapia fingerlings. *International Journal of Scientific & Engineering Research* Vol. 4(3): 1-8.
8. Awotoye, O.O., Dada, A.C. and Arawomo, G.A.O. (2011). Impact of palm oil processing effluent discharge on the quality of receiving soil and river in Southwestern, Nigeria. *Journal of Applied Science Research* 7(2): 111-118.
9. Boyd, C.E. (1990). *Water quality in ponds*. Birmingham Publishing Co. UK.

10. Brezing, D. (1986). African palm by-products in primary processing plants: treatment of effluents In: *Mesa Redonda latinoamericana sobre Palma Aceitera, Valledupar,* Colombia 8-12 junio 1986, ORLAC FAO, p 151-160.
11. Chavalparit, O. (2006). Clean technology for the crude palm oil industry in Thailand. Ph.D. Thesis, Wageningen University, 237p.
12. Chen, J.C. and Lin, C.Y. (1995). Responses of oxygen consumption, Ammonia-N excretion and Urea-N excretion of *Penaeus chinensis* exposed to ambient ammonia at different salinity and pH levels. *Aquaculture* 136: 243-255.
13. Ekiye, E., Ebiare and Luo, Z. (2010). Water quality monitoring in Nigeria: case study of Nigeria's industrial cities. *Journal of American Science* 6(4): 22-28.
14. Fakayode, S.O. (2005). Impact assessment of industrial effluent on water quality of the receiving Alaro river in Ibadan, Nigeria, *AJEAM-RAGEE*, 10: 1-13.
15. Hartley, C.N.S. (1988). *The oil palm*. 3rd Ed. Longman Scientific and Technical, UK. 14-17.
16. Ho, C.C., Tan, Y.K. and Wang, C.W.(1984). The distribution of chemical constituents between the soluble and the particulate fractions of palm oil mill effluents and its significance on its utilization/treatment. *Agricultural Wastes* 11(1): 61-71.
17. Ibrahim, A.H., Dahlan, I., Adlan, M.N. and Dasti, A.F. (2012). Comparative study on characterization of Malaysian palm oil mill effluent. *Research Journal of Chemical Sciences* Vol. 2(12): 1-5.
18. Kanu, I. and Achi, O.K. (2011). Industrial effluents and their impact on water quality of receiving rivers in Nigeria. *Journal of Applied Technology in Environmental Sanitation* 1(1): 75-86.
19. Maybeck, M., Chapman, D. and Helmer, R. (1989). *Global freshwater quality: A fresh Assessment.* Blackwell Publishers London, 31p.
20. Morenikeji, O.A. (2010). The final hurdle to be crossed in the eradication of Dracunculiansis in Nigeria. *East African Journal of Public Health* 6(3): 332-333.
21. NESREA, (2011). National Environmental (Surface and Groundwater Quality) Regulations. National Environmental Standards and Regulations Enforcement Agency.
22. Perez, R. (1997): Feeding pigs in the tropics. Food and Agricultural Organization. Animal Production and Health Paper,
23. Wang, W., Wang, A., Chen, L., Liu, Y. and Sun, R. (2002). Effects of pH on survival, phosphorus concentration, adenylate energy charge and Na^+, K^+ ATPase activities of *Penaeus chinensis* Osbeck Juveniles. *Aquatic Toxicol.* 60:75-83.
24. Water Aid (2007). Sanitation and Economic Development: Making a case for the MDG orphan, http:// www.wateraid.org/documents/sanitation-and-economic-development.pdf.
25. WHO (1993). *Guidelines for drinking water quality*. 2nd Edn., World Health Organisation. Geneva, ISBN: 9241545038, 1399p

Legislation and Policy Issues on Climate Change as Potential Tools for Sustainable Development in Nigeria – A Review

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ABSTRACT

Climate change is a major problem that is aggravated by almost all forms of modern day technological development efforts in addition to ancient traditional practices. Fossil and ice-core evidence shows that the earth has gone though many regular very dramatic climate changes. African countries especially West Africa is generally acknowledged to be one of the most vulnerable continents to the effects of climate change. Environmental degradation has been implicated as both remote and immediate causes of climate change threatening human existence. In this regard, the 1992 UN conference on Environment and Development, otherwise known as the "Earth Summit" of Rio de Jeneiro generated an action plan for sustainable development in the 21st century, which has become the policy instrument that drives environmental programmes in most developed countries. Principle 3 of the Rio Declaration on Environment and Development provides that "The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations". In the bid to develop via industrialization, developing countries pursued uncontrolled development models whose fall out, degrade the environment, leaving a legacy of deterioration of health quality and generation of health hazards, destruction of flora and fauna, pollution of water resources, air and noise pollution and the destruction of traditional economic infrastructures. Environmental Impact Assessment (EIA) is one of the perceived tools for combating the hydro-meteorological hazards of climate change. This paper is set out to review the roles of legislation and policy on climate change issues. Other climate change adaptation and mitigation and enforcement strategies are also discussed.

Key words: Climate change, Legislation, Policy, Environmental Impact Assessment, Mitigation strategies, Adaptation strategies

INTRODUCTION

Climate change is a deviation from the normal climatic conditions of an area due to land- atmosphere, land-ocean and ocean-atmosphere interactions which cause the alterations of the balance of gases in the earth's atmosphere, otherwise called radioactive forcing which are the factors responsible for the global warming and climate change [14].

Climate change is projected to have significant impacts on conditions affecting Bio-resources. Increase in the concentration of Green House Gases (GHGS), carbon dioxide (CO_2), nitrous oxide (NO_2), methane (CH_4), chlorofluoro carbons, ozone and aerosols, are strongly implicated in the observed climate changes in this century. Climate change will erode the genetic store for agriculture and medical plants as well as useful animals which are irreplaceable. There is no longer any doubt that the earth's climate is changing and will continue if unchecked. The consequences are far reaching on every life. If the world future is to be secured, action is crucial. Deep cut in global emissions of GHGS are necessary to temper climate change from resulting in irreversible and potentially catastrophic planetary changes. The need for enactment and enforcement of relevant legislations and policies therefore becomes necessary.

The environment had been seriously eroded as the evidences abound in our cities in the forms of climate change or global warming, different kinds of erosion, flooding, chemical hazards, different types of pollution, rising sea level, changes in vegetation, etc. These disasters are acknowledged to be caused directly or indirectly by the creation, operation or disposal of the built environment undertaken by man. The consequential loss of homes, possessions and often lives and livelihoods often leads to economic and development impoverishment.

In the bid to develop via industrialization, developing countries are constrained to pursue the development models whose fall outs assault and degrade the environment. How to develop creatively, without compromising the native integrity of the environment now constitutes a major challenge. Environmental Impact Assessment is the perceived tool for achieving the desired balance.

Nigeria is one of the few developing countries that have specific relevant legislation as exemplified by the Nigeria's Environmental Impact Assessment (EIA) Act [3, 4] which has a practical relevance as an environmental management tool especially in respect of core infrastructure projects.

The negative impacts of man's unwise use of the natural environment as well as the legislative and policy approaches to mitigate further escalation of the already degraded environment are discussed in this paper.

The information used for the compilation of this paper were obtained from assiduous review of past works carried out by stakeholders on climate change matters in different research and tertiary institutions both within and outside Nigeria. In most cases, these works were compared with most recent published works in journals in the same field. To obtain more recent information, internet materials were extensively used.

Causes of Climate Change: The following itemized factors are some of the causes of climate change as extensively discussed in [18]

- Human Activities
- Agricultural Activities
- Fossil Fuels
- Deforestation [19]
- Livestock [9]

MITIGATION FACTORS [18]

Deep cut in GHGs emission

Clean Development Mechanism (CDM)

Emissions trading

New systematic projects and policies

Animal cross breeding

Reforestation

Implementation of Payments for Environmental Services (PES)

Capturing carbon/ Carbon sequestration schemes launched by the Kyoto protocol's CDM [7]

Coral transplantation as a management tool

ADAPTATION STRATEGIES [18]

Conservation agriculture and improved irrigation

Change in times of planting and crop types

Traditional technology

Setting up alert systems to help foresee weather events

Development of climate-proofing crops

EFFECTS OF UNCONTROLLED INDUSTRIAL DEVELOPMENT ON THE ENVIRONMENT

Deforestation

Forests are large areas of land with trees and are noticeable in areas with sub equatorial and monsoon types of climates. Deforestation is a process whereby trees are felled for several purposes, but without replanting to replace the felled ones. The importance of the forest to man cannot be over emphasize. They act as sanctuary for rare and/or endangered animals. Forests act as storm breaks, thereby protecting the towns and villages from destructive storms. They provide useful products such as wood and char-coal for fuel, fiber for paper and textiles, medicine from the bark and leaves of some plant, breeding ground for animals and supply of food and materials for building houses.

In 1975, the total area of forest of all types in Nigeria was estimated at about 360,000sq km or about one third of the country total land area. It was also estimated that the annual harvest of sawn timber from high forest was 1.5 million cubic meters which would take between 25 to 30 years to denude the forest of matured timbers. The rapid rise in domestic consumption of timber due to increased rate of building construction results from the rise in population and income [10, 11].

When forest are cleared, the soil are exposed to erosion devastation, floods occur, and rivers and

lakes are filled up with silt. The water becomes dirty and impure for mankind. The removal of tree canopy (particularly the leaves) has effect on the rainfall pattern of that area as there is less leaf surface area for the transpiration of water, which in turn affects the relative humidity of the atmosphere. The repeated cultivation of crops on cleared area tends to exhaust the soil of its mineral content [15]. Deforestation in general has reduced the extent, diversity and stability of the Nigerian forests. The Food and Agricultural Organization (FAO) of the United Nations estimated that Nigerians destroy about 600,000 hectares of her forest every year through careless exploitation and husbandry [13]. Such careless exploitation of the forest has been implicated in a number of worsening environmental problems in the country including soil erosion and infertility, desertification and flooding and the worst scenarios of global warming and climate change.

Desertification

Desserts are barren, waterless and treeless lands and often sand covered such as Sahara desert which spread across African continent. Desertification is the encroachment of the desert on land that was once fertile. Desertification can be induced either by natural process or by the action of man. Natural hazards such as drought and sand deposit by winds are prime factors in the desertification process. Desertification is more pronounced in the northern part of Nigeria. The river basins were not left out of desertification. This is due to natural hazards (Drought and sand particles transported by winds to the area) and man's unwise use of the lake environment. Desertification is dangerous to man. It leads to famine, diseases and destruction of crops, livestock and man. It is also directly implicated in the climate change scourge. Desertification can be controlled through irrigation, terrace ploughing and planting of trees and grasses.

Pollution

Environmental pollution can be categorized into three groups. These are air or atmospheric pollution, aquatic or water pollution and land or surface area pollution. The World Health Organization (WHO) [22] defined air pollution as "situation in which the outer ambient atmosphere contains materials in concentrations which are harmful to man and his environment". Man's activities on the earth surface have largely degraded the quality of the lower atmosphere. The growth and development of industries and Urbanization has contributed greatly to the excess carbon monoxide produced by combustion and other human activities. Carbon monoxide reacts with the blood vessel and prevents it from taking up oxygen and the people are suffocated. In Nigeria, several rural towns that had in the past enjoyed fresh and dry air are currently experiencing air pollution problems [12]. This is due to industrialization process and expansion in human activities without due consideration to their detrimental effects on the environment.

Aquatic or water pollution is the discharge of unwanted biological, chemical and physical materials into water bodies from man's environment. The pollutants are usually chemical, physical and biological substances that affect the natural condition of water. This incidence is responsible for the wide spread water contamination in most Nigeria cities especially the Niger-Delta areas. Also solid wastes have equally flooded the water ways in these urban centers.

Land surface pollution is the occurrence of unwanted materials or waste on land. The commonest pollutant on land is the waste products that are often scattered on land area in the cities. According to Onwioduokit [16], most environmental problems are due to the production or consumption of goods whose waste products translate easily into pollutant. Ayeni [1] and Sada [17] believed that the emergence of urbanization is responsible for the rapid accumulation of solid waste. Generally, it would appear that the growth of urbanization and industrial development coupled with improper wastes management have added a great dimension to land area pollution in Nigeria.

Legislations and Policies Regulating Uncontrolled Industrial Development in Nigeria

Enactment of the Environmental Impact Assessment (EIA) Act

The United Nations Conference on Environmental Development (UNCED) dubbed the Earth Summit in Rio de Janeiro, Brazil in 1992, adopted Agenda 21, a blueprint of environmental principles, policies and actions required to be taken by all countries into the 21st Century. A key supporting Instrument of the Agenda was the Declaration on the Environment, a set of principles to guide environmental conduct. Principle 17 of the declaration states inter alia "Environmental Impact Assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority."

The Federal Government of Nigeria enacted the Environmental Impact Assessment (EIA) Act No. 86 of 1992 as a demonstration of her commitment to the Rio Declaration. Prior to the enactment of the EIA Act in Nigeria, project appraisals were limited predominantly to feasibility studies and economic-cost-benefit analysis. Most of these appraisals did not take environmental costs, public opinion, and social and environmental impacts of development projects into consideration. The EIA Act prescribes that all Agencies, Institutions (whether public or private) except exempted by the Act, shall, before embarking on proposed projects, apply in writing to the Federal Ministry of Environment so that subject activities can be quickly identified and environmental impact assessment applied as the activities are being planned. The Act made provision for all stakeholders (agencies, public, experts, NGOs, communities, etc.) to be notified, consulted and or given the opportunity to make comments on the EIA of a project prior to approval or disapproval.

The EIA Act is unique in some respects. First, it is the first of its kind in Nigeria. Secondly, it makes EIA mandatory where proposed projects or activities are likely to cause significant environmental effects. Thirdly, Environmental Impact Assessment, unlike other environmental laws is proactive in nature. It is meant to prevent, reduce or mitigate the negative effects of projects or activities on the environment before the commencement of such projects/ activities.

EIA ACT NO. 86 OF 1992

The Nigerian EIA Act gave the Federal Ministry of Environment the implementing mandate and requires that the process of EIA be mandatorily applied in all major development projects right from the planning stage to ensure that likely environmental problems, including appropriate mitigation measures to address the inevitable consequences of development, are anticipated prior to project implementation and addressed throughout the project cycle.

Objectives of the EIA

The objectives of the EIA Act of 1992 among others include:

i. The establishment of the environmental effects of proposed activities before a decision is taken to embark upon them

ii. Promotion of the implementation of appropriate policy in all Federal land, States, and Local Government areas consistent with all laws and decisions making processes through which these goals in (1) above may be reached.

iii. It encourages the development of procedures for information exchange, notification and consultation between organs and persons when proposed activities are likely to have significant effects on boundary or trans-state or on the environment of bordering towns and villages.

Projects requiring EIA

Projects in agriculture, fisheries, quarries, water supply, waste treatment and disposal, transportation, ports, infrastructure, petroleum, mining, power generation, etc. are to go through the EIA before implementation.

Some of the issues addressed in the EIA Act include:

(a) The minimum content of an EIA study –

Section 4 specifies the minimum content of an EIA to include:

- A description of the proposed activities,
- A description of the potential affected environment, including specific information necessary to identify and assess the environmental effects of the proposed activities,
- A description of the practical activities,

- An assessment of the likely or potential environmental impacts of the proposed activity and the alternatives, including the direct or indirect, cumulative, short-term and long-term effects,
- An identification and description of measures available to mitigate adverse environmental impacts of the proposed activity and assessment of those measures,
- An indication of gaps in knowledge and uncertainty, which may be encountered in computing the required information
- An indication of whether the environment of any state or local government areas outside Nigeria is likely to be affected by the proposed activity or its alternatives, and
- A brief and non-technical summary of the information provided under the above listed paragraphs.

(b) A Mandatory Study List (as listed in schedule of the Act appendix
A) Includes projects in agriculture, fisheries, quarries, water supply, waste treatment and disposal transportation, ports, infrastructure, petroleum, mining, power generation, etc.

(C) Description of excluded projects (section 15):
- Projects with non or minimal environmental effects
- Projects to be implemented in national emergency or in the interest of public health or safety.

(d) Follow-up Programme, e.g.
- Mitigation compliance monitoring
- Studies

(e) Provision for establishment of public access to records relating to EIA

(f) Power to make regulation by the Federal Ministry of Environment
- Prescribing list of projects or classes of projects for which EIA
is required or not required.
- Procedures and requirements relating to EIA.
- Conduct of assessment by review panels.

EIA Procedural and Sectoral Guidelines for some Nigerian Economic sub-sectors.

The EIA Procedural Guideline contain a list of steps which when carefully followed shall result in better project planning and a streamlined decision making process. These steps include, brief descriptions of the project environment and process, legal framework, identified impacts etc. These steps are detailed in Annex 1of the Procedural Guideline. The sectoral guidelines provide sector-specific guide for preparation of EIA reports.

Sectoral guidelines have been developed for the following sectors:

i. Oil and Gas, including petroleum refining, petrochemical industry pipelines, on-shore, offshore exploration and drilling, etc.
ii. Infrastructures – including airports construction, harbors construction and expansion, railways, highways, etc
iii. Industries – including all other manufacturing industries, besides those in the oil and gas sector
iv. Agriculture - all agricultural practices including land clearing, afforestation projects, etc.
v. Mining – including solid minerals prospecting and exploration.

Summary of steps involved in the EIA procedure in Nigeria:
i. The submission of project proposal to the Federal Ministry of Environment for screening to determine the need or otherwise for EIA.
ii. The vetting of Terms of Reference (TOR) for the EIA studies to ensure that only significant issues (impacts) are studied in the EIA. A Site Verification exercise may be required to aid this process.
iii. Submission of draft EIA report for review.
iv. Review of draft EIA report
v. Submission of final EIA report, which addresses all the issues raised from review exercise
vi. Decision-making by the Federal Ministry of Environment's technical committee and the Honorable Minister.
vii. Certification (issuance of Environmental Impact Statement (EIS) and certification).
viii. Mitigation and Compliance monitoring to ensure compliance with all stipulated mitigation measures and project specifications in the projects EIA report.

Project Reviews:
In line with the EIA guidelines, a draft EIA Report submitted to The Federal Ministry of Environment by a proponent is evaluated by the Ministry to establish the type of review to be adopted. There are different forms of reviews, depending on the nature, scope, anticipated impact, risks, etc. that may arise in project planning and implementation, and an EIA report may be subject to any or a combination of these reviews.

Types of projects reviews:

In-house review
All draft EIA reports forwarded to the Ministry are reviewed in-house to assess how far issues raised in the Terms of Reference (TOR) have been addressed and to determine if the draft EIA reports are suitable for public review (if necessary).
If the in-house review finds that the issues in the report do not merit putting it on public display, the review process may be terminated at the in-house review stage. Some

projects (e.g. those that fall under Category III of the EIA Act) may be recommended for approval by the Ministry's In-House Panel of Experts.

Public review (public display)

In accordance with the provisions of Section 25 of the EIA Act, interested members of the public are given the opportunity to participate in the EIA review process through comments on project reports that are put on display. Such displays are usually done for a 21 working day period at strategic locations. Notices of such venues of display are usually published in the National and relevant State daily newspapers and information about such display are complemented with further announcements on the relevant state electronic media. Often times, the venues of displays include the Local Government Headquarters, where a project is located, the State Ministry of Environment or Environmental Protection Agencies, The Federal Ministry of Environment's Zonal Offices, Liaison Office Lagos and the Headquarters, Abuja. Comments received from the display venues are forwarded to the Federal Ministry of Environment Headquarters for collation and evaluation preparatory to the Review Panel meeting for the project.

Review panel

After the conclusion of the public display exercise, The Federal Ministry of Environment may decide to set up a review panel to review the draft EIA report depending on the sensitivity or significance of the comments received.

The review panel meetings are held in the public so that stakeholders can utilize this opportunity to put forward their views and concerns for consideration. The choice of members of the review panel depends on the type of project, its scope as well as the ecosystem to be affected. However, the Chairman of the affected Local Government(s) and the Commissioner of Environment of the project location are always included in the Panel.

Mediation

When a project is likely to cause significant adverse effects that are immitigable, or public concerns about the project warrant it, such a project is referred to the Federal Ministry of Environment Ministerial Council for subsequent referral to mediation. For a mediation to be set up, Ministerial Council would have been convinced that the parties involved are willing to participate in the mediation and to abide by its decisions.

EIA approval

After the submission of a satisfactory Final EIA report, the Federal Ministry of Environment may decide to set a number of conditions for the approval of the implementation of the project. Such conditions usually include a statement that mitigation measures highlighted in the projects EIA report shall be complied with.

Environmental Impact Monitoring (EIM)

This is designed to monitor the Environmental Management Plan and concerns during project operations. It is also designed to assess the extent to which commitments contained in EIA reports are reflected during the various phases of project development and operations.

Impact Mitigation Monitoring (IMM) exercises are conducted to assess the degree and effectiveness of the mitigation measures proffered in an EIA report. Hence, relevant documents, in-house monitoring records as they affect the project, the project implementation schedule, as well as all other documents to support the environmental good housekeeping of the project are scrutinized and verified.

The foregoing clearly indicates that Nigeria has a comprehensive and modern piece of legislation that should drive sustainable development without jeopardizing the climate and environment

Challenges of Environmental Management

Poverty and Illiteracy

Poverty and illiteracy are both challenges as well as consequences of environmental mis-management. The high level of poverty and illiteracy in Nigeria is directly linked to the current level of environmental pollution and degradation in the continent. These classes of the population are often more aggressive in issues related to their personal survival than environmental management. This lack of interest and awareness often lead to more reckless environmental behavior which in turn breeds more environmental problems and leads to a vicious cycle of poverty [6].

Poor Access to Environmental Information

More often than not, the public do not have easy access to environmental information held by public authority and making information about the environment publicly available is essential for achieving sustainable economic development [5]. With access to environmental information, the people will have full knowledge of the implications of their activities on the environment and are thus able to participate more effectively in decision making processes that affect their environment [21].

Results from a survey carried out by Babalola , Babalola and Okhale [2] in Delta state showed that radio and television were the most available (93% and 96% respectively), the most easily accessed (70% and 73% respectively) and the most effective sources of environmental information (61% and 64% respectively). Several studies have reported the effectiveness of the mass media, particularly the radio and television in creating awareness about public health and environmental issues [20]; [8]. This is often associated with their wide geographical coverage and the relatively cheap cost of acquiring and using them in contrast to the print media. These media however do not provide for live interaction which is necessary for effective environmental policy implementation.

On the other hand, government officials, internet and the library were the least effective sources of environmental information to the respondents (23%, 21% and 24% respectively). In her study of environmental information provision to oil producing communities in Nigeria, Ugboma [20] also reported low usage of the library as the source of environment information. According to her, only 1.2% of the respondents have used the library in meeting their information needs. The major environmental information required by the respondents is related to waste management (93%) and health (81%). Language barrier (63%) and inadequate information provision (56%) constituted the major constraints to accessibility of environmental information by respondents in the study area. This result is consistent with the findings of Ugboma [20].

Lack of awareness of environmental pollution sources

Ignorance of what constitutes pollutants to the environment is suffered by both the elites and the illiterates alike. Babalola , Babalola and Okhale [2] conducted a study in Delta State, Nigeria to ascertain respondents awareness of environmental pollution sources. The results showed that many of the respondents are aware that oil spillage (92%), pipeline vandalization (84%), soil erosion (82%) and bush burning (79%) constitute sources of environmental pollution. However, out of the140 respondents, only 43 (31%) are aware that use of firewood and charcoal for domestic cooking are
sources of environmental degradation and consequently the mostly talk about climate change.

This suggests that most of the respondents are only aware of environmental problems that directly affect them and their immediate environment but are ignorant of global ecological problems and how their domestic practices might contribute to these problems. Industrialization was considered a key indicator of development. States and Municipal governments gave tax and other concessions to lure industrialists to establish industries in their domains, and the citizens being uninformed, lived happily with the resultant pollution and hazardous wastes. Over time, hot and heavy, metal laden, coloured effluents discharged into streams by textile factories for an example, in certain localities assumed mythical references (including disease causative properties). Industrial effluents and sludge were erroneously used as manure to produce fresh but deadly crops for the kitchens and dining tables of our urban population. Fishes and crabs caught from polluted rivers and lagoons were sold and eaten freely. Containers of chemicals (and pesticides) littered the surroundings in open dump-sites waiting to be picked by innocent and illiterate folks who would use them to store their own food and water. Particulates from quarries, asphalt, cement and similar industries settled on feeding stuffs forming layers of crust that inevitably get consumed as part of the regular meal. Fumes from stacks occlude sunlight and cause burning and other irritations of the eye, nose, lungs and skin.

Implementation strategies of legislation and policies of the government on the environment

Institutional strengthening and capacity building

For Nigeria to meet the challenges of the rapidly evolving complex issues of environmental protection in the world, the Ministry of Environment must evolve and sustain a program of human resources development that will aid capacity building and the development of a feasible operational work force structure including recruitment of staff with requisite skill for efficiency and productivity and provision of an enabling working environment. Training and re-training on the job, regular workshops and seminars, tours, excursions etc. motivation, medical facilities / staff clinic, staff canteen, insurance, rewards, sanctions etc. are necessary.

Strengthening autonomous environmental protection agencies in the states

Establishment and strengthening of environmental protection agencies in the 36 states of the Federal Republic of Nigeria and the Federal Capital Territory will bring environmental issues closer to the grass root thereby achieving greater results.

Adequate funding: Internal funding sources include allocations / subventions from Government and internally generated revenue and external sources include grants / donations from international donor agencies such as: Green Peace, UNDP, UNEP, World Bank, ADB, NGO's, and Private Individuals. Adequate funding is paramount in effective enforcement of environmental management guidelines, legislations and policies.

Full computerization / database & geographic information system (GIS) development:
The Federal Ministry of Environment should embrace Information Technology Development. The operations of the ministry should be fully computerized; appropriate database and GIS developments are necessary for efficient service delivery. These will continue to evolve, to cope with the dynamics and complexities of managing the environment. In addition, GIS development is necessary if the ministry must cope effectively with the protection of the environment. The development of a GIS and Spatial Analysis Centre will allow the ministry to analyze large expanse of the environment and would be able to proffer feasible environmental management solutions.

Research and Development programmes

Pro-active Research and Development Programmes that will aid sustainable development and efficient service delivery must be put in place. Necessary impetus that will aid such Research and Development programmes should be provided. The areas of Research would depend amongst others on feedback on services rendered, database information, scenarios build up and future plans on environmental maintenance.

Effective information dissemination / feed-back mechanism

(a) Information Dissemination

The Public Relation Units concerned with environmental monitoring should be strengthened with modern information dissemination equipment e.g. digital video camera, still camera, radio transmitters and communication gadgets: information bulletin publications – magazine, handbills etc. town criers for rural communities, jingles, programme sponsorship on electronic media, competitions such as drama, essays, cleanest area councils / schools, markets etc. internal information network system, directory of service departments & key officers, reactivation of the radio communication network, creation of a website, purchase of an outside broadcasting (O.B.) van.

(b) Feed- back mechanism through

- public complaint telephone lines (to be manned effectively)
- establishment of zonal offices in districts
- functional inter-departmental relationship

Effective grievances redress methodology (quick response mechanism)

- The grievance redress methodology should be in line with the time frame stipulated in the "Servicom Charter"
- There must be efficient information gathering, collation and dissemination.
- A register of complaints, enquiries and requests should be maintained for all service offices.
- There must be an effective correspondence of complaints, requests and/or enquiries to the appropriate service departments/units.

Service appraisal / monitoring mechanisms

An effective internal monitoring system should be put in place to evaluate the service delivery of every department in terms of response time to complaints, quality of services and users satisfaction. Standards and methodology for service evaluation should include environmental impact assessment, surveillance / vanguard team and quality control/ job certification etc.

Public and private sector participation

This is aimed at achieving set goals through public and private sector participation from other stakeholders such as sister agencies, law enforcement agencies, mass media, corporate organizations, NGOs and others.

Environmental education in schools and environmental information data base

The Nigerian government, through the Federal Ministry of Environment (FME) and other relevant agencies, should increase efforts to educate the public on environmental issues using both print and electronic media. Environmental Conservation Clubs should be set up in secondary schools in collaboration with the Federal Ministry of Education on the development of environmental educational master plan and curricula for both formal and informal educational system in Nigeria. FME should provide the public with excellent and up-to-date reading materials on environmental issues in environmental reference libraries. These will serve as the national network for environmental monitoring, data gathering and information dissemination.

CONCLUSION AND RECOMMENDATIONS

In spite of the global rapid advances using Geographical information system (GIS) and simulation models, there is no clear picture on the direction of climate change policies in Nigeria. The policies are felt in principle and not in practice as implementation strategies are not being appropriately articulated.

Global environmental collapse is not inevitable if all humans should think of sustainable development rather than economic expansion. Conservation strategies have to become more widely accepted.
It is now widely recognized that proper control of industrial development and processing is feasible. The Environmental Impact Assessment (EIA) process is now well established as a key to successful control of impacts of industrial development on the environment, especially with respect to the controlled use of limited natural resources and mitigated discharge of pollutants. EIA offers a golden opportunity for the achievement of sustainable development in Nigeria. However, one of the major constraints for the effective implementation of EIA as a central tool for sustainable industrial development is that the EIA is seen differently from technical feasibility studies. To resolve this problem, the EIA Act must be revised appropriately and adequately funded. New projects should be subject to Environmental Impact Assessment in strict accordance with the spirit of the Act.
Already existing companies should undergo periodic environmental audits (EA) to assure their compliance with environmentally sound practices. EIA officers should be trained, and re-trained while effective monitoring activities should be frequently carried out by the regulators.
Environmental awareness is a pre-condition for pro-environmental behavior and sustainable environmental management. Environmental information should be provided in the local languages to remove language barrier. More environmental public enlightenment activities should be conducted. People should be educated on environmental implications of their behaviors that might contribute to global ecological changes such as global warming/climate change and ozone layer depletion. The government should provide adequate funding for agencies concerned with environmental management and ensure proper implementation of programs and policies. Environmental education should be incorporated into the school curriculum at

all levels in order to build a generation of environmentally conscious citizens. Finally, government should prioritize provision and adequate funding of both public and school environmental reference libraries because they are veritable sources of environmental information and vehicles of public enlightenment and personal development.
Adequate punitive sanctions should be meted out for environmental misuse at all levels.
Though a lot of strategies have been proposed, it must be noted that staff discipline, welfare, provision of good working environment, utility vehicles, etc. are necessary ingredients towards achieving effective environmental management and subsequently, sustainable economic development.

REFERENCES

Ayeni M.O. (1978). *Patterns Process and Problems of Urbanization in Nigeria: Geography of National Developments.* Heineman Education Books Ltd., Ibadan.

Babalola, Y.T.; Babalola, A.D. and Okhale, F.O. (2010). Awareness and accessibility of environmental information in Nigeria: Evidence from Delta state. *Library Philosophy and Practice 2010*.

EIA (1992). Environmental Impact Assessment: Act no. 86, 1992: Federal Republic of Nigeria official gazette. No.73, vol.79.

EIA (1992). Environmental Impact assessment: Procedural Guidelines: The Federal Ministry of Environment, 1995.

EIR (1992). The Environmental Information Regulations. Approved by both Houses of Parliament. http://www.englandlegislation.hmso.gov.uk/si/si1992/Uksi_19923240_en_1.htM

Ekpeyong, E. (n.d.) Environmental Awareness As A Panacea For Sustainable environmental management in Africa. http://www.iaia.org/iaia09ghana/documents/cs/CS5_Ekpenyong_Environmental_Awareness_as_a_Panacea.pdf

International Panel on Climate Change. (2007). *Climate change: The physical Science Basis.* Contribution of working group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Retrieved from www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

McCarthy, M. & Brennan, M. (2009) Food risk communication: Some of the problems and issues faced by communicators on the Island of Ireland (IOI) Food Policy 34, 549–556)

Muller Alexander (2008) In: Spore Special Issue (2008).*Climate change*. CTAWageningen, the Netherlands.24pp.

NEST (1991). Nigeria's Threatened Environment: A National Profile, Ibadan, Nigeria

NEST (1992). *The Challenge of Sustainable Development in Nigeria.* Pp.152 -172 An NGO Report Prepared For United Nations Conference on Environment and Development, Rio De Janeiro, Brazil June 1-12.

Obajimi, M.O. (1998). Air pollution – A threat to healthy living in Nigerian rural towns *Proceeding of The Annual Conference of Environmental Protection Society of Nigeria,* Ilorin.

Okafor, F.C. (1988). Rural development and the Environment: Degradation Versus protection. Pp. 150-163. In: *Environmental Issues and Management in Nigeria Development.* P. O. Sada and F.O. Oemerho (Eds.). Ibadan: Evans Brothers Ltd,

Okali, D.U. (2004). *Climate change and Nigeria. A guide for policy makers*. A joint project of NEST and GCSI. Ibadan: NEST publications. 20pp.

Omiegbe, O. (1999). Bush burning and its effect in Africa. A case study of Nigeria. *Benin Journal of Environment Education,* **1(1):** 10-20

Onwioduokit, E.A. (1998) An alternative approach to efficient pollution control in Nigeria. *Proceedings of the Annual Conference of Environmental Protection Society of Nigeria.* University of Ilorin, Ilorin, Nigeria

Sada P.O. and Odemerho, F. O. (1988). *Environmental Issues and Management in Nigeria Development.* Evans, Ibadan

Spore Special Issue (2008). A bi-monthly magazine of the Technical Centre for agricultural Cooperation (CTA).*Climate change*. CTAWageningen, the Netherlands.24pp.

United Nation Environment programme (UNEP) In: Spore Special Issue (2008).*Climate change*. CTAWageningen, the Netherlands.24pp.

Ugboma, M. U. (2002). Environmental Information Provision in Nigeria: The Case Study of Oil Producing Communities. *African Journal of Library, Archives & Information Science* Vol 12 (2) 189-199.

UNESCO (1992). Report of the United Nations Conference on Environment and Development (UNCED) Rio de Janeiro, 3-14 June. http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm

World Health Organization: The Impact of Development Policies on Health. Pp. 21-40. In: *A Review of the Life Nature.* A. Dianna and D.Cooper (Eds.). WHO, Geneva (1990).

Nigerian's Perception of Climate Change: Implication for Adaptive Measures

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ABSTRACT

To communicate climate change and adaptation to the common man poses a challenge. Before now, adaptation to climate change is generally associated with how trees and forest ecosystems can adapt to climate change. The present menace of climate change has called for adaptation to its varied changes. This study sought to show how and when Nigerian populace perceived climate change and the adaptive measures they have taken to address it. Three research questions namely: How has Nigerian populace perceived the effect of climate change; When did Nigerian populace experience the local effect of climate change and how have they adapted their life to the climate change. These guided the study and a questionnaire was used for data collection. Based on survey data from 600 respondents randomly selected across the six geopolitical zones of Nigeria, 68% of the respondents strongly believed that they have directly perceived climate change and experienced the local effects of climate change in their zones. Furthermore, the perception influenced the adaptive capacity of the 46% of the respondents to climate change in their area. The findings of the study have implications for effective climate change policy communication. Gathering and disseminating evidence of climate change and its effects can be an efficient strategy to increase people's perception of having experienced climate change and hence to consider the need to take adaptive measures.

INTRODUCTION

To communicate climate change and adaptation to Nigerians poses a challenge. Before now, adaptation to climate change is generally associated with how tress and forest ecosystems can adapt to seasonal changes and which economic sectors determine the implementation of adaptive measures. The present menace of climate change also needs both human adaptations to its varied changes. In describing the effect of climate change, Chukwukere, (2013) said:

We are moving into a climatic state of Emergency (CSE). When it rains, humans, animals, plants, the valleys, the hills, the plains, the rural areas, the cities are drowned in flood, when it shines, humans burn, plants wither, Animals roast, metals melt."

The above situation has a lot of consequences which has resulted to Health State of Emergency, (Chukwukere, 2013). According to her:

Familiar diseases develop newer strains. All defy conventional treatment. Strange disease combinations are emerging on a day to day basis. Non-communicable diseases are getting increasingly challenging to Healthcare. The Earth and its inhabitants are under an awkward state, climatic state of Emergency and health state of Emergency.

Climate change is the altering of long stand of pattern of temperature and precipitation. Global temperature is rising as a result of human induced alteration of the physical, biological, chemical and radiological integrity of the environment including air, water, land and food (Chukwukere, 2013 and Gore, 2013). This has caused more extreme weather events like flooding and heat waves arising from production of greenhouse gases (GHGs) resulting to the depletion of ozone layer of the atmosphere inducing global warming. Due to increase in global temperature, the ice caps are melting in the North Pole and filling the body of waters in the oceans. There are heavy floods and wild fires in Europe, Asia, Australia and the America. Africa is the worst hit by the destructive effects of weather. According to Blennow, (2012), knowing what triggers human respond to climate change is crucial in communicating climate change policies. The question one may need to ask is: how has Nigerians perceived the climate change as well as initiate adaptive measures to cope with the effects.

Nigeria is not among the countries known for natural disasters such as earthquake, tsunamis or volcanic eruptions. The country witnesses occasional flooding at the coastal areas without much socio-economic disaster. In recent time according Ezigbo (2012), Nigeria lost N2.6 trillion 'worth of property to 2012 flood disaster. Sidi, (2012) reported at the fourth Global Forum on Disaster Risk Reduction in Geneva that a comprehensive assessment of a total losses resulting from 2012 flooding which ravaged many states in Nigeria showed that the country lost a total of N2.6 trillion to the flood. The 2012 Nigeria floods began in early July, killed 363 people and displaced over 2,100,000 people as at November (Sidi, 2012; Ola, 2012; B. B. C, 2012; Nnamdi, Chukwura and Adeyemi, 2012). Chonoko (2012) reported that tens of thousands hectares of farmland have been submerged since the start of the flood in July raising concerns about food security. The 2012 flood disaster in Nigeria brought the country to the limelight of climate change disaster. It made many Nigerians experience the local effects of climate change. This study wish to find out the adaptive measures initiated to future occurrence of the flood or other disasters.

Research Questions

Three research questions guided the study:

- How have Nigerian populace perceived the effect of climate change?
- When did Nigerian populace experience the local effect of climate change?
- How have they adapted their life to the effects of climate change?

METHOD

After the menace of 2012 Nigeria floods and its experience the researchers randomly selected 600peoples across the six geopolitical zones in the country to determine the extent the Nigerian populace appreciates the climate change and its effects to life and property. A questionnaire: Climate Change Appreciation (CCA) was developed by the researchers in which each respondent is to indicate the extent he/she agrees to the items in the questionnaire. Percentage was used for data analysis and any mean percentage below 2.50 is rejected while mean percentage above and equal to 2.50 is accepted. The study is a survey research. Six research assistants were used for the study. CCA consists of 28 items organized in four point Likert scale

S/N	ITEM	SA	A	D	SD	X
1	Experience of heavy downpour	200	204	100	92	2.9
2	Experience scotching hot weather	300	192	50	58	3.1
3	Gradual diminishing of some species in the ecosystem	213	210	22	155	1.8
4	Drastic change in seasons	221	272	91	6	3.2
5	Fast decaying of agricultural product	311	198	81	10	3.3
6	Reduction in tree yields	239	210	101	50	3.1
7	When it rains, we are drowned in flood	400	122	32	46	5.3
8	When it shines, people burn.	400	50	31	29	5.3
9	When it shines, plant wither	461	39	62	38	3.2
10	When it shin animals roast	214	219	123	4	2.9
11	There is climate state of emergency	302	201	42	55	3.3
12	Familiar diseases develop newer streams	315	200	55	30	3.3
13.	Strange disease are emerging	295	216	40	49	3.2
14.	Earth and its inhabitants are under awkward state	191	321	30	58	2.7
15.	There is rise in epidemics	302	211	52	35	3.3
16.	There is health state of emergency	221	172	100	108	2.3
17.	Experienced change in weather 20 years ago	161	202	232	5	2.8
18.	Experienced climate change 5 years ago	261	279	55	25	3.4
19.	Experienced climate change in 2012	392	194	5	9	3.6
20.	2012 Nigerian flood is natural disaster	117	93	217	73	2.1
21.	2012 Nigerian flood triggers adaptive measures	194	121	139	46	2.1
22	You learnt about climate change from news	139	151	146	164	2.4
23	You experienced it from its local effect	297	101	131	71	3.1

24.	Adaptive measure is a challenge	321	172	182	5	3.2
25.	Government develops adaptive measures	113	171	203	113	2.5
26.	Drainages are built	291	161	123	25	3.1
27.	Pollution campaign is on news	261	279	55	25	3.4
28.	Individual devices means of adaptation	461	23	62	54	3.4

RESULT

Table 1: Mean Percentage Responses to Climate Change Appreciation in Nigeria

DISCUSSION

In the table above, only items 3,20,21,22 had mean percentage below 2.50, the rest are had their mean percentage equal to and above 2.50 and thus are accepted. This showed that substantial number of the respondents has experienced the climatechange and its effects before 2012 flood in Nigeria and adaptive measures were devised by individual to cope with the change in weather. This means that majority of the Nigerians populace are aware of the climate change and have experienced its local effects. These are reflected in some of the comments in the 2012 Nigeria flood. Sidi (2012) said that worst flood in 50 years have killed 140 people, left hundreds of thousands homeless and raised fears of a food crises. The president on visiting the people made homeless by the country's worst flooding in at least 50 years, called it natural disaster (Goodluck, 2012). Chonoko (2012) said that 623900 people had been displaced and 152575 hectares of farmland destroyed so far. We are very sad over these flood incidences in the country.

It is not only the flood effect; the drastic hot weather has a lot of health implications that are killing. The hot weather seams favorable to the growth of virus, fungi, and many others. Sickness is in Malaria at this time is killing people every day. According to Chukwukere (2012), non-communicable diseases are getting increasingly challenging to healthcare services and strange disease combinations are emerging everyday while familiar diseases develop new strains and many deaths are registered every day.

However, most consequences of the climate change as mentioned above may be perceived as natural disaster. But 2012 Nigerian flood made clearer to the Nigerians the local effects of climate change leaving nobody in doubt. Formally from May to September, Nigeria has rainy season and suffers from seasonal flash floods. These flash floods are sometimes lethal especially in the rural areas or overcrowded slums where drainage is poor or does not exist. According to Inyama, Muanya and Adapetum (2012) on 2nd July, 2012, many Nigerian coastal and inland cities experienced heavy rains and residents of Lagos were grasping for breath due to the flooding. In mid-July 2012, flooding in Ibadan metropolis caused some residents at Challenge, Oke – Ayo and Eleyele to flee from their residences and save their lives. In late July, 2012, BBC reported that at least 39 people were killed due to flooding in the central Nigerian Plateau state. Many Nigerians experienced climate change directly during the 2012 Nigerian flood that affected

2100000 people and rendered hundreds homeless (Phanpe, 2012). Natural disaster like the flood is not a frequent occurrence. The 2012 Nigerian flood was the type since 50 years just as Japan Tsunami happens every 100 to 150 years and for Indian Ocean, it only occurs once every 400 to 600 years where the necessary precautions are not put in place.

According to Lauterjung (2004) after the India Tsunami, National Tsunami warning Focal Points were established, local authorities were trained in disaster management which led to higher awareness on the part of the people. This is in accordance with Blennow (2012) which said that knowing what triggers human response to climate change is crucial in communication policy. In Nigeria, after 2012 Nigerian flood, a lot of measures were input in place. Individuals first adjusted their mental disposition to the occurrence and decided how to survive in the situation especially with agricultural products in terms of preservation from heat. Awareness campaign is carried out and environmental management was the key word. Roads are constructed with drainage. Thus gathering and disseminating evidence of climate change and its effects was efficient strategy to increase the respondents' perception of having experienced climate change and hence to consider the need to take adaptive measures.

Conclusion: Climate change is as a result of pollution of the atmosphere due to human activities. This has effect on every area of the world in different ways such as heavy floods and wild fires all over the world, scotching heat and burning temperatures, increase in communicable and non-communicable diseases, challenges in holistic healthcare. Researchers have found enough proof to assert that numerous health disorders experienced by humans in this country are environmentally induces. We have to work inwards and use inexpensive, indigenous options available for us as we strive to cut down our carbon foot prints and heal ourselves and our environment

REFERENCES

BBC (2012). Nigeria deadly flooding in Jos Plateau State. News Report. July 24th 2012.

Blennonw, C. (2012). Climate change: believing and seeing implies adapting. PLOS ONE. Nov. 21st. 2012.

Chukwukere, F. N.(2013). The green pathway to health and recovery: Home-grown options in third world countries. Henco Print. Owerri.

Chonoko, I. (2012). Nigeria flooding called natural disaster. Reuters November 5, 2012. Retrieved Nov 26th 2012.

Al Gore (2013). The climate reality project. In The Green Pathway to Health and Recovery: Home-Grown Options in Third World Countries. Henco Prints, Owerri

Ezigbo, O.(2012). Nigeria lost N2.6tn to 2012 flood disaster. Fourth Global Forum in Disaster in Risk Reduction, Geneva, 2013.

Inyama, N; Muanya, C and Adapetum, A. (2012). Lagosians gasp for breath as flood ravages the city. The Guardian Nigeria. Retrieved September,2012.

Lauterjing, J. (2004). Lost in Japan: How to defend against tsumanis. German Research Centre for Geo-science.

Phampe, M. (2012). Nigeria deadly flooding in Jos Plateau State. BBC July, 24, 2012.

Sidi, S. (2012). Nigeria lost N2.6tn to 2012 flood disaster. African-Al Jazeera. English. http://www.aljazeera.com/news/africa/2012/10/2012.

Reducing Impact of Climate Change through Environmental Education and Counselling: Perception of School Children

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ABSTRACT

Climate change is the greatest environmental issue facing the world today. Climate change is linked to human action from burning of papers in our houses to poor use of land. It has become a critical issue in our environment because it affects our agriculture, education, economy, health and social life. Unfortunately, young school children lack the knowledge and awareness of this issue. Environmental education and counselling have been identified as useful tool for creating awareness on the need for school policy makers to educate and involve young school children in taking important decision on issues affecting them including reducing the effects and impacts of this climate change. Human beings including young school children are today suffering from the impacts and effects of climate change and so policy makers in schools need to provide strategies for the protection and management of the environment. The focus of this paper is the perception of young school children's on the strategies of reducing impacts and effects of climate change in schools and communities which was based on the lessons learnt from Environmental Education and counselling programmes carried out in some selected secondary schools in Anambra State, Nigeria within the period 2009-2012. Three research questions guided the study. The sample consisted of 600 students selected through simple random sampling. A 42-item questionnaire was used to collect data. Data was analyzed using frequency and percentages. Findings from the study revealed that all the strategies are capable of reducing impacts and effects of climate change. Based on the findings, it was recommended among other things that school children should participate in decision making in schools, homes and communities.

Key words: Climate change, environmental education, counselling strategies, school children

INTRODUCTION

In recent times, climate change has become an environmental issue facing the world. The impacts and effects of this monster called climate change are experienced globally. For most people, the expression "climate change" means the alteration of the world's climate that we humans are causing. This is in line with the official definition by the United Nations Framework Convention on Climate Change (UNFCCC, 2008) that climate change is the change that can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Climate change is not a natural phenomenon but the alteration in the atmosphere that are over and above natural climate variations as a result of human activity. According to Nasuru (2009) climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. Climate change also refers to an increase in average global temperatures (Enete, 2010). In particular, the Intergovernmental Panel on Climate Change (IPCC, 2008) defines climate change as a change in the state of the climate that can be identified by changes in the mean and / or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change manifests in various ways including rising temperatures, droughts, desertification, heavy precipitation, flooding and rising sea levels, extreme weather events such as cyclones etc (Peters & Maria 2011). Natural events which came as a result of human activities are believed to be contributing to this increase in average global temperatures. This means that the situation can be changed if human beings transform their ways of living to be more sustainable and friendly to the environment.

Nigeria as a developing country in the West African region, is not excluded from climate change issues. The country is experiencing adverse climate conditions with negative impacts on the welfare of millions of people today. These negative impacts are persistent droughts, flooding, off season rains, dry spells and rising temperature. The specific cause of climate change according to Madu (2013) is the human-induced alterations of the natural environment which is currently causing global warming. Others include oceanic processes, biotic processes, variation in solar radiation received by earth, plate tectonics and volcanic eruptions. Climate change is currently at the centre of the daily lives of Nigerian citizens due to the burning of fuels, gases, papers in homes to poor patterns of land use. The results of this negative trend are diminishing water resources, increased malnutrition, water borne disease such as diarrhea, vector-borne diseases such as malaria, drowning injuries, severe mental and physical trauma particularly for communities living along side major river deltas and low-lying coastal areas (Afe, 2008). Similarly, Ciplet, Roberts & Edwards (2013) asserted that the negative impacts of climate change are temperature rise, erratic rainfall, sand storms, desertification, low agricultural yield, drying up of water bodies, and flooding. Furthermore environmental degradation and attendant desertification are major threats to the livelihoods of the inhabitants of the area including children.

Climate Change and Children

Research by UNICEF (2011) indicated existing evidence to show that children's social, moral, cognitive and physiological immaturity leaves them more susceptible to the adverse effects of environmental degradation. Compared to adults, children are more susceptible to the negative effects of environmental degradation and those children are excluded or discriminated against because of their economic or social background. Ciplet, Roberts and Khan (2013) pointed out that the impacts are more severe for children in educationally deprived areas with less funding, living in poverty, for children living with disabilities and for children in countries that have weak governance and poor educational system. This is because they are more vulnerable to poor air quality, contaminated water, drowning and extreme heat. More so the girls are more vulnerable due to existing gender inequalities that, for example, can limit their access to education and nutrition (Okosi, 2011). Also the impact of climate change on boys' and girls' access to quality education have not yet received much attention nor have the possibilities of education to support initiatives for sustainability.

Climate change is a complex scientific and social problem. Effectively dealing with it presents an immense challenges, yet educating and counselling students about it offer students fruitful learning oppourtunities (McCright, O'Shea, Sweedes, Urquhart & Deleke, 2013). While children are among the most vulnerable to climate change, they should not be considered passive or helpless victims. Children are powerful agents of change, and studies Hart & Roger (2010) and (Nwokolo &Anagbogu, 2010) have found that many children can be extraordinarily resilient in the face of significant challenges. Providing children with empowering counselling and relevant education on disasters and climate change in a school environment can reduce their vulnerability to risk while contributing to sustainable development for their communities. Therefore educating and counseling girls and boys are among the best ways of strengthening community adaptation to climate change, as indicated by Women action committee (2010).

Climate Change, Environmental Education and Counselling

Environmental education and counselling are needed in the school because these systems provide children the opportunity to participate equally with adult stakeholders in addressing this ugly menace. Environmental education according to Stapp (1997) is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and to associated problems, aware of how to help solve these problems and motivated to work towards their solution. Also Oghone (2012) defined environmental education as a process aimed at developing a world population that is aware of and concerned about the total environment and its associated problems and has the attitudes, motivations, knowledge, commitment and skills to work individually and collectively towards solutions of current problems and the prevention of new ones.

On the other hand, counselling is a process of helping individuals through their own efforts to discover and develop their potentialities both for personal happiness and social usefulness. Cobia and Hendson (2003) suggested that counselling is an enabling process, designed to help an individual come to terms with his life as it is and ultimately to grow to greater maturity through learning to take responsibility and to make decisions for himself. Bassey, Ejue & Bassey (2005) defined counselling as a range of counselling services provided with the aim of enhancing positive self-concept, attitude, perceptions, and overall social development of the human person. Counselling is to help an individual to make his own decisions and choices in the light of his feelings and needs. Hence counseling would help the students become more aware of the realities of climate change to be able to make informed decisions and take responsibilities for mitigating climate change within their environment.

Environmental education and counselling should be integral parts of the education process aimed at practical problems of an interdisciplinary character, build a sense of values and contribute to public wellbeing. The focus should reside mainly in the initiative of the learners and their involvement in action and guided by both the immediate and future subjects of concern. From the above definitions the main objectives of environmental education and counselling are:

(a) **Awareness –** to help individuals and social groups become aware of and sensitivity to the total environment and its allied problems,

(b) **Knowledge –** to help individuals and social groups gain variety of experiences with the total environment and to acquire a basic understanding of the environment, its associated problems and humanity's critical responsible presence and role in it.

(c) **Attitudes –** to help individuals and social group acquire social values, strong feelings of concern for the environment and the motivation for actively participating in its protection and improvement.

(d) **Skills -** to help individuals and social groups acquire the skills for working towards the solution of environmental problems such as digging holes, non-littering of school compound, using sand bag method to wage flood, planting trees (palm trees and domestic shrubs) ,compost keeping, indiscriminate throwing of paper among others (Women action committee,2010).

(e) **Participation –** to help individuals and social groups develop a sense of responsibility and urgency regarding environmental problems through personal and community involvement to ensure appropriate action to help solve these problems and avoid future problems (Nwololo &Anagbogu, 2010).

Oghone (2012) is of the view that Environmental Education program should be incorporated in schools in order to reduce future impact of climate change through the following strategies:- including environmental education in the school curriculum, training new and old teachers, counseling and raising awareness by teachers and children, non-formal education by children themselves, guaranteeing a protective physical environment by stake holders, assurance of quality water, sanitation and hygiene in schools, hand washing in schools, development of green schools and carrying out projects in the community.

One of the ways of ensuring effective incorporation of environmental education in schools is to investigate the extent of awareness of climate change by school children as well to as develop counseling strategies for reducing impact of climate change through environmental education. This builds from John Dewey's belief that knowledge and learning are most effective when human beings work collaboratively to solve specific, strategic, real world problems (cited by Minkler & Wallerstein, 2011). Parker and Roberts (2006) added that involving students in developing intervention strategies serves to ensure that students know what is expected of them, reduce unnecessary confusion, and establish consistency in learning. It is against this background that the objectives of the present study are to:

1. Find out the impacts of climate change as perceived by school children.
2. Investigate the effects of climate change as perceived by school children.
3. Find out the education and counselling strategies for reducing the impact of climate change as perceived by school children.

Research Questions

The study is guided by three research questions

1. What are the impacts of climate change as perceived by school children ?
2. What are the effects of climate change as perceived by school children ?
3. What are the education and counselling strategies for reducing the impact of climate change as perceived by school children?

METHOD

The study employed the survey method. The population of the study was all the students of the public schools in the twenty-one Local Government Areas (LGA) of Anambra State, Nigeria. The sample consisted of 150 students from each of the four Local Government Areas (LGA) and they were selected through random sampling. On the whole 600 students were selected for the study. The instrument was researchers' developed questionnaire which covered the impact, effects and strategies for reduction of climate change. The 42 item questionnaire titled ''Children Perception of Impact Reduction of Climate Change through Environmental Education and Counselling'' (CPIRCCEEC), was divided into three major sections. Section A is made up of 11 check list items on impact of climate change, Section B is made up of 16 checklist items on the effect of climate change and Section C is made up of 15 items on strategies for reduction. The instrument was validated by experts in the Department of Geology and environmental studies of Nnamdi Azikiwe University, Awka. It was pilot tested among students in Delta State, Nigeria. The test – retest method was employed in establishing reliability of the instrument. The reliability coefficient of 0.72 was found and was considered appropriate for the study. For the administration of the instrument, copies of the questionnaire were distributed to the 600 selected students by the researchers with the assistance of six trained research assistants. The responses were collated and simple percentages were used to answer the research questions. The decision rule and cut off point was 5o% which means that any score of 50% and above is accepted while any score below 50% is rejected.

RESULTS

In line with the research questions, the data was presented in tables and analyzed below.

Table I: Frequency counts and percentages on the impact of climate change as perceived by the students.

S/N	Items	Frequency	percentage
1.	Rising temperatures	600	100
2.	Droughts	250	41.7
3.	Heavy Precipitation	400	66.7
4.	Flooding	600	100
5.	Rising sea levels	500	83.3
6.	Extreme weather events	450	75.0
7.	Deforestation	420	70.0
8.	Diminishing water resources	200	33.3
9.	Erratic rainfall	600	100
10.	Sand storms	200	33.3
11.	Low agricultural yield	600	100

Table 1 shows the frequency count as well as the percentage of the respondents on the impact of climate change. From the above table, apart from items 2 ,8 and 10 with 41.7% and 33.3% respectively, all the other items scored above 50%. This implies that they are all impacts of climate change as perceived by school children.

Table 2: Frequency count and percentages on the effects of climate change as perceived by the students.

S/N	Items	Frequency	percentage
1.	Poor sanitation	450	75.0
3.	Low Agricultural production	420	70.0
4.	Reduction in care of livestock	420	70.0
5.	Increased vector-borne diseases e.g malaria	600	100
6.	Increased waterborne diseases e.g diarrhea	500	83.3
7.	Poor water quality	600	100
8.	Inadequate access to clean water	400	66.7
9.	Extreme heat	350	58.3
10.	Intensive agricultural land use	480	80.0
11.	Bush burning	450	75.0
12.	Extraction of fuel wood	400	66.7
13.	Drowning	500	83.3
14.	Mental and physical trauma	600	100
15.	School dropout	600	100
16.	Malnutrition	500	83.3

Table 2 shows the frequency counts as well as the percentage of the respondents on the effects of climate change. The respondents perceived all the items as the effects of climate change in Anambra State, Nigeria. This is because all the items scored 50% and above.

Table 3: Frequency count and percentage on the strategies for reducing the impact of climate change as perceived by the students.

S/N	Items	Frequency	Percentage
1.	Counselling on the need to planting trees and shrubs around the school environment.	600	100
2.	Counselling and sensitization on the need to planting flowers and protect planted flowers for beautification of school environment.	600	100
3.	Creating awareness of climate change reduction process through peer-tutoring.	500	83.3
4.	Interactive group counselling and demonstrations on using sand bags to wage erosion in the school environment.	420	70.0
5.	Educating children on the benefits of using energy bulb in class rooms to reduce excessive heat.	450	75.0
6.	Counselling children against use of paper, water-proof etc to litter the school environment.	600	100
7.	Children should be counselled on the impacts and consequences of impact change in the assembly.	420	70.0
8.	Counselling children on how to avoid playing and staying in the rain to avoid drowning.	600	100
9.	Using posters and bill boards to educate and help children understand the risks they face and how to respond to climate change warnings	500	83.3
10.	Teaching the children to develop school gardens to strengthen food security and improve nutrition.	600	100

11. Advising children not only on stopping bad actions that harm the environment but also to increase good deeds that protect it	400	66.7
12. Counselling children to become involved in designing, developing and disseminating high quality information about climate hazards and their likely future changes	350	58.3
13. Teaching the children to promote hygiene in schools through proper washing of hands after using the toilet, etc.	480	80.0
14. Mobilization of children to champion the climate change awareness campaign in the school.	450	75.0
15. Using social skills groups, self-monitoring, and individual meetings with children to reduce use of fireworks and refuse burning	400	66.7

In table 3 the analysis of the strategies for reducing impact of climate change through environmental education as perceived by school children shows that all the items were above 50% and therefore accepted.

DISCUSSION

The study revealed that the impacts of climate change as perceived by children are rising temperatures, heavy precipitation, erratic rainfall, low agricultural yield, flooding, rising sea levels, deforestation among others. The afore mentioned impacts conform with the ones listed by UNICEF (2011) and Madu (2013). This level of awareness of the impact of climate change among the children in this study may be due to the fact that the effect of this ugly monster called climate change is almost the same irrespective of the place and race (Parks & Roberts. 2006). However the school children's rejection that drought and diminishing water resources are impact of climate change suggest that the students had never experienced them in their environment. This notwithstanding, the findings indicate that the children are aware of the impact of climate change and might be able to benefit from education and counselling for climate change mitigation. There is thus a need as recommended by United Nations Internal Strategy of Disaster Reduction (2008), to develop mechanisms to actively engage and empower children in their communities and local governments, in the assessment of vulnerability and impacts and the formulation of activities that would cushion the effects of climate change.

On the effects of climate change, the study revealed that poverty, low agricultural production, reduction in care of livestock, increased vector-borne diseases and water borne diseases, poor water quality, bush burning, extraction of fuel wood, drowning, malnutrition, school dropout, mental and physical trauma are the effects of climate change. The finding supports that of Okeke (2010). For children to identify the impacts of climate change draws one's attention that the effects of climate change have grown to high proportions and dominated public discussions that even children are aware of. There is no doubt that these effects, if not tackled, are likely to alter the health status of millions of people, through increased deaths, disease and injury due to heat waves, floods, storms, fires and droughts. As the IPCC (2007) pointed out, increased malnutrition, lack of access to education, diarrhea disease and malaria in some areas would increase vulnerability to extreme public health and development goals will be threatened by longer-term damage to health systems from climate change disasters.

Finally the findings indicated that environmental education and counselling strategies can be used to reduce the impact of climate change. These strategies basically are mitigation which are actions such as using sand bag to reduce erosion, planting trees, having school compost, among others and adaptation like transferring technology ideologies to children, collaboration and cooperating of children with adult stakeholders among others. The strategies also include a broad range of issues which counseling would be used to improve in schools. This is in line with Afe (2008) who asserted that mitigation and adaptation are two complementary strategies that can reduce the risk of climate change and strengthen affected communities. These strategies work in concert with one another to promote academically and socially productive behaviors such as compliance and attentiveness to climate change issues (Mills & Lecomte, 2006). When a combination of education and counselling strategies are used, they would help students to begin to understand the environmental issues and what they could do to help in a global cause as important as climate change

CONCLUSIONS

The study empirically established that environmental education strategies can be used to reduce the impact of climate change in Anambra State, Nigeria. In the light of this, environmental education should be included in the curriculum. More so if awareness is created early for the children then the extent of the impact and effect of climate change will be drastically reduced. Also it was empirically established that the strategies if applied will go a long way to reduce the impact and effect of climate change in our environment now and in the future. The strategies suggested do not represent a consensus on the best way forward. But they have provided examples and ideas and challenge teachers and counsellors to take actions and improve their critical roles in educating and preparing tomorrow's citizens to tackle the challenges of climate change.

RECOMMENDATIONS

Based on the study, the following recommendations were made.

1. The ministry of education, policy makers and curriculum planners should incorporate climate change environmental education (CCEE) into the curriculum with adaptations for the local context.
2. The teacher training programmes should now cover climate change environmental education, this will enable them develop necessary skills and pedagogical support.
3. Students in conjunction with the school management, counsellors and ministry of education should raise awareness of CCEE through the media, seminars, workshops, flyers, bill boards and posters.

4. The students should be encouraged by counsellors to carry this climate change message to their homes and communities.
5. The school children should participate in decision making in the school, homes and communities.
6. Students should engage in after school activities which provide opportunities for them to interact with their environment through excursion, field trips, research and action projects and to practically apply what they have learnt.
7. The school management and counsellors in conjunction with students should develop environmentally sustainable schools which provide well designed compound.

REFERENCES

Afe, J.C.(2008) Climate and Urban children: Impacts and implications for adaptation in developing countries. Ilorin: Ade Pres

Bassey, A., Ejue, J. & Bassey, I. (2005). Attitudinal patterns of counsellors and teachers towards counselling curriculum for schools. *Journal of World Council for Curriculum and Instruction Nigeria Chapter Forum 5* (2)48-44.

Ciplet, D., Roberts, T. & Edwards, G. (2013) Climate and Development Lab: An experiment in engaged education for global just sustainability. Journal of Sustainability Education 5, 1-12

Ciplet, D., Roberts, J. T. & Khan, M. (2013). The Politics of International Climate Adaptation Funding: Justice and Divisions in the Greenhouse." Global Environmental Politics 49–68.

Cobia, D., & Henderson, D. (2003). *Handbook of school counselling*. Upper Saddle River, NJ: Merrill Prentice Hall.

Enete,S.A.(2010) Scaling up and Mainstreaming Climate Change Adaptation and Disaster Risk Reduction in the Education Sector'2,33-42.

Hart, B.A.& Roger, O.C.(2010). Children's Participation in Sustainable Development: The theory and practice in community development and environmental care, London : Earthscan

IPCC (2008). Climate Change 2007 (Fourth Assessment Report): Synthesis Report Summary for Policymakers. Geneva: IPCC.

Madu, I.A.(2013) Achieving environmental sustainability, peace and security through sustainable development and peace education. Enugu: Mark-new world.

McCright, B., O'Shea, F., Sweedes, P., Urquhart, M. & Zeleke (2013). Promoting interdiscplinarity through climate change education. Nature Climate change 3,713-716

Mills, E.,& Lecomte, E. (2006): From risk to opportunity: How insurers can proactively and profitably manage climate change. Retrieved from http://eetd.lbl.gov/EMills/PUBS/PDF/Ceres_Insurance_Climate_Report_090106.pdf

Minkler, M., & N. Wallerstein. (2011). Community-based participatory research for health: From process to outcomes. Jossey-Bass

Nasuru, C.B.(2009). Climate change and disaster risk reduction. Retrieved from www.unisdr.org/climate-change

Nwokolo, C.N. & Anagbogu , M.A.(2010). Guidance and Counselling in Primary Schools. Lagos: Mark New-world.

Ogbone,E.N.(2012) Water, Sanitation and hygiene Education: Children and adolescents leading the way in Niger Delta. Warri: Poe Press.

Okosi , O.O.(2011). Community participation for Understanding and Improving the Physical Environment of the Schools for Children. Calabar: Ekanem press.

Parker, B. C., and Roberts. J. T. (2006). "Globalization, vulnerability to climate change, and perceived injustice." Society and Natural Resources 19(4):337–355. Retrieved September 18, 2012.

Peter, S.T. & Maria, J.(2011). Disaster Prevention for Schools: Guidance for education sector decision-makers. Journal of Environmental Education 5, 1-12

Stapp, W.B.(1997).The concept of environmental education. Michigan: MacGregor

UNFCCC(2008) Article 1, Definitions on climate change. Retrieved from http://unfccc.int/essential_background/convention/background/items/1349.php.

UNICEF (2011). Protecting Rights Through Child-Friendly Schools. New York :UNICEF

Back on Track Podcast Series, (www.educationandtransition.org/resources/protecting-rights-through-child-friendly-schools).

Women Action Committee(WAC) (2010).Using indigenous method to fight environmental disaster in schools. A paper presented to secondary and primary schools in Aghamelum local Government area.

THEME 8: CLIMATE CHANGE AND MILLENNIUM DEVELOPMENT GOALS (MDGS)

Assessment of Climate Change Adaptation Strategies towards the Achievement of the Millennium Development Goals (MDGs) in Nigeria: A Panacea for Environmental Sustainability

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ABSTRACT

Climate change is a major threat to sustainable growth and development in Africa and the achievement of Millennium Development Goals (MDGs). Nigeria is particularly vulnerable to climate change because of her over dependence on rain-fed agriculture, compounded by factors such as widespread poverty, unemployment and weak capacity. Climate change brings with it changes in weather patterns that can have serious repercussions for all. This study assessed the adaptation strategies used by Nigerians and how they have help in environmental sustainability. Descriptive survey design was adopted and a multi-stage random sampling was used to select six hundred (600) respondents from south-east, south-south and south-west zones of Nigeria. The following four research questions guided the study:1) What climate change adaptation strategies on ensuring environmental sustainability are Nigerians aware of? (2) To what extent do the masses at the grassroot utilize these adaptation strategies to cope with the effect of climate change on environmental sustainability? (3) What are the barriers to effective climate change, adaptation strategies on environmental sustainability in Nigeria? (4) What strategies would be adapted to bring the climate change adaptation strategies to the masses at the grassroot? Questionnaire was the instrument used for data collection. Data were analysed using means and remarks. Results showed that Nigerians should be aware of quality information and enlightment campaign about climate change and building resilient systems which could without shocks among others. Appropriate ways of utilizing these climate change adaptation strategies, barriers to adaptation strategies and strategies to bring the adaptation strategies to the masses at the grassroot were also assessed. Based on the findings of this study, it was recommended that information on climate change adaptation strategies should be disseminated at the grass root level through the use of local dialects, bill-board advertisements, community radio and enlightenment campaign in market places, the church and places of public gathering.

Keywords: Assessment, awareness, climate change, adaptation strategies, environmental sustainability

INTRODUCTION

Climate change is a major threat to sustainable growth and development in Africa and the achievement of Millennium Development Goals(MDGs). Nigeria is particularly vulnerable to climate change because of her over dependence on rain-fed agriculture, compounded by factors such as widespread poverty, unemployment and weak capacity. Climate change is a term used for changes in weather condition in the past few years. It is also known as global warning or changes in weather patterns. Global warning is increase in average temperature of planet earth said to be caused by continuous emission of gasses that trap heat to the earth's atmosphere. In an upper part of the atmosphere (10-19 kilometers above sea level) certain gases trap heat and radiate it thereby increasing the earth's average surface temperature. Without these gases, the average temperature of the earth will be 33^0C colder and unsuitable to support life. These heat trapping gases are known as Green house gases (GHG) and they include carbon (IV) oxide (CO_2), water vapour (H_2O), methane (CH_4), ozone ($)_3$), nitrous oxide (N_20), and carbon (II) oxide (C0). [1] These GHG have natural cycles that keep them balanced and available at certain range in the atmosphere. Certain human anthropogenic activities like burning of fossil fuel, gas flaring, deforestation release gaseous products made up of one or more GH gases. These gases stay for a while in the environment, and many escape after a long time by the action of wind to the stratosphere (upper atmosphere). Depending on the kind of gas released, it may be trapped by trees, it may also be changed in reaction with oxygen available in air, or it may be dissolved in sea water.

The GHGs are helpful to mankind but hold the potential to be harmful in large amounts. With increase in the GHGs, more heat is trapped to the earth thus increasing the earth's average temperature and thereby tilting weather and climate conditions of the earth to an anomalous state. This results in series of weather variations in different places on earth. Ocean surge, irregular rainfalls, torrential rainfall, massive flooding, desert encroachment, health problems among a series of weather aberration have been seen within the past few years [2]. Similarly, ozone layer depletion has been linked to climate change. The ozone layer is a layer of gas present in an upper part of the atmosphere constantly reacting in the presence of Ultraviolet (UV) light. Ozone gas protects planet earth from harmful UV radiations allowing non-harmful UV radiations to pass. Since the ozone layer contains gases in reaction, these gases can react with other kinds of gases that travel up that altitude. From certain substances used by man like aerosols, refrigerants and fire extinguishers, gases like halons and fluorocarbons are released. These gases escape to the upper atmosphere and react with ozone molecules forming compounds that cannot protect against harmful UV radiations [3].

The Intergovernmental Panel on Climate Change (IPCC), a body set up in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environmental Programme(UNEP) to provide authoritative information about climate change phenomenon, produced enough evidence in their first report in 1990[4] to show that climate change is a reality and that it is being caused by human anthropogenic activities.

IPCC predicts that climate change caused by the emission of green house gases especially CO_2 will cause drought in some parts of the world and flood in other parts and the poor countries will be hit the most because of their low capacity to cope with the changes. Also, the Nigerian Environmental Study/Action Team(NEST)[5] reported that sea level rise and repeated ocean surges will not only worsen the problems of coastal erosion but will also increase problems of floods, intrusion of sea water into fresh water sources and ecosystems, destroying such stabilising systems as mangrove, and affecting agriculture, fisheries, and general livelihoods.

Nigeria is among the United Nations (UN) which aimed at achieving the MDGs by 2015. For the purpose of this study, only goal 7 of the MDGs, which has targets and indicators enunciated by [6] will be investigated. Goal 7 of the MDGs is focused on ensuring environmental sustainability with the following targets and indicators. To achieve environmental sustainability, Nigeria has the following as targets namely. Target I: To integrate the principle of sustainable development into country policies and programmes and reverse the loss of environmental resources. Target 2: Reduce to halve, by 2015, the proportion of people without sustainable access to safe drinking water. Target 3: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers. To assess the extent to which these targets have been met, there are eight (8) indicators as follow; Indicator I: Proportion of land covered by forest. Indicator 2: Ratio of area protected to maintain biological diversity to surface area. Indicator 3: Energy use per $1 GDP. Indicator 4: Carbon (IV) oxide emission and consumption of ozone – depleting chlorofluorocarbon (CFCs). Indicator 5: Proportion of population using solid fuels. Indicator 6: proportion of population with sustainable access to an improved water source, urban and rural. Indicator 7: Proportion of urban population with access to improved sanitation. Indicator 8: proportion of households with access to secure tenure (owned or rented). This study therefore focused on assessing the awareness of climate change adaptation strategies to ensure environmental sustainability in Nigeria.

Nigeria is climate change conscious, hence serious awareness moves are being made towards devising adaptation strategies that will enable her cope with the effect of climate change to ensure environmental sustainability. Adaptation refers to adjustments in practices, processes or structures in response to projected or actual changes in climate, with the goal of maintaining the capacity to deal with current and future changes. Adaptation to climate change also refers to activities that reduce the negative impacts of climate change and /or takes advantage of new opportunities that may be presented. It includes activities that are taken before impacts are observed (anticipatory) and after impacts have been felt (reactive). According to [7], he stated that even if efforts to reduce green house gases (GHG) emissions are successful, it is no longer possible to avoid some degree of global warming and climate change. This is supported by [8] which stated that as a result of green house gases already in the atmosphere from past and current emissions, our planet is already committed to at least as much warming over the 21st century as it has experienced over the 20th century(0.75^{o} C). This implies that in addition to mitigation practices (risk reduction) been developed to combat climate change, adaptation to already existing climate change is essential. This fact is also made more explicit by [9] which stated that while mitigation is necessary to reduce the rate and magnitude of climate change, adaptation is essential to reduce the damages from climate change that cannot be avoided. Other researchers [10][11] advocated many ways by which awareness of climate change adaptations should be tackled in order to maintain environmental sustainability in Nigeria. This entails increasing resilience by building a resilient system which could withstand shocks and accelerate the pace of progress towards sustainable development. To achieve this, Nigeria created awareness of some adaptation strategies like better erosion control, better drainage channels for flood control; clearing of refuse for improved sanitation and stoppage of indiscriminate dumping of refuge on drainages, use of better water storage system, fast – maturing and high yield maize, cassava and other crops among others. As a matter of fact, mainstreaming climate change adaptation strategies into Nigeria's economic blueprints and development master plans is an important strategic action at this stage of our development because emergency preparedness guarantees effective contingency plans to protect citizens, property and the environment.

In an environment that is sustainable, people everywhere in the nation have learnt how to highly depend on their environment for their source of livelihood. The regions around the coast lands are the richest wetland in the world and the home of numerous species of aquatic and terrestrial plants and animals. Riverine communities are attached to their environment, that they made their living from water and forest as farmers, fishermen and hunters. But with the environmental degradation cased by climate change, such as change in agricultural activities deforestation, bush burning, animals migration, everywhere being prone to gully erosion, change of fresh water which is un-conducive for living, no production in farming, fishing and hunting. Very few have turned to traders, dealing on different kinds of goods. Only few are employed in industries and in the civil service. Their fishing and farming have been impaired by the deployable environment. This is a major cause of poverty in these coastland areas.

Despite the rate at which Nigerians utilize the adaptation strategies, yet there are some barriers to effective climate change adaptation implementations. Some of the barriers were enumerated as poor response on early warning system, public enlightenment, lack of access to weather forecast technology, non-availability of water storage facilities, refusal of the people to relocate to relief camps, high cost of land use system in Nigeria, non – availability of credit facilities, government irresponsiveness to climate risk management, inadequate knowledge on how to cope with or build resilience, and limited income to move from their homes. To this end, some strategies are adopted to bring climate change adaptation strategies to the masses at the grassroot.

It is against the above background that this study sought to assess the awareness of climate change adaptation strategies by Nigerians, how the affected people have utilized the adaptation strategies and what strategies are being adopted to bring climate change adaptation strategies to the masses at the grassroot. Therefore the problem of the study, posed as a question is: what climate change adaptation strategies on environmental sustainability are Nigerians aware of and how have they utilized them to cope with the effect of climate change on their environment? Proffering answers to these questions are the thrust of this study.

Research Questions

The following research questions guided the study.

1. What climate change adaptation strategies on ensuring environmental sustainability are Nigerians aware of?
2. To what extent do the masses at the grassroot utilize these adaptation strategies to cope with the effect of climate change on environmental sustainability?
3. What are the environmental sustainability in Nigeria?
4. What strategies would be adopted to bring climate change adaptation strategies to the masses at the grassroot?

METHOD

The study adopted descriptive survey research design. The study was carried out in south-east south-south and south-west geopolitical zones of Nigeria. The three zones were recently vulnerable to flood devastation which eroded most of the areas (Fig I, II, III).

Fig 1: Anambra State Governor, Mr. Peter Obi and his aides (South – East Zone) wade in knee-deep water in a riverine community.

Source:chikaoduahblog.wordpress.com

FigII: Flooded Vehicles and houses in a riverine community in Adofule in Ondo State

Fig III: Flood in Okpe and Okoamaka in Delta state

Multi-stage random sampling was employed in the selection of the respondents for the study. In each zone, one state was randomly selected to make a total of three (3) states. The states chosen were those affected by the flood. These were Anambra in south-east, Delta in south-south and Ondo in south-west. In each state, two local governments were selected to make a total of six local government areas. These were Anambra west and Ogbaru in Anambra; Okpe and Okoamaka in Delta and Emureile and Adofure in Ondo. With the assistance of the Local Government Chairmen, one riverine community each was randomly selected to make a total of six riverine communities. In each riverine community, with the help of Community Leaders, one hundred (100) were randomly selected by balloting with replacement. A sample size of six hundred (600) formed the respondents. The instrument for data collection were a questionnaire titled "Adaptation strategies adopted in Nigeria"(ASIN). The instruments were faced validated by two lecturers from University of Nigeria, Nsukka. Their input was incorporated into the final version. The instruments were trial-tested on 20 riverine members in a community outside the study area. A reliability of 0.73 was computed using test-retest technique with an interval of two weeks and the collected copies were correlated using Pearson-product moment correlation coefficient. The questionnaires were administered to the respondents by the researchers with the help of six research assistants, one from each community. Data were collected and analysed using means and remarks. A mean of 2.50 and above indicated that the respondents agreed with the item statement while a mean of 2.49 and below indicated disagreement with the item statement.

Results

The results of the study are presented in tables 1,2,3 and 4

Table 1: Mean scores of the respondent on the awareness of the climate change adaptation strategies on environmental sustainability.

S/N	Items	Mean	Remark
1	Quality information and robust enlightenment campaign should be made known to Nigerians about climate change on environmental sustainability before the disaster.	2.05	Not aware
2	Building resilient systems which could withstand shocks and difficulties	1.99	Not aware
3	Construction of better and wider drainage channels for flood control like huge water catchment pits.	1.79	Not aware
4	Clearing of refuse for improved sanitation and stoppage of indiscriminate dumping of refuse on drainages	2.59	Aware
5	Relief camps for temporal resettlement in case of disaster and provision of food are to be made available by the government.	2.65	Aware
6	Fast-maturing and high yield varieties of maize, cassava and vegetables were to be introduced and used by farmers	3.00	Aware
7	Deforestation for local wood fuels and other land use.	2.99	Aware
8	Overgrazing of pasture land by animals could lead to soil erosion use of better water storage system such as underground, plastic(surface) and other surface tanks	1.59	Not aware
9	Building of homes on stilts by the ministry of housing and urban development	1.46	Not aware
10	Use of huge sums of money to purchase drugs to combat various water-borne diseases such as diarrhea, cholera and typhoid fever.	2.77	Aware

11	The Nigeria Meteorological Agency (NMA) are investing more on weather forecasting with little technologies needed in the area of accurate predictions and warming systems.	1.69	Not aware
12	Understanding the life history of crop pest and disease to enable them harvest early enough.	1.25	Not aware
13	Early plating and mulching so that irregularity in changes in planting season will not affect them.	2.00	Not aware
14	Use of cover crops like potato, melon to protect the land from excessive heat and erosion.	1.66	Not aware

Evidence from the result abound that Nigerians are aware of items 4, 5, 6, 7, 10 and are not aware of items 1, 2, 3, 8, 9, 11, 12, 13 and 14. Nigerians are supposed to be aware of all the climate change strategies so as to maintain environmental sustainability.

Table 2: Mean scores of respondents on extent of utilization of adaptation strategies to climate change by the masses at the grassroot.

S/N	Item	Mean	Remark
1	Enlightenment campaign before any disaster	1.05	Not used
2	Building of resilient systems which could withstand shock and difficulties	1.20	Not used
3	Drainage channels for flood control	1.88	Not used
4	Stoppage of indiscriminate dumping of refuse	1.64	Not used
5	Relief camps allotted for temporal resettlement in case of disaster.	2.65	Used
6	Fast-maturing varieties of maize, cassava and vegetables	2.91	Used
7	Use of other sources of energy/fuel other than wood fuels so as to save biodiversity	0.89	Not used
8	Use of better water storage system such as underground, plastics(surface) and other surface tanks	1.20	Not used
9	Pedestrian bridges built with wood are used during flooding to have access to other parts of the community	0.66	Not used
10	Homes built on stilts are used during flooding	0.59	Not used
11	There is access to health care centres for the treatment of water-borne diseases like diarrhea, cholera, typhoid fever.	2.70	Used
12	The information from Nigeria meteorological agency is disseminated to use in local dialects for prompt response	0.48	Not used

Table 2 revealed that the masses utilize items 5, 6, and 11 while items 1, 2, 3, 4, 7, 8, 9 and 10 were not utilized by the masses. This shows that the masses are yet to use the adaptation strategies to cope with the effect of climate change on their environment.

Table 3: Mean scores of respondents to the barriers to effective climate change adaptation strategies in Nigeria for environmental sustainability.

S/N	Item	Mean	Remark
1	Poor response to early warning system and public enlightenment.	3.00	Agree
2	Lack of access to weather forecasting technology.	2.79	Agree
3	Non – availability of water storage facilities.	3.43	Agree
4	Refusal of the people to relocate to relief camps.	2.66	Agree
5	High cost of land use system in Nigeria.	3.05	Agree
6	Non – availability of credit facilities.	2.98	Agree
7	Government irresponsiveness to climate risk management.	2.78	Agree
8	Inadequate knowledge on how to cope with or build resilience.	3.00	Agree
9	Limited income to move their property from their homes.	3.20	Agree

Table 3 revealed that the respondents agreed that all the items are barriers to effective climate change adaptation strategies in Nigeria for environmental sustainability.

Table 4: Mean scores of respondents on the strategies to bring the adaptation strategies to the masses at the grassroot

S/NO	Item	Mean	Remark
1	Information on climate change adaptation should be disseminated at the grassroot level through the use of local dialects, bill board advertisements, community radio and enlightenment campaign in markets, the church and public gathering.	3.00	Agree
2	Government should bring more relief materials to the affected masses in their communities.	2.99	Agree
3	Increased supply of fast-maturing maize, cassava and other cash crops should be brought at regular times.	3.35	Agree
4	More available relief camps with provision of food and other relief materials should be provided in the event of flooding.	3.40	Agree
5	Nigerians Environment Management Agency (NEMA)should not only publish warning about floods and evacuation of communities but should make adequate arrangements of where to and how to go.	2.87	Agree

Responses from table 4, asserted that the masses agreed strongly to the item statements. This implies that the adaptation strategies of the government should be made to be understood and felt by all the riverine communities.

DISCUSSION

From the study, it was revealed that Nigeria, in an attempt to tackle climate change and its devastating effects should make all Nigerians to be aware of the adaptation strategies. Some of these adaptation strategies are information dissemination (2.05) use of cover crops to protect excessive heat (1.66) building homes on stilts (1.46); understanding the life history of plant pests (1.25) weather forecasting with little technologies on accurate warming systems (1.69); wider drainage channels for flood control (1.79) This meant that the adaptation strategies being embarked upon were just a tip of the iceberg. The ideas of [8][9] emphasized that adaptation strategies are essential to reduce the damage from climate change (flooding) that cannot be avoided, essentially when the massed know about them.

Findings from table 2 showed that the adaptation strategies were not utilized by most people in the communities. Use of other sources of energy other than wood fuels(0.89); Pedestrian bridges(0.66); Homes built on stilts(0.59); Dissemination of information in local dialects for prompt response (0.48); Complaints about provisions of food at the relief camps(1.00) and among others. This meant that the communities utilized these adaptation strategies to the barest minimum. This is in corroboration with [12] who asserted that pedestrian bridges built with wood are biodegradable and thus have short life span. Furthermore, he noted that shelter is one of the basic needs of man, therefore riverine communities who are unable to relocate for financial reasons develop trauma as a result of the flooding.

Table 3 revealed that there are both intrinsic and extrinsic barriers to effective climate change adaptation storage in Nigeria for environmental sustainability. They are poor response to early warning and public enlightenment, lack of access weather forecasting technology, Non-availability of water – storage facilities, refused of the people to relocate to relief camps, high cost of land use system, non-availability of credit facilities, government irresponsiveness to climate risk management; inadequate knowledge on how to cope with or build resilience and limited income to move their property from the homes. This is affirmed by [13] who said that intrinsic efforts from farmer and extrinsic supports from government are needed to be able to break the barriers to effective climate change adaptation.

From table 4, it was found that information on climate change adaptation should be disseminated at the grassroot level through the use of local dialects, bill board advertisement, community radio and enlightenment campaign in markets, the church and public gathering. Fast-maturing maize and cassava and other cash crops should be readily supplied. Above all government – federal, state, local interventions with NEMA making adequate arrangements for people's evacuation were the responses of communities in order to bring climate change adaptation strategies to the grassroot. This is in line with what NEMA and Ministry of Environment warned riverine communities to evacuate but without government support[12].

CONCLUSION

Mainstreaming climate change adaptation into Nigerian's economic blueprints and development master plans is an important strategic action at this stage of our development because preparedness guarantees effective contingency plans to protect citizens, property and the environment. Resources should be invested and concentrated on developing specific adaptation measures that affect Nigeria mostly like flooding that wash away farms and farmlands, some buildings were weakened while some were collapsed and those remaining were not safe for human habitation. Barriers for effective climate change adaptation strategies should be tackled by both intrinsic (Communities) efforts and extrinsic (government) supports. Integrating these efforts in a synergistic manner usually results in a more effective adaptation to climate change impacts. Therefore adaptation strategies of the impacts of climate change must be given priority if the nation's MDGs on environmental sustainability will ever be achieved.

RECOMMENDATIONS

Based on the findings, these recommendations were put forward:

1) Information on climate change adaptation strategies should be disseminated at the grassroot level through the use of local dialects, bill board advertisements, community radio and enlightenment campaign in market places, the church and places of public gathering.
2) The government –federal, state and local –interventions and NEMA, Ministry of Environment, Nigerian Meteorological Agency and Ministry of Housing and Urban Development should strengthen hands together to ensure effective and timely response during emergencies.
3) Government, different churches, and other philanthropists should increase more relief materials and foods to the affected masses in their communities.
4) Fast-maturing maize, cassava and other cash crops should be supplied regularly to resuscitate the community.
5) Financial support (loans) should be given to farmers affected by disaster caused by climate change to enable them start off again.
6) A National Adaptation Framework (NAF) should be developed for all the geographical zones in Nigeria, which must include resettling of victims of environmentally-induced migration.
7) Nigeria should establish a National Climate Change Commission (NCCC) with the mandate to deal with all climate change issues.

REFERENCES

1 Climate Change Mitigation and Adaptation in Nigeria. A suggestive Research Draft. Retrieved on 02/05/2013 from http://trpns.com/wp-content/uploads/2011/09/Climate- Change-Mitigation-and-Adaptation-in-Nigeria.pdf

2 United State Global Change Programme(2009). *Global Climate Change Impacts in the United States, Global Climate Change Chapter.* Retrieved on 02/05/2013 from http://downloads.globalchange.gov/usimapcts/pdfs/global.pdf

3 United State Climate Science Programme(2008). Trends in Emission of Ozone Depleting Substances, *Ozone Layer Recovery and Implications for Ultra Violet Radiation exposure Synthesis and Assessment Product* 2.4.

4 IPCC(2001) Summary for Policy Makers (A report of working Group I of the Intergovernmental Panel on Climate Change). *Online at www.ipcc.ch*

5 NEST(2004). Climate Change and Nigeria: A guide for Policy Makers. *The publication of the Nigerian Environmental Study Action Team(NEST).*

6 Idowu, B.(2008). Attainment of MDGs through Educational Reforms: A Road map for Nigeria. In B. G. Nworgu(Ed) *Educational Reforms and the Attainment of the MDGs. The Nigerian experience,* 1-3, Nsukka: UniversityTrust Publishers.

7 Eboh, E(2009). Implications of climate change for Economic Growth and Sustainable Development in Nigeria. *Enugu Forum Policy Paper 10. African Institute for Applied Economics.* Nigeira.

8 Nzeadibe, T.C.(2010). Climate Change Awareness and Adaptation in the Niger Delta region of Nigeria. *African Technology Policy Studies Network Working Paper Series No 57*.

9 Ozor, N.(2009). Understanding Climate Change. Implications for Nigeria Agriculture, Policy and Extension. *Paper presented at the National Conference on Climate Change and the Nigeria Environment organized by the Department of Geography,* Nsukka: University of Nigeria.

10 Anyadike, R. N. C.(2009).*Climate Change and Sustainable Development in Nigeria: Conceptual and Empirical Issues*. Enugu: Institute for Applied Economics.

11 Adesina, F.A. & Odekunle, T.O.(2011). Climate Change and Adaptation in: Some Background to Nigeria's response III. *International Conference on Environmental and Agricultural Engineering*, 15(2), 74-80.

12 Uyigue, E.& Agho .M.(2007) Coping with Climate Change and Environmental Degradation in the Niger Delta of Southern Nigeria. Retrieved on 09/06/2013 from http://priceofoil.org/content/upload/2007/06/07.11%Climate_Niger_Delta.pdf

13 Ozor, N; Madukwe, M.C. Enete, A.A. (2010). Barriers to Climate Change Adaptation among Farming Households of Southern Nigeria. *Journal of Agricultural Extension* 14(1), 114 – 124.

Physics Teachers' Assessment of Climate Change: Implication to Millennium Development Goals (MDGs) Delivery

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ABSTRACT

The study was a descriptive survey of Physics teachers' assessment of the causes and effects of climate change and its implication to the Millennium Development Goals (MDGs). The purpose of this study is to investigate the level of the climate change literacy possessed by Senior Secondary School Physics teachers. A sample of seventy-nine (79) Physics teachers was selected from all the secondary schools in Umuahia North Local Government Area of Umuahia Education zone of Abia State. Four (4) research questions and two (2) null hypotheses guided the study. The instrument for data collection was a modified four point Likert Scale whose reliability was determined as 0.87. Data collected were analyzed using mean for the research questions and X^2-test for the hypotheses. The result indicated that Physics teachers are not aware of the causes and effects of climate change in African countries like Nigeria and their subsequent effects towards sustainable development and achievement of the MDGs target. Implications of the findings were discussed and it was recommended that for the achievement of the MDGs target it is necessary among other things to train Physics teachers on issues involving climate change through seminars, workshops and conferences should be regularly organized for them to improve themselves and update their knowledge on current issues like causes and effects of climate change to meet up with the demands of the environmental changes for sustainable development.

Keywords: Physics, Millennium Development Goals (MDGs), Climate change and Sustainable development

THEME 9: CLIMATE CHANGE AND NATURAL RESOURCE MANAGEMENT

Socio-Economic Vulnerability and Household Level Adaptation to Climate Change: A Study of Forest Communities in Ondo State, Nigeria

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ABSTRACT

This paper assessed the socio-economic vulnerabilities and household level adaptation of farmers in selected forest-based communities around Akure Forest Reserve in Ondo State, Nigeria to increasing risks arising from climate change. An impact and vulnerability assessment within an integrated assessment framework that included both natural and human sub-systems interactions was adopted for the study. Quantitative and qualitative methods including administration of household questionnaires, interviews with key informants and focus group discussions and analysis of collected data and information were employed. This paper describes different factors contributing to the farmers vulnerability to climate change and their interaction with different climatic variability in the study area. The paper further examined the people's perception about climate change and strategies employed by the farmers to face the great climate inter-annual variability and extreme events. Findings revealed that farmers in the study area were highly vulnerable due to high level of illiteracy and low income among other factors. About 87% of the farmers in the study area had employed traditional adaptation strategies to cope with climate variability and extreme events. The study provides information that can improve knowledge and understanding of the relationships between climate variability and problems related to food security and sustainable agricultural development in the study area.

Key words: Climate change, vulnerability, forest communities, Akure Forest Reserve. Nigeria

Role of Ecotourism in Climate Change Adaptation

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ABSTRACT

Climate change is threatening all aspects of human development. This paper reviews the role of ecotourism in climate change adaptation in Nigeria. In ecotourism, environmental conditions are influenced by climate which invariably determines choice of tourist destination, length and quality of tourism seasons and biodiversity resources that form the major attraction. Adaptation to climate change is a central element in the development planning strategies for ecotourism since it is dependent on the natural environment. As a non consumptive utilization of biodiversity, it is a form of nature-based tourism which aim at conserving natural resources, local culture and also improve the well-being of local people. Biodiversity conservation in ecotourism enhances adaptation to climate change by protecting the forest to stabilize the climate. Ecotourism helps to raise conservation awareness about environment to community and visitors, provide financial justification for natural resources conservation and also provide livelihood diversification in communities that are vulnerable to achieve resilience to their livelihoods. These capacities will enhance adjustment in behavior and in resources for the design and implementation of effective adaptive strategies to reduce the harmful effects of climate change.

Keyword: Ecotourism, Biodiversity conservation, Climate change, Adaptation, Awareness

INTRODUCTION

Tourism is a global phenomenon that has experienced rapid growth over the years and currently the world largest industry. It is the largest employer of labour and generates more revenue than any other type of business. International arrivals shows an evolution from a mere 25 million in 1950 to an estimated 806 million in 2005, corresponding to an average annual growth rate of 6.5% (WTO, 2007).Travel and tourism consumption, investment, government spending, and exports are expected to grow by 4.6% (in real terms) and total US$6.5 trillion in 2006. The 10-year growth (2007-2016) forecast is 4.2% per annum illustrating the outlook for strong long-term growth. It is therefore valued highly by many countries and in many cases holds a very prominent position in development strategies. Increase in leisure, the growth in real income, mobility, technological improvement in communications and international transportation, and demographic changes in the West have led to the strong global demand for tourism

(Godbey and Robinson, 1997). This growth has significant implications for developing countries, which are attracting an increasing share of global international tourist arrivals from 20.8% in 1973 to 42% in 2000 (WTO, 2002). This represents an important source of foreign exchange and the principal export earner for 83% of the developing countries. For the world poorest country, tourism is the second most important source of foreign exchange after oil (Manstny, 2001). Moreover, UNWTO (2009) ascertained that tourism contributes to sustainable development, poverty reduction and the Millennium Development Goal.

Major environmental and socio-economic problems has been recorded in the process, including pollution of various kinds, deforestation, loss of habitat, overcrowding, economic and cultural dislocation, inflation, and local resource shortages. Conventional tourism has not been sustainable and has done little to improve local living standards or protect the environment. Ecotourism emerged as a response to these issues. A type of specialty travel that incorporate diverse array of activities and tourism type, from bird watching, scientific study, photography, diving, trekking, to regeneration of damaged ecosystems. The International Ecotourism Society (TIES) defines ecotourism as 'responsible travel to natural areas that conserves the environment and improves the well - being of the local people'. Ecotourism asserts the principles of minimizing impacts, building environmental and cultural awareness and respect, providing positive experiences for both visitors and hosts, providing financial benefits for conservation, providing financial benefits and empowerment for local people, and raising sensitivities to host countries' political, environmental and social climate (TIES, 2008).

Ecotourism has also been able to capitalize on the increased motivation to experience and preserve natural environments, which stem in part from more fundamental changes in societal values (Blamey, 1995; Diamantis, 2004). It has become the fastest growing sector of the tourism industry growing three (3) times faster than the industry as a whole (Huybers and Bennett, 2002; The International Ecotourism Society, 2008). There can be no doubting of the increasing trends in environmental concern allied with historically prevalent trend of travel as a form of escape to nature, driven by 'the pressures of urban living which encourage people to seek solitude with nature' therefore increasing the numbers of visitors to national parks and other protected areas (Ceballos-Lascurain, 1990). Ecotourism is distinguished from conventional tourism in that it employs measures to reduce negative impacts on the natural and cultural environment.

Climate Change and the Tourism Sector

The tourism sector has been identified as a significant contributor to climate change (Table 1). Greenhouse Gas emissions include emissions from transports, accommodation and activities which accounted for about 5% of the total global CO_2 emission most of which is particularly emitted from aviation as reported by (UNWTO-UNEP-WNO, 2008). In 2005, tourism's contribution to global warming was estimated to be between 5% to

14% of the overall warming caused by human emission of green house gases (Simpson *et al.,* 2008). According to the Davos Declaration on climate Change and the Tourism sector has to "rapidly respond to climate change, within the evolving UN framework and progressively reduce its Greenhouse Gas (GHG) emissions, if it is to grow in a sustainable way" (SCP, 2010).

Table 1: Tourism as a Contributor to Co_2 Emissions

Sub-Sectors	**CO_2 Emissions (Mt)**	**Percentage of Sector Emissions (%)**	**Remark**
Air Transport	522	40%	**Transportation of tourists equals 75% of sector emissions**
Car Transport	418	32%	
Other Transport	39	3%	
Accommodation	274	21%	
Activities	52	4%	
Total	1,307		
Total World **(IPCC 2007)**	26,400		
Tourism Contribution	**4.95%**		**Excluding non-CO_2 emissions and impacts on climate**

Source: UNTWO-UNEP-WMO 2008.

Since the transportation industry's contribution to GHG emissions is very high, measures designed to reduce the impacts may increase transportation cost and changes in tourist travel pattern i.e. changes in transportation mode and destination choices (ITC, 2011).

CLIMATE CHANGE IN NIGERIA

Over the past 900,000 years, the earth experienced cycles of ice ages, each followed by warmer interglacial periods. Currently, global climate is undergoing such a change, but this time towards a record warmer climate powered by warming. Climate change is any long-term significant change in the 'average weather' that a given region experiences. Average weather may include average temperature, precipitation (rain and snow), and wind pattern. It involves changes in the average state of the atmosphere over durations ranging from decades to millions of years. These changes can be caused by dynamic processes on earth, external forces including variations in sunlight intensity and more recently by human activities (Intergovernmental Panel on Climate change, 2007). United Nation Framework Convention on Climate Change defined climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere in addition to natural variability observed over comparable time period.

In Nigeria, increasing patterns of weather elements such as rainfall and temperature have been observed and the cause has been thought to be anthropogenic (Iheanacho, 2011). Some climate change indicators in Nigeria are temperature rise, higher sun intensity especially in the morning hours, shorter harmattan season that is becoming warmer and drier, increased wind activities aided by the changing landscape which is progressively being devoid of forest cover thereby exposing the environment to increased wind action while rainfall pattern and intensity has been altered and unpredictable as observed by Nigerian Environmental Study Team (NEST, 1991). Today, unfortunately, deforestation, desertification and climate change are fast becoming a major challenge. Nigeria has the largest annual deforestation rates in the world, estimated at 3.5% (approximately 350,000-400,000 hectares per year) and has lost 55.7% of her primary forests (http://rainforests.mongabay.com/20nigeria.htm). Studies from 1901 to 2005 showed a temperature increase in Nigeria of 1.1^{o}C, while the global mean temperature increase was only 0.74 ^{o}C. In the same period the amount of rainfall decreased by 81mm (National Centre for Genetic Resources and Biotechnology 2008). It was noticed that both of these trends simultaneously had sharp changes in the 1970s, suggesting that over-exploitation of forest resources might be held responsible. The combination of extremely high deforestation rates, increase temperatures and decreasing rainfall are all contributing to desertification. The carbon emissions from deforestation is also said to account for 87% of the total carbon emissions of the country. Global warming and climate change set the context in which sustainable environmental management for tourism will be implemented (ITC, 2011). In ecotourism, environmental conditions are influenced by climate which invariably determines choice of tourist destination, length and quality of tourism seasons and biodiversity resources that form the major attraction. The tourism sector is affected by climate change since the attractiveness of a region for tourism is being determined by the natural environment.

PROTECTED AREAS AND ECOTOURISM

Ecotourism is about traveling and visiting natural areas where nature still exists in a relatively undisturbed state. It is rather disappointing that renewable natural resources are being utilized by humans than ever before at the rate exceeding their natural abilities to renew themselves (Nature Conservation Sector, 2006). If land use for human activities is the problem, then protecting some natural habitat from loss in protected areas is part of the solution to safeguard species and habitat diversity as part of local, national and global heritage. A protected area is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values**.** (IUCN, 2008). Generally, in Nigeria, there are 445 forest reserves, 7 strict nature reserves, 1 biosphere reserve, more than 20 natural regeneration plots, more than 200 permanent sample plots, 32 game reserves/sanctuaries, 3 fish parks, 7 national parks and 3 Ramsar sites (Federal Government of Nigeria, 2001). Globally, protected areas have increased by 515% since 1970 (Eagles1997). Advantages of the protected areas include provision of baseline system to assess land use effect on biodiversity, regulating and mitigating anthropogenic impacts on biodiversity, provision of food, fresh water, fuelwood, fibre, genetic resource, and biochemicals. Protected areas also provide significant ecosystem services to local communities, nation and international communities through climate regulation, disease regulation, invasion resistance, flood regulation, water purification, pollination, seed dispersion and erosion regulation. Ecotourism attractions, whether wildlife viewing, wilderness hiking or dramatic natural landscape tend to be found in these protected areas which serve as a non-consumptive utilization of the natural resources.

Climate Change Adaptation

Adaptation refers to all those responses to climate change that may be used to reduce vulnerability, or to actions designed to take advantage of new opportunities that may arise as a result of climate change (Burton, 2009). The IPCC defines adaptation as "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects." Resilience is "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self organization, and the capacity to adapt to stress and change" and is a subset of adaptation that represents less change from the status quo compared to other adaptation options. Adaptive capacity is the ability or potential of a system to respond successfully to climate variability and change, and includes adjustments in behaviour, resources and technologies. The presence of adaptive capacity has been shown to be a necessary condition for the design and implementation of effective adaptation strategies so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change. Adaptive capacity also enables sectors and institutions to take advantage of opportunities or benefits from climate change, such as a longer growing season or increased potential for tourism.

The Fourth Assessment Report of the IPCC (2007) recognizes that some adaptation is occurring, but on a very limited basis, and affirms the need for extensive adaptation across nations and economic sectors to address impacts and reduce vulnerability. Vulnerability to climate change may be defined as: "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes (Leary et al, 2007). Approaches to adaptation are shown in Table 1.

Table 1: Approaches to adaptation

Types of adaptation	Characteristics	Examples
Autonomous adaptation	Adaptation that takes place naturally or not as a conscientious response to climate change	Natural responses of plant species to e.g. drought or to seasonal changes (earlier spring). Autonomous farming practices (changes to sowing dates)
Building adaptive capacity	Creating the information and regulatory, institutional and managerial conditions that enable adaptation to be undertaken Education and capacity-building	Climate change research funding Awareness creation among farmers Development of policy support tools
Adaptive measures	Taking actions that help reduce vulnerability to climate risk or exploit opportunities	Creating water collection and storage facilities Introducing new crop varieties Resource management tools and infrastructure

Source: IPCC, 2001

Adaptation can take different forms, such as better education, training and awareness of climate change, or it can take the form of more technical measures, such as drought-resistant seeds and better coastal protection.

ROLE OF ECOTOURISM IN CLIMATE CHANGE ADAPTATION

Eco-tourism is defined by the International Union for Conservation of Nature IUCN (1997) as, "Environmentally responsible travel to natural areas, in order to enjoy and appreciate nature (and accompanying cultural features, both past and present) that promote conservation, have a low visitor impact and provide for beneficially active socio-economic involvement of local peoples." A close linkage exists between climate and tourism. In fact, climate defines the length and quality of tourism seasons and plays a major role in destination choice and tourist spending. Climate also affects a wide range of environmental resources that are critical attractions for tourism, such as snow conditions, biodiversity, water levels and quality. Moreover, climate has an important influence over environmental conditions that can deter tourists including disease spread, and extreme events such as heat waves, floods and extreme storms (UNWTO-UNEP-

WMO, 2008). However, like most sectors of economic activity, tourism is vulnerable to the impacts of climate change. Many of the projected climate changes will impact the attractiveness of tourist destinations. Examples of climate-related stresses include hotter summers, droughts, extreme weather events, water scarcity, and ecosystem degradation (WHO, 2008). Eco-tourism could be negatively impacted by climate change, since climate change will impact different ecosystems upon which eco-tourism is built, e.g. forests and wildlife. The extent of the impact of climate change on tourism activities is dependent on how well the natural resources on which it relies can adapt to climate change (Turton *et al.,* 2009). Adapting the sector to the impacts of climate change requires a multidimensional strategy that involves nature conservation, infrastructure development and technology development. Access to technology, such as early warning systems and infrastructure, is essential in reducing vulnerability and increasing the tourism sector's capacity to adapt. Substantial investment on information is required in Nigeria where climate change has been identified as a known risk but little information exists to evaluate the type and severity of climate change impact on the tourism sector. Developing and adapting eco-tourism can be a powerful ally for nature conservation, by generating much needed revenues for the maintenance of natural areas and reserves and through environmental education and awareness for both the local population and tourists. Climate neutrality is also enhanced in ecotourism through promotion of environmental friendly airline, the use of public transit to destination, engaging in muscle-powered leisure activities, and provision of climate neutral accommodation.

Biodiversity Conservation

Biodiversity conservation in ecotourism enhances adaptation to climate change by protecting the forest to stabilize the climate. Biodiversity encompasses all species of plants, animals, micro organism, the ecosystems and ecological processes of which they are part. It is the wealth of all life forms found on earth - animals, plants and microorganisms in their millions and their differences, the gene they contain and the intricate systems they form. Moral justification and value to human existence are the two major reasons for conserving biodiversity (Christ, *et al*., 2003). Conservation is the planned management of a natural resource or the total environment of a particular ecosystem to prevent exploitation, pollution, destruction, or neglect and to ensure the future use of the resource. The goal of biodiversity conservation therefore is to ensure that such resources are not consumed faster than they are replaced. Protected areas are important for the conservation of biological diversity, recreation and tourism as well as a range of meeting community objectives. Protected areas mitigate the impact of climate change through carbon capture storage and act as a buffer against natural disaster. The forest in a protected state is an attraction for tourist to enjoy and appreciate, forest contribute to ecosystem preservation, biodiversity conservation, protection of storm, flood and drought. Ecological value of the forest according to Eike (2010) unfolded that one square meter of forest soil stores up to 200 litres of water (flood prevention), one spoon of forest soil contains more organisms than human living on earth, one hectare of beech tree forest can evaporate up to 50,000 litres of water (cooling effects) while a fully grown tree is binding with its wooden volume about 900Kg carbon dioxide (Forest stock). Healthy bio-diverse environments play a vital role in maintaining and increasing resilience to climate change, and reducing climate-related risk and vulnerability. The general trend in ecotourism is to increase experiences by encouraging activities such as long-distance walking, camping, boating, sport hunting, sight-seeing, swimming, cultural activities, bicycling, observing wildlife and nature, skiing, visiting historical places and horse riding among others, attracts most attention (Gengiz, 2007).

Conservation Awareness

Adaptation to climate change can take the form of better education, training and awareness of climate change. Ecotourism is the impetus of awareness that educate the public about the importance of environmental issues and its consequences before they occur. It promotes environmental education to both host and guests. Nature tourists provide an ideal audience for environmental education. They appreciate, understand and learn about the importance of nature and are eager to learn about local habitats, animal behaviour and conservation issues. Environmental education is most effective when pre and post-trip information is made available to bring about appropriate behaviour to minimize negative impacts. Nature guides, printed materials, visitor centers, and video are effective medium of providing ecotourists with environmental education which lead to changes in their interaction with the environment. Ecotourism can help raise awareness among policy makers about the importance of conservation, land management and the opportunities that flow from it (Andy and Alan 2005).Regular dialogue with communities, guides and government officials and visitors about the importance of minimizing environmental impacts and of the relationship between ecotourism industry and conservation of the natural resources on which ecotourism depends bring about high awareness among stakeholders on the need to protect and conserve these resources to be able to maintain a successful ecotourism industry. Increased awareness about environmental problems and opportunities to the locals potentially shift local activities from unsustainable practices. Many residents are motivated to protect their areas and may change their patterns of resource use when they realize the global importance of their natural resources. These capacities will enhance adjustment in behavior and in resources for the design and implementation of effective adaptive strategies to reduce the harmful effects of climate change.

Justification for natural resources conservation

The potentials of protected areas that conserve natural resources to attract visitors are among the reasons why government, non-governmental organization and residents support protected areas. Ecotourism provides protected status to an area or strengthen the protective status of an existing protected area or reserve particularly if it can generate income and provide other national benefits. International tourism motivates government officials to think more about the importance of managing natural areas. Economic benefits arising from ecotourism can be a powerful incentive for the conservation of protected areas at both the community and governmental level. Visitors are more attracted to natural area if it is protected, which in turn adds justification to the existence of protected areas. Ecotourism can further directly contribute to protected area conservation objectives by providing a source of revenue for reinvestment back into the conservation programme that it support (Steven and Guy 2002). Financial justification of ecotourism for natural resources conservation through entrance fee, levies, concession, donations and other economic activities are realized for the benefit of environmental conservation and community livelihoods (Andy and Alan 2005).

Provision of livelihood diversification in vulnerable communities

Rural communities' livelihood is directly linked to natural resource. Many survive through agriculture, hunting, fishing and pastoralism. When threats to these resources from both external sources and within the community impact their livelihood some activities may need to change and ecotourism can be a way to help the community adapt, mitigate and compensate for this change (Ogara *et al.,* 2013). Ecotourism interests can convince local people that their resources are more valuable when intact than when extracted from the ecosystem. When a user fee or visitor admission fee structure is imposed, real economic incentives for protected areas can catalyze their formulation (Agardy, 1993). Hadejia Nguru wetland in Nigeria provide wintering stop-over sites for 68 different waterbird species such as Ruff *Philomachus pugnax* and Spurwinged Goose *Plectropterus gambensis* which serves as an ecotourism site suitable for bird watching. Wetlands help mitigate against flooding, filter waste and serve as nursery for fisheries Local communities has been empowered to restore the ecosystem to counter the mal-adaptation impacts which has restored more natural flood pattern and has increased household income. Ecotourism has provided alternative source of livelihood to community members and restoration of the community livelihood in the face of economic down turn due to the impact of climate disruptions as reported by Ogara *et al* (2013) that ecotourism offered opportunities for livelihood diversification away from pastoralism that was resilient enough to climate change, and provided the community with a sense of ownership for their resources and created community cohesion which is an important asset for rural community social capital in Kenya. Ecotourism encourages the use of indigenous guides and local products. It provides local people with economic incentives to safeguard their environment (BirdLife International, 2008). Local communities' bordering ecotourism destinations can provide home stay opportunity and education which will invariably provide additional income for household and increase awareness of sustainable product. Through its multiplier effect, ecotourism has great potential to provide socio-economic benefits for local economies via improved standards of infrastructure. Tourism often times help to create jobs and raise standard of living when primary traditional sources of livelihood such as farming and fishing are in decline due to the impact of climate change (Hill, 1993; Sharpley, Sharpley and Page, 1997; Fleisher and Felsentein, 2000).

CONCLUSION

The contributions of tourism to the millennium development goals cannot be overemphasized. Therefore it becomes essential that the tourism industry play its part in mitigating emissions and helping poorer regions to adapt to climate change. Enhanced protection and management of natural ecosystems and more sustainable management of natural resources play a critical role in climate change adaptation strategy. Protecting the Nigerian remaining forests from destruction is an important tool for stemming the harmful effect of green house gas emissions. By adopting ecotourism as a sustainable model, the forest cover is increased, the canopy is created and in the long run, the climate improves.

REFERENCES

Agardy, M.T. (1993). Accommodating ecotourism in multiple use planning of coastal and marine protected areas. *Ocean and Coastal Management*, 20 (3): 219-239.

Andy D. and Alan M. 2005. Ecotourism Development – A Manual for Conservation Planners and Managers Volume 1: An Introduction to Ecotourism Planning, Second Edition. The Nature Conservancy, Arlington, Virginia, USA. Pp 31-39.

Anonymous 2012. Critical Nanotechnology Needs in Forest Products Industry. www.nist.gov, retrieved on 3-11-2012. http://rainforests.mongabay.com/20nigeria.htm. Site visited on 03-11-2012.

BirdLife International (2008). Improved livelihoods at Arabuko-Sokoke Forest in Kenya. Presented as part of the BirdLife State of the world's birds website. Available from: http://www.birdlife.org/datazone/sowb/casestudy/221. Checked: 18/08/2013

Blamey, R.K. 1995.The nature of ecotourism. Bureau of Tourism Research, Canberra, Australia

Burton, I., 2009. Climate change and the adaptation deficit. In: Schipper, E.L. & Burton, I. (eds.) The Earthscan Reader on Adaptation to Climate Change. London: Earthscan: 89-95.

Ceballos-Lascurain 1990.Tourism, Ecotourism and Protected Areas. Paper presented at the 34thWorking Session of the Commission of National Parks and Protected Areas, Perth, Australia.

Christ, C., Hillel, O., Matus, S. and Sweeting, J., 2003. Tourism and Biodiversity: Mapping tourism's global footprint. Conservation International. Pp 1140

Diamantis, D. 2004. Ecotourism: Management and Assessment. Thompson Learning, Dimitrios D. (2004): Ecotourism: Management and Assessment. Thompson Learning, Belmont, CA. Pp 1-24.

Eagles, Paul F. J. (1997). International Ecotourism Management: Using Australia and Africa as Case Studies. Available at http://www.ahs.uwaterloo.ca/rec/ecotour.htm.

Eike O. 2010. Strategic Approaches for Developing Sustainable and Competitive Tourism Products. Fifth International Meeting of the United Nations World Tourism Organization (UNWTO) on the Silk Road. Samarkard, October 2010. Available at www. Sustainable-tourism.com.

Federal Government of Nigeria (2001). First National Biodiversity Report.

Fleischer, A., & Felsentein, D. (2000). Support for Rural Tourism: Does it make a Difference? *Annals of Tourism Research,* 27, 1007-1024.

Gengiz T 2007. Tourism, an ecological approach in protected areas: Keragol-Sahara National Park, Turkey. *Int J of Sustainable Development and World Ecology,* 14: 260-267

Godbey, G. & Robinson J., 1997 The Increasing prospect for leisure. *Parks and Recreation,* 32(6), 75-82

Hill, B. (1993). *The Future of Rural Tourism,* Washington DC: Department of Parks and Recreation.

Huybers T. and Bennett J., 2002. Environmental Management and the Competitiveness of Nature-Based Tourism Destinations. Edward Elgar Publishing, Gloucestershire, UK.

Iheanacho C.O. 2011. Vulnerability Assessment of the Nigerian Forestry Sector to Climate Change. Proceedings of the 34th Annual Conference of the Forestry Association of Nigeria held in Osogbo, Osun State Nigeria. 360-370pp.

Intergovernmental Panel on Climate Change (IPCC) 2007 'Summary for Policy Makers'. In: M.L Parry, O.F Canziani, J.P Paluticuf, P.L., van der Linden and C.E Hanson (Eds) Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge, United Kingdom and New York. Pp 976.

International Trade Centre (ITC) 2011. Inclusive Tourism: Environmental Management and Climate Change. Technical Paper, Geneva. Pp 88. www.intracen.org

International Union for Conservation of Nature (IUCN). 1997. "Ecotourism." In B*eyond Fences: Seeking Social Sustainability in Conservation.* Gland: IUCN. Pp 22

IUCN, 2008: What is a protected area? Available at http://www.iucn.org/about/work/programmes/gpap_home/pas_gpap/ Accessed on 7th August 2013.

Leary, N., J. Adejuwon, W. Bailey, V. Barros, M. Caffera, S. Chinvanno, C. Conde, A. De Comarmound, A. De Sherbinin, T. Downing, H. Eakin, N. Nyong, M. Opondo, B. Osman, R. Payet, F. Pulhin, J. Pulhin, J. Ratnasiri,, E. Sanjak, G. von Maltitz, M. Wehbe, Y. Yin and G. Ziervogel. 2007. 'For Whom the Bell Tolls, Vulnerabilities in a Changing Climate, A

Manstny, L. 2001.*Treading Lightly: New Paths for International Tourism*.Worldwatch Institute, Washington, D.C, paper no. 159.

National Centre for Genetic Resources and Biotechnology 2008. State of Plant Genetic Resources For Food and Agriculture in Nigeria (1996-2008). A Country Report. 82pp.

Nature Conservation Sector, 2006: Protected Areas of Egypt: Towards the future. Egyptian Environmental Affairs Agency.www.eeaa.gov.eg Pp 71.

NEST 1991. Nigeria's Threatened Environment. A National Profile. Nigeria Environmental Study/Action Team, Ibadan.

Ogara O.W., Olesarioyo J. S. and Eunice B.O. 2013. Community Based Conservation and Ecotourism as an Environmental Management Practice for Climate Change Adaptation in Ewaso Nyiro arid land ecosystem, Samburu County Kenya. *Journal of Environmental Science and Water Resources* Vol. 2(4), pp. 106 – 111.

Page, S. and Dowling R., 2001. Ecotourism: Pearson Education Limited. Harlow, Essex.

Sharpley, R., Sharpley, J. &Page, S. (1997). *Rural Tourism: An Introduction.* London: International Thomas Publishing.

Simpson, M.C., Gössling, S., Scott, D., Hall, C.M. and Gladin, E. (2008) *Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices.* Paris, France: UNEP. University of Oxford, UNWTO, WMO.

Steven S and Guy M.2002. Linking Conservation and Ecotourism Development: Lessons from the UNESCO-NTA Lao Nam Ha Ecotourism Project /March 2002 pp 1-10

Sustainable Consumption and Production (SCP) 2008. Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices. United Nations Environment Programme Division of Technology, Industry, and Economics. Retrieved on 11-08-2003 from http://www.unep.fr/scp/publications/details.asp?id=DTI/1047/PA pp 152

The International Ecotourism Society (TIES) 2008. Ecotourism fact and statistics. Retrieved 10th December 2009, fromwww.ecotourism.org.

Turton S., W. Hadwen, R. Wilson, B. Jorgensen and D. Simmons (Eds) 2009. The Impacts of Climate Change on Australian Tourist Destinations. Brisbanne: CRC for Sstainable Tourism

UN World Tourism Organization 2009. From Davos to Copenhagen and Beyond: Advancing Tourism's Response to Climate Change. UNWTO Background Paper. Madrid. UNWTO.

UNWTO and UNEP and WMO (2008), Climate Change and Tourism: Responding to Global Challenges, (prepared by Scott, D., Amelung, B., Becken, S., Ceron, JP, Dubois, G., Gössling, S., Peeters, P. and Simpson, M.C.), UNWTO, Madrid, and UNEP, Paris.

World Health Organization (WHO). 2008. World Malaria Report 2008. Available at http://apps.who.int/malaria/wmr2008/malaria2008.pdf.

World Tourism Organization (WTO) 2007. Facts and Figures. Retrieved 23 June, 2007, from www.unwto.org.

WTTC (World Travel and Tourism Council), 2006. *WTTC Progress and Priorities: Travel and Tourism. WTTC*, Madrid.

Enhancing Science and Engineering Information Diffusion for Climate Change Risks and Natural Resource Management

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ABSTRACT

This paper presents how innovative science and engineering information diffusion to enhance climate change mitigation and adaptation research infrastructure empower people for resilience and sustainable environment in Africa. It creates a strategic framework for planning and delivering innovation diffusion in the target demographics. In this review, the paper elaborates on the adverse consequences of climate change effects in Africa, the efforts so far taken by the region, the current barriers to deal with the problems, and presents a framework for planning the required responses. The consequences of climate change disaster risks from a science and engineering research infrastructure policy perspective, social, economic, political, and environmental viewpoints, calls for early adoption and widespread diffusion of innovations in Africa. Likewise, there is more urgent need to plan national, sub-regional, and regional strategies for climate change mitigation and develop comprehensive plans in response to the current and environment-related interventions. The paper provides a strategy for addressing the science and engineering related risks of climate change in the region. Most science and engineering outreaches have high failure rates. Africa is already facing gloomy social, economic, political, and environmental impacts of climate change risks. A strategic framework to mitigate climate change effects in the context of the diffusion of innovation is presented. The foci are to: strengthen the database to aid climate change research, raise knowledge and awareness of climate change mitigation and adaptation, enhance gender mainstreaming, curb gas emissions, technology transfer, communication strategy, theory, ethics, and develop collaborative research.

INTRODUCTION

Innovative science and engineering information diffusion to enhance climate change mitigation and adaptation policy infrastructure in Africa is critical for climate change resilience. Awareness levels on the benefits of science, technology, and engineering innovations among the African communities are quite wanting indeed. The low levels of awareness among citizens on climate change adaptation and mitigation issues and options is a huge setback to policy implementation. For example, many surveys have established low public awareness among Ugandans on the opportunities and benefits of EAC integration, MDGs, besides the EAC climate change policy (Eyotaru, 2013). Uganda has determined that climate change is manifested in extreme climatic events such as drought, high temperatures, heavy rains, hail storms, floods, and landslides. The sub-regional body has formulated a framework for planning effective national and regional climate change policy.

The policy communication responses be crafted to reflect the following background: **c**limate change risks and disasters have continued to exact severe incidents of social, economic, environmental, political, and legal challenges at local, national, regional, and global levels; climate change disaster risks impacts are more severe in the sub-region and across Africa; African continent is one of the most vulnerable global spheres to the adverse impacts of climate change disaster risks; economies of the EAC states are largely dependent on climatic and natural environmental resources. Others are: pervasive mass poverty, low awareness of adaption strategy; cancerous state corruption, rain-fed agricultural regime dominated by peasantry, high vulnerability to climate change disaster risks; low awareness and access to information, and low research on climate change disaster risks. In addition, increasing frequencies of natural disasters like droughts, floods, and landslides are among the top climate change risks in the region (GoT, 2006, 2012). Others are: sea level rise which also leads to infrastructure destruction along the coasts, submerging Indian Ocean small islands, salt water intrusion, contamination of fresh water wells along the coasts in Tanzania, beach erosions in Mombasa, Kenya, rampant floods, and droughts.

METHODOLOGY

In this review, we collated published evidence on climate policy and communication to enhance capacity building for national and sub-regional vulnerability, adaptation, and mitigation innovations to climate change using relevant search terms. Information was accessed using internet search engines and libraries. All documents that were obtained during the review process were used to broaden the search for primary information sources. Initially additional information was sought from the databases of national, regional, and international agencies. In the searches, we looked for documents referring climate change policy and awareness communication strategy. Climate change policy diffusion and widespread adoption of innovations in science and technologies for community adaptation and mitigations. First, retrieved documents were scrutinized for relevance and then carefully examined for evidence. The information was then consolidated and summarized to chart the way forward using the available infrastructures or facilities in different social, economic, environmental, legal, and policy applications. Finally, the information was consolidated and summarized to chart the way forward using the available infrastructures or facilities in different economic sectors. The reviewer was biased in favour of published literature accessible via internet searches, and relied on English language documents only. In summary, the study looked for documents referring to climate change policy and communication framework in the East African sub-region.

RESULTS AND DISCUSSION

Applying Science, Engineering, Research, and Climate Change Policy Communication

The objectives of climate change communication approaches are to assess the effectiveness of the regional climate change adaptation and mitigation policy awareness communication; establish the information communication channels employed and message reach (audience exposure); audience participation in message design; identify the challenges of developing an effective communication strategy for the timely implementation of the national action plan for climate change adaptation, and explain the effectiveness of public communication campaign evaluation. For example, communicating climate policy can use different communication approaches with a focus on: blowing away the myths, a new way of thinking, linking policy and communication, audience principles, style principles, and effective management. The following methods are recommended:

- Target audiences
- Branding and key
- Messages
- Public relations
- Seasonality
- Using different channels
- Television and radio
- Printed media
- Electronic media
- Help lines stakeholder engagement
- Direct engagement
- Advertising
- Community outreaches
- Field demonstration centres
- Social media (social networking)
- Community (citizen journalism)
- Volunteer youth clubs (volunteering).

Responding Effectively to Climate Change Disaster Risks Effects on the Society

The recent and current efforts to contain and reverse the adverse effects of climate change disaster risks taken by the East African Community sub-regional countries are still a work in progress. For example, Uganda has launched a national climate change policy development process following the national stakeholders' climate change conference (MWE, 2012). Besides, in the last few decades, Uganda has experienced an increase in the frequency and intensity of extreme weather events with serious socio-economic consequences (GoU, 2010). With rampant poverty, weak institutional capacity, lack of skills on climate change adaptation and mitigation, inadequate skills in disaster management, lack of technology, inadequate funds, and an economic dependence on natural resources; Ugandans are already vulnerable to adverse effects of climate change. Poor climate conditions will continue to wipe the agricultural outputs, leading to higher food prices, dwindling national come, and worsening export trade. Today, 98% of Ugandans are unaware of energy efficiency technologies and clean alternative energy sources. Lack of awareness of climate issues needs a communication strategy on all environmental conventions on climate change (GoU, 2010).

Common Barriers to Climate Change Science-Engineering Innovation Diffusion Process

The key issues related to climate change include: inadequate disaster risk management as a result of impacts made worse by climate change; Uganda's position in international climate change negotiations is not strong enough to represent and effectively articulate and influence the global negotiations the interests of Uganda; water supply endangered in quality and quantity because of climate change; and inadequate mainstreaming of climate in other important sectors such as communication, energy, food security, and agriculture. The hurdles to enabling environment are:

- Conflicting sectoral policies and legal instruments
- Conflicting interests of involved entities
- Media less interested in covering climate change policy issues
- Climate change is given low priority by policy and insufficient allocation of resources
- Poor public information and transparency
- Awareness of climate change challenges low or biased
- Cooperative sharing of responsibilities and mainstreaming weak.

Grappling With Climate Change Policy Development Mainstreaming in Uganda

In a move to guide its climate change adaptation actions, Uganda's national adaptation programme of action (NAPA) was developed in 2007. Currently, the national development plan considers climate change as a framework to support performance of other sectors, with the following four main objectives intended to: develop national capacity to coordinate and implement climate change adaptation and mitigation activities in the country in support of social welfare and national development; ensure climate proof development planning; promote low carbon economic development; and meet Uganda's obligations to implement UNFCCC and its Kyoto Protocol (KP).

The focal institution for climate change activities in Uganda is the CCU. It is being upgraded to the status of a department (MWE, 2013). The climate change unit has made these initial gains by 2014:

1. NAPA pilot projects in three different ecological regions were launched in 2012.
2. Draft climate change mainstreaming guides were produced for all sectors to enable them to integrate climate change policy into their investment development and budgets.
3. Public awareness campaign was conducted in some 10 districts in Eastern Uganda. This was the continuation of the previous similar awareness campaigns done in the central, western, northern, North- western and far eastern regions of the country.
4. Integration of climate change in the national education curriculum was undertaken in partnership with the national curriculum development centre for Uganda.

5. Research on gender and climate change was undertaken by CCU in collaboration with Makerere University, resulting in a report and a documentary on gender and climate change ready for publication and distribution, targeting well over 1,500 stakeholders.
6. Developed a draft nationally appropriate mitigation action framework, yet to be validated by stakeholders before submission to the UNFCCC secretariat.
7. Launched and commenced implementation of a CDC capacity development project. .
8. With many CDM projects, Uganda is ranked as Africa's third best in CDM performance.

Locking Horns with Climate Change Policy Infrastructure Development in Rwanda

At the moment, Rwandan climate change NAPA is being implemented amidst huge barriers. The main challenges to the national policy framework for mitigation and adaptation policy actions are: Insufficient knowledge and research, limited integration of adaptation measures in ongoing institutional efforts, absence of knowledge sharing and information dissemination, weak intersectoral and multi-stakeholder coordination and collaboration, and lack of climate change resilient planning, budgeting, and policy infrastructure. The government of Rwanda in collaboration with UNDP launched a national project on (GoR & UNDP): Supporting integrated and comprehensive approaches to climate change adaptation in Africa- building. As a result, the country has embarked on individual, community, institutional, and national capacity building process to address climate change risks and opportunities through a national approach to adaptation and mitigation framework. The following outputs are expected to be realized from the project:

- Sustainable management of environment, natural resources, and land use;
- Enabling policy for effective environmental management/ecosystem-established;
- Economic productivity enhanced with environmental and natural resources;
- Capacity at national, district, and community levels restored and protected vital ecosystems;
- Climate resilient policies and measures;
- Financial options for national adaptation costs expanded at local, national, sub-regional, and regional levels; and
- It is established that the impact of climate change disaster risks have continued to be quite dire in the EAC sub-region's social, economic, political, environmental, and natural resources.

Confronting the Challenges of Barriers to Rwandan's Climate Policy Communication

Rwandan government has embarked on an aggressive climate change NAPA amidst a wide range of barriers to the planned implementation of the proposed policy framework. The obstacles include: insufficient knowledge and research; limited integration of adaptation measures in ongoing institutional efforts, absence of knowledge sharing and information dissemination, weak intersectoral and multi-stakeholder coordination and collaboration, and lack of climate change resilient planning, budgeting, and policy setting. Rwanda and UNDP have launched a national climate change project called: Supporting Integrated and Comprehensive Approaches to Climate Change Adaptation in Africa-

Building a Comprehensive National Approach in Rwanda. The major objective of the project is to develop the institutional, individual, and systemic capacity to address climate change risks and opportunities through a national approach to adaptation. The following project outcomes and impacts are envisaged: sustainable management of environment, natural resources, and land use; enabling policy framework to support effective environmental management and ecosystem-established; economic enhancement using natural resources in an environmentally friendly way; capacity at national, district, and community levels to restore and protect vital ecosystems against degradation; climate resilient policies and measures; and financial options for national adaptation costs expanded at local, national, sub-regional, and regional levels.

Holistic Approach to Climate Change Policy and Research for Community Outreaches

In addition, the general political EAC integration has been hindered by information gaps, according to the Ugandan government. Climate change threat is already manifested in Uganda. The consequences of ignoring a coordinated and coherent action are severe. The following issues were identified among the important areas: inadequate climate change communication is acting as a barrier to successfully responding to climate change in Uganda, there is lack of coordination in communicating climate change policy information in Uganda, several governmental and non-governmental bodies could act as a central hub for climate change information, public engagement, poor funding (low budget), and low public profile, and the most urgent priority for effective communication of climate change in Uganda is the development of a central coordinating body that can engage with all sectors of society. Uganda has already identified several issues for its national action plan for climate change strategy. Traditional coping strategies to climate change risks were discussed during the PRA with local communities. Data were collected and analyzed. The list below shows the ranking of identified intervention areas (MWE, 2012) in communities:

- Indigenous knowledge (IK) documentation and awareness creation;
- Farm forestry;
- Water resources;
- Weather and climate information;
- Policy, legislation and planning;
- Land and soil management;
- Disaster preparedness;
- Alternative livelihoods;
- Health; and
- Infrastructure.

The East African media is not yet fully engaged in covering climate change science, technology, and engineering innovation research issues. Training programs to assist both journalists and editors are essential, but civil society organizations must also improve the way they engage with the media, packaging information in a clear and simple way and actively attracting media attention. Local languages lack terms for many key concepts involved in climate change –including 'climate change' itself. Communicators should attempt to explain climate change using terms that already exist, using graphic examples of local environmental problems and innovative communication methods to get the message across. Raising awareness of climate change is critical. Local and national politicians are ill informed about climate change although environmental services are decentralized under local governments. Needless to say, awareness campaigns should focus on local politicians to act on climate change. In Uganda, the MPs have now formed a special parliamentary committee on climate change adaptation and mitigation awareness communication campaigns.

Over 20 million Ugandans (68.5%) are classified as food insecure. The major cause of food insecurity in Uganda is climate change manifested in form of extreme weather conditions like: drought; shortage of water and pasture, crop failure, famine, increased food prices, food/Emergencies, inter district migrations, economic loss/loss of income, high temperatures; lead to escalating vectors (pests and diseases), crop wilting, poor yields, heavy rainfall; crop destruction, soil erosion, leaching, contaminating water sources, animal and crop diseases, flooding; increased crop, livestock, and human diseases; loss of lives and livestock; destruction of crops and infrastructure, post harvest losses, water pollution (GoU, 2010).

IDENTIFYING AND TACKLING VULNERABILITY ISSUES IN CLIMATE CHANGE POLICY IMPLEMENTATION

The East African Community sub-region is vulnerable to impacts of climate change, affecting key economic drivers like water, agriculture, energy, transport, health, forestry, wildlife, land use, infrastructure, and disaster risk management among others (EAC, 2011). The impacts include water stress and scarcity food insecurity diminished hydropower generation potential; loss of biodiversity and ecosystem degradation; increased incidence of disease burden; destruction of infrastructure; high costs of disaster management as result of increased frequency and intensity of droughts, floods, and landslides associated with the El Niño phenomenon. The process of developing the East African Community climate change policy was initiated. The summit directed the development of a regional climate change policy and strategies to urgently respond to the adverse impact of climate change, including addressing the challenge of food insecurity as a result of climate change. In addition, the development of the policy is in fulfilment of the objectives of the EAC; to develop policies and programmes aimed at widening and deepening cooperation among Partner States in accordance with the treaty for the establishment of the EAC. The policy process was guided by the emerging issues and potential opportunities. The Policy was developed in a participatory approach by experts from the five EAC states of Burundi, Kenya, Rwanda, Uganda, and Tanzania.

The East African Community policy elements are grounded on three key pillars: adaptation, mitigation and climate change research. The pillars need capacity building; technology development and transfer; finance; education, training, and public awareness based on information and knowledge management. Gender issues are well integrated into sub-regional policy. Key adaptation priorities will include strengthening meteorological services and improving early warning systems; disaster risk management; risk reduction, preparedness, mitigation and reconstruction; scaling up of efficient use of water and energy; irrigation; crop and livestock production, protecting fragile ecosystems like wetlands, coasts, marine, forestry; land use, soil; tourism; infrastructure; and reducing climate infections, illnesses, and diseases.

Mitigation measures include afforestation, reforestation, promoting energy efficiency, efficient crop and livestock production systems, efficient transport systems, waste management, and renewable energy. The East African climate change policy aims to create, develop, and sustain adaptation and mitigation capacity at all levels. Adaptive capacity refers to the potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences (Smit, & Pilifosova, 2001). An adaptive capacity is the capability of a system to adjust to impacts of climate change. These factors determine climate change impacts adaptive capacity: wealth, science, technology, education, institutions, information, infrastructure, and social capital.

Given the actual and potential adverse effects of climate change it is vital to identify relevant adaptation options including capacity building, policy reform, integration into sectoral policies and project-level activities. A set of locally-driven criteria determined the selection of priority adaptation activities. They include (UNFCCC, 2002): level of adverse effects of climate change; poverty reduction to enhance adaptive capacity; synergy with other multilateral environmental agreements; and cost-effectiveness. The criteria priorities are: loss of life and livelihood; human health; food security and agriculture; water availability, quality and accessibility; essential infrastructure; cultural heritage; biological diversity; land-use management and forestry; other environmental amenities; and coastal zones and associated loss of land.

DEVELOPING A NATIONAL FRAMEWORK FOR CLIMATE CHANGE ACTION STRATEGY FOR TANZANIA

The policy strategy considers national development policies, strategies, and plans are: environment, water, land, forestry, energy, transport, agriculture, livestock, fishery, health, and gender. Tanzania and the rest of East African Community states of Burundi, Rwanda, Uganda, and Kenya have developed national adaptation program of actions, which are in various stages of implementation. The NAPAs identified urgent and priority projects that are needed to enhance adaptation capacities to the adverse impacts of climate change. Kenya, on the other hand, has already prepared a national climate change response strategy which spells out the priority areas for adaptation and mitigation.

Climate change mitigation potential in the region can be achieved particularly through the energy sector by harnessing geothermal power along the East African rift valley, wind energy, hydropower, solar energy and natural gas; waste management like methane recovery, cogeneration by industrial and agricultural sectors. The East African Community treaty (EAC, 1999) calls for co-operation in the management of the environment, disaster preparedness and management, protection and mitigation measures especially for the control of natural and man-made disasters. The objective of the UNFCCC is to stabilize GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure food security and sustainable economic development (UNFCCC, 2005).

The aim of the policy is to coordinate climate change regional strategies, programmers, and actions. The objectives are to: establish a regional framework to guide the harmonization, coordination and implementation of climate change initiatives amongst member states; identify priority adaptation and mitigation action areas and roles of the states and other stakeholders to address climate change in the region; promote public awareness and socio-economic importance of climate change, including vulnerability, impacts, risks, and response measures in the region; promote capacity building efforts through, inter alia education, training, research, technology development and transfer, information and knowledge management; promote climate change research and observations through monitoring, detection, attribution and model prediction to enhance climate change preparedness; support the integration of climate change into regional development processes and planning including disaster risk management and gender equality; and facilitate resource mobilization to implement national and the East African climate change policy strategy and master plan.

There are daunting challenges facing national and regional mitigation actions and strategies. Despite the EAC countries to get finance, technology, and capacity to support mitigation measures in African countries under the KP, the following challenges still exist:

1. Lack of financial resources to implement mitigation actions identified in the NAPAs
2. Weak science and engineering research capacity;
3. Weak policy infrastructure and policy research dissemination initiatives;
4. Appropriate mitigation actions;
5. Inadequate technical capacities to develop climate change mitigation project activities;
6. Bureaucracy and high costs of CDM project development processes;
7. Accessible database for project management, monitoring, and evaluation; and
8. Weak institutional capacities and lack of legal and regulatory frameworks for CDMs.

Likewise, the implementation of the policy mandates the East African Community secretariat and each member state to undertake the following: various implementation instruments should be developed to implement the policy. These include an elaborate climate change strategy and master plan. Member states undertake to develop country specific policies, strategies, plans of action, legislation and establish institutional arrangements for addressing climate change in line with the East African Community policy. The EAC secretariat collaborates with relevant East African Community organs and institutions and state institutions in the execution of regional programmes, projects, and activities. This would be achieved by strengthening and mobilizing of capacities of the relevant institutional facilities to meet the climate challenges. There should be well planned institutional framework to plan, effect, coordinate, monitor, and evaluate policy implementation.

Financial resources to implement the policy are key elements in the implementation of the policy; substantial funds will be required to support mitigation and adaptation initiatives; and sustainable funding to be mobilized from the development partners. Likewise, technology development and transfer are equally critical for the policy implementation. Development and transfer of technology are vital for adaptation and mitigation. The areas of focus in the field of technology include: adaptation and mitigation options; barriers to technology access; research, development; and best environmental technological and best alternative technologies.

The effectiveness of climate policy implemented implementation should lead to the following issues and options: enhance technology development and transfer, including hard technological solutions such as drip irrigation, water harvesting, drought tolerant crop varieties, renewable energy technologies and building technologies; and soft technology such as knowledge, systems, procedures and best practices; address technology transfer barriers, including rules of trade agreements, intellectual property rights (IPRs) and technical trade barriers such as standards, eco-labelling; and enhance and support research and development capacity to development and manufacture cleaner production technologies for climate change mitigation and adaptation. The capacity building for climate change mitigation shall focus on the following policy interventions:

- Research and systematic observations;
- Education, training and public awareness;
- Technology transfer and development;
- Information sharing, communication, and knowledge management;
- Institutional strengthening and development;
- Climate change finance;
- Science and engineering capacity building;
- Climate change negotiations; and
- Partnership building and networking.

CLIMATE CHANGE POLICY AND INNOVATION RESEARCH FOR MITIGATION AND ADAPTATION ACTIONS

A monitoring and evaluation framework is vital for climate policy success in the region. The EAC secretariat develops tools and guidelines for monitoring the implementation of the policy at regional level. These include the climate change responsive monitoring and evaluation mechanisms, the EAC climate change strategy and master plan (EAC, 2012). Likewise, climate in Africa is diverse, and controlled by complex interactions between the oceans, land, and atmosphere at local, regional, and global scales (ICSU, 2008). As a consequence, and considering the fact that livelihoods at all levels – from the individual household to the regional economy – depend heavily on climate, several studies have concluded that Africa is among the most vulnerable continents to the climate changes that threaten even higher temperatures and greater variability in future (ICSU, 2007). The continent's vulnerability is likely to increase in future.

However, the adaptive capacity of local, national and regional institutions in Africa is relatively low, due to weak economic, human, infrastructural, information, governance, corruption, and conflicts that worsen the fragile situation (ICSU, 2007; 2008). n. As a result, Africa is faced with the option of grappling with economic, scientific, engineering, political, and social issues with limited scientific capacity, public awareness, and finance to implement policy infrastructures. Capacity building here means providing frameworks for project identification, formulation, and implementation and making the greatest possible use of existing skills and resources. The six capacity building issues are: building and strengthening human capital; providing research infrastructure, adequate remuneration, and incentives for researchers, so as to retain capacity; communicating more effectively between science and society; and developing the culture of strong links between science and policy; strengthening the links between education and research, and among researchers in different parts of Africa to form critical mass threshold.

Some of the most important bottlenecks faced in capacity building are: lack of an integrated or cross-sectored framework; lack of very high-level political commitment; communication difficulties among the agencies, institutions, government departments, NGOs, and communities involved in the capacity-building activity; data gaps and weaknesses; securing cross-border and inter-regional cooperation; bureaucratic systems and difficulties in identifying training opportunities; lack of awareness; public awareness-raising activities in civil society; capacity-building should be integrated into the overall public-sector reform; specific capacity-building projects are more successful when they establish policy links to other ministries such as agriculture, water, energy, and finance; capacity building involves institutional and human resource development, institutional capacity building should involve decision- makers at top level; donors and host countries should adopt a long- term approach to capacity building and this requires financial sustainability; national capacity building activities and demand-driven, and ensure needed support for lasting outcomes .

In addition, some of the critical issues are: lack of funding, new technologies, and spare parts and know- how needed for equipment maintenance; the loss of trained staff who take up more attractive offers outside the public sector results in a brain drain, and compromises future capacity development; lack of functional institutional, policy, and legal frameworks to build capacity; lack of political stability or the existence of security problems; recruiting talent into science is a concern; widening gap between advancing scientific knowledge, technology, and society's ability to capture and use them; knowledge gaps will require putting in place strategies for science and technology development that are linked to effective policies; and disconnects between research and policy.

Furthermore, capacity building faces key challenges in the sub-region. Knowledge, technology, and capacity gaps with a few exceptions, countries in sub-Saharan Africa lack the capacity to conduct research on natural and human-induced hazards and disasters, or to apply the knowledge and deploy technologies to mitigate disasters (ICSU, 2007). Research is needed on how to communicate warnings of impending disasters effectively, and how to disseminate knowledge to help communities to improve their resilience. The values, needs, and interests of different groups and stakeholders should be taken into account. Rural communities have developed specific coping strategies. Vulnerability and resilience of technological systems all countries, including those in sub-Saharan Africa, depend on their power transmission and information technology infrastructure, and the level of dependence is likely to increase as African countries seek to bridge the 'digital divide'. More natural hazards such as floods, earthquakes, and atmospheric weather conditions may affect the technological systems and cause widespread chaotic situations and economic loss.

It is also known that for effective transfer of information to policy and decision-makers, there is a need to establish dialogue among scientists, policy- and decision-makers. As environmental degradation is not only a technical (scientific) problem, any discussion of environmental degradation should involve policy- and decision-makers. At first, research is needed on how to translate research results into policies that minimize the human and economic cost of hazards, for example, in land use planning and environmental issues. There is more urgent need to transmit scientific knowledge on hazards to support early warning and preparedness. The challenge is how to provide relevant education at different levels (communities, schools, tertiary institutions) to facilitate mitigation of hazards. A balanced gender consideration and gender equity perspective are needed in disaster risk management policies, plans, and decision-making processes, including those related to risk assessment, education, and training.

It is imperative that climate change science, engineering, and public awareness-raising communication campaigns should be directed, as far as possible, at the stakeholders at all levels, and use all infrastructures to ensure understanding of early warnings of forthcoming hazards and disasters. It is vital to introduce key research findings into school and tertiary curricula by developing teaching aids, for example, DVDs, CDs, and posters. On-line computer-aided interactive learning modules should be developed, for example, case histories with real data and tutorial exercises (an on-line module is being developed by universities in Mauritius, Malta, and the South Pacific dealing with vulnerability of islands to natural disasters). The African Virtual University in Nairobi (Kenya) developed teaching materials. Similarly, the University of South Africa (a distance learning institution) offers a module in disaster management. The University of Botswana has considered a framework on 'virtual centres' that are used to coordinate and link climate research scientists working on environmental hazards and disasters with other multiple climate stakeholders.

It is highly recommended that mass communication theories like diffusion of innovations theory are required in climate change policy innovation dissemination. The focus of diffusion of innovations theory is creating awareness through information dissemination among the target audiences (Rogers, 1962). Diffusion model identifies the problem as lack of information whose goal (outcome) is behaviour change. The solution to lack of climate change information is information the transfer to spur the required knowledge, attitude and practice. The different types of interventions include: social marketing, entertainment, advocacy, social networking, and education. The diffusion of innovations theory studies how, why, and at what rate new ideas spread through cultures (Rogers, 1995). The relevance of innovation diffusion theory is to explain the importance of information dissemination as a precondition for awareness, attitudinal, and behaviour change for adoption and mitigation of, climate change technology and research innovations (Okaka, 2010). At every level of society that is, from ordinary citizens and farmers, to the media, civil society organizations and local and national governments on the need for reliable information on climate change is very high as less is known about how to communicate climate change (Panos, 2012).

Public awareness of climate must be raised about the carbon trading that delivers incomes to individuals, families, and companies. Knowledge sharing of the costs and benefits of carbon trading is an essential step to accessing the financial advantages that carbon trading brings (Panos, 2012). As a result, there is a need for the policy information gaps to be plugged and dissemination of information to be refined for climate change policy to have impact in Africa (Okaka, 2011). Most of the severe problems of the increasing vulnerabilities to the impacts of climate change among the indigenous communities in Uganda have come about because there are still information gaps regarding the functions, values and importance of the wise use of natural and environmental resources by communities, institutions, and industries. The governments, researchers and research institutions, research networks, civil society organization, communities, and external development partners in the East African Community are aware of this fact. It is imperative for the Africa to develop an effective regional climate change adaptation policy advocacy campaigns on the hazards of climate change disasters. Africa must achieve sustainable development goals led by ICT innovations, collaborative research, global cooperation, and gender equality (UN FCCC, 2002).

Again, in the republic of Tanzania, NAPA projects considered the country's climate change related vulnerabilities in all sectors which are important to the economy (GoT, 2012). After identification of vulnerabilities in each sector, key adaptation options and strategies that would best address those vulnerabilities were developed. The consultations were undertaken at national, regional as well as district levels. Using a list of agreed criteria that best suits Tanzanian conditions and local environment, 14 priority project activities were identified. The following activities were ranked in order of their perceived importance in fighting poverty:

- Water efficiency in crop irrigation to boost production and conserve water areas;
- Alternative farming systems and water harvesting;
- Develop alternative water storage programs and technology for communities;
- Community based catchments conservation and management programmes;
- Invest in renewable sources such as wind, solar, biomass, hydro, biodiesel;
- Promotion of use of cogeneration in the industry sector for lost hydro potential;
- Afforestation programs in degraded lands using adaptive and fast growing trees;
- Develop community forest fire prevention plans and programmes;
- Establish community awareness campaigns for preventive health hazards;

- Develop sustainable tourism, wildlife outreaches, and rural communities wildlife resources; water harvesting and recycling;
- Construct infrastructures like: sea walls, sand beaches, beach management system; and
- Establish good land tenure system and facilitate sustainable human settlements.

The studies of communication strategies for energy policy leaders found high demand for radio, TV, libraries, radio, books, reports, NGOs, newspapers, magazines, professional journals, internet, colleagues, telephones, and report reading on climate change and global warming (Okaka, 2010).

CONCLUSION

There are disastrous social, economic, political, and environmental consequences due to climate change in Africa. It would suffice to develop a sustainable framework for mitigating climate change effects in the context of public communication. Climate change poses a significant threat to lives and livelihoods in Africa. Government policies, low-carbon technologies and financial support from international donors will all play a role in East African Community's responses to climate change. But central to the fight against climate change is effective communication in public engagement.

The strategic priorities outlined in the new national climate change policy guidelines and policy principles in the first East African climate change policy are intended among others, to:

- Mainstream and coordinate response to climate change; communicate effectively and promote participatory approaches;
- Promote community-based approaches to adaptation;
- Devote adequate attention to capacity development and institutional set-ups;
- Devote adequate attention to technology needs, development, and transfer;
- Identify, develop, and positively influence financing mechanisms;
- Provide a credible delivery structure for climate information communication services;
- Address cross-cutting issues in community outreaches and communication ethics;
- Deploy ICTs in all climate change policy and communication activities; and
- Gender mainstream for applied gender equality and equity in decision making.

Furthermore, at all levels of society, right from ordinary citizens and farmers, to the media, civil society organizations and local and national governments, the need for accurate and reliable information about climate change is very high. Public awareness must be raised about the emerging carbon trading sector. There gains in carbon trading for incomes to citizens and in curbing GHG emissions risks. On its part, the African Development Bank (AfDB) has fashioned its corporate functions to enhance the role of effective communication strategy for climate change policy for sustainable development in Africa. The bank's mandate on climate change mitigations, adaptation, and financing policy is pivotal to its mandated core business. ADB has adopted a holistic result-oriented action plan because climate seriously threatens poverty reduction policies for achievement of the MDGs in Africa. Climate change has exacted a deathblow on agriculture, food and water security, human and animal health, biodiversity, land and environmental degradation in Africa.

REFERENCES

East African community secretariat (EAC). (1999). The Treaty for the Establishment of the East African Community, Arusha, Tanzania. East African Governments. Arusha, Tanzania.

Eyotaru Olive. (2013). East African integration hindered by information gaps – minister, Daily Monitor newspaper, page 1, Tuesday, July 23, 2013, Nation Group: Kampala.

Government of Uganda (GoU). (2010).Climate change policy draft 2012. Ministry of Water and Environment: Kampala, Uganda.

Government of Tanzania (GoT). (2006, 2012).Tanzania NAPA guiding principles. Government of the Republic of Tanzania. Dar-es-Salaam. Tanzania.

Government of Rwanda and UNDP (GoR / UNDP). (2012).Rwanda and UNDP climate change project. Government of the Republic of Rwanda and UNDP Rwanda. Kigali, Rwanda.

International council for science regional office for Africa (ICSU-ROA). (2008). Science plan: Global environmental change (including climate change and adaptation) in sub-Saharan Africa. Pretoria, South Africa.

International council for science regional office for Africa (ICSU-ROA). (2007). Science plan: Sustainable energy in sub-Saharan Africa. Pretoria, South Africa.

National environment management agency (NEMA). (2002). Localizing global environmental conventions. A simple guide for Uganda. Government of Uganda. Kampala.

Okaka, Wilson. (2010). Developing regional communications campaigns strategy for environment and natural resources management policy awareness for the East African community. Research journal of environmental and earth sciences 2(2): 106-111, 2010

Okaka, Wilson. (2011). Developing effective climate change policy communication for sustainable development in Africa. Climate change stakeholders' forum. .Available on the following website: www.stakeholderforum.org/…ach/index.php/cif-day2...South Africa.

Panos. (2012).Communicating climate change in Uganda: Challenges and opportunities, Cardiff University in partnership with Panos Eastern Africa: Kampala.

Rogers, E.M. (1962, 1995). Diffusion of innovations. The Free Press, New York.

United Nations FCCC. (2002).Report of the conference of the parties on its seventh session, held at Marrakesh from 29 October to 10 November 2001. Available on the following website: www.eac.int

The Effect of Illegal Mining Activities on Vegetation: A Case Study of Bontefufuo Area in the Amansie West District of Ghana

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ABSTRACT

The destruction of vegetation cover is one of the major factors contributing to climate change. The study investigated the distribution of trees, shrubs and herbs in the mined and unmined communities of Bontefufuo namely: Esaase, Manhyia, Aboabo and Mpatuam. The research was intended to determine the relationship between spatial distribution of vegetation, composition and examine the effects of vegetation loss in the area. A total of forty 40 plots (10 m x 10 m) were studied. In each community, five (5) plots were studied each for mined and unmined areas. The mean numbers of plant population were determined and analyzed using ANOVA. There were significant differences among the tree, shrub and herb populations at $P<0.05$. The number of tree and shrub population was reduced in the mined areas compared to the unmined area. Herbs were predominant in the mined areas and were found to be much higher than in the unmined areas. Photographic images revealed that the activities of illegal small-scale mining have resulted in land degradation through compaction of the topsoil and laterite deposition. Climate change issues still remain a global concern and vegetation cover which plays an imperative role of regulating the carbon dioxide concentration of the atmosphere should be restored.

keywords: unmined area, mined area, herbs, shrubs, trees

INTRODUCTION

Artisanal mining is a significant subsector of the mining industry in Ghana, accounting for about 10% of the annual gold output (Akabzaa, 2001). It involves illegal mining activities and creates challenges for monitoring and regulating small-scale mining activities in the country. A UN study on artisanal activities and poverty reports that there may be 50,000 – 80,000 people engaged in illegal small-scale mining activities in Ghana (Carnegie *et al.,* 2000).

While illegal mining activities have often made headlines for their destruction of the vegetation and the danger they pose to the lives of those engaged in it, very little investigation have been conducted to find out why people engage in it in spite of its dangers. It is clear that these activities thrive among the rural, poor, the unemployed and the communities with no alternative income generating activities. Though illegal, hazardous, and inimical to the country's development, it serves as a source of income and livelihood for these mining communities and their over one million inhabitants. To these rural folks, it is the only way to raise the needed capital to invest in facilities and equipment that make life worth living and to raise enough money to pay monthly bills. Undoubtedly, artisanal mining activity in Ghana has come to stay in view of the numerous economic and social benefits that it has bequeathed on the various communities, and for the fact that unemployment problem is on ascendancy in the country.

Bontefufuo is an area in Amansie West District of Ashanti region which has tropical forest vegetation. The people are mainly cocoa farmers with a few of them being traditional gold miners from colonial time.In spite of the economic gains accrue from their farming activities on the land, considerable areas of land and vegetation have been cleared to accommodate surface mining activities. The forests are the greatest victims of these activities, which can be gauged from the depletion of the forest in the entire mine belt. Extensive mining activities have rendered large areas of the communities turned into degraded land, creating unfavorable habitat condition for plant growth. The numbers of tree and shrub species have reduced considerably due to mining activities. Recent news items in a section of the Ghanaian media reported that “there has been incessant and blatant depletion of more than 80% of forest reserves in these mining communities, and the heavy pollution of these rivers: Birim, Ankobra, and Pra all in Ghana (Ghana Business News (GBN), 2010). Mining activity is one of the contributing factors to environmental degradation. It creates large chunk of debris on the land, open pits and destruction of land for farming and settlement. This has momentous adverse impact on the land and vegetation (Heath *et al*., 1993).

METHODOLOGY

Location and size

Bontefufuo is located in the Amansie West District of Ashanti region of Ghana. It shares boundaries with the Amansie East District in the west, Atwima Mponua District in the east, Atwima Nwabiagya District in the north and Amansie central in the south. The Amansie west District falls within latitudes 6.05° West and 6.35° North and longitude 1.40° South and 2.05° West. The District covers an area of about 1,364 sq. Km and forms about 5.4% of the total land area of the Ashanti Region The district has twelve (12) area councils, fifty three (53) unit committees with 53 electoral areas, one constituency and one traditional council. Manso Nkwanta is the District capital and it is about 65 km from Kumasi (AWDA, 2004).

Demographic Characteristics

According to 2010 national population census and group’s projections, the District population was estimated at 144,104 and the density estimated at 105 persons per sq.km at a growth rate of 2.9% between 1984 and 2010. Though the population density is comparatively lower than that of the region and national estimate of 127 and 212 persons per sq. Km. respectively, the dispersed nature of settlement with low population density makes access to basic services difficult and expensive. About 80% of the population are Christians. The 0-14 age cohorts constitute 41.9% of the total population whereas the aged group 65 and above make up only 5.3%. Thus the dependent population consisting of the total of the two age cohorts constitutes about 47.2% of the total population in the District (AWDA, 2010).

Natural Vegetation

The District lies entirely in the rain forest belt and exhibits moist semi-deciduous characteristics. It is much resourced with timber, herbs of medicinal value and fuel wood. However, the virgin forest cover has been degraded in several areas. Factors such as increased population, excessive and reckless logging for export and galamsey activities are responsible for the alarming rate of deforestation in the district. As a result, the typical forest cover of the district has been destroyed and replaced by a mosaic of secondary forest, shrub covered land and agricultural holdings. It is only in areas, particularly those immediately outside the forest reserves in the District that traces of virgin forest are found. Four main forest reserves are in the district; the Apamprama forest reserve, Gyeni river forest reserves, Oda river forest reserve and Jimira forest reserves (AWDA, 2004).

Mineral Deposits in the District

Among the resources identified in the district are potentially rich mineral (gold) deposits. Areas with such deposit include Esaase, Tetrem, Essuowin, Mpatuam, Tontokrom etc. Quite a large area of the district has been acquired as concessions by some companies who have been licensed for prospecting work. It is estimated that there are about 21,361,400 cubic meters of soil containing 5,209,866 grams of gold in the Jeni and Bonte rivers. Apart from the companies with large concessions in the district, there are many other interested parties in the mining industry. There are many pockets of small illegal mining groups in the district who employ very crude methods to win gold involving a large portion of the youth in their activities. The activities of these various groups are not regulated and not well organized to be seen as part of a total package development efforts in the district (AWDA, 2004).

Data Collection

Vegetation in the mining towns namely Esaase, Manhyia, Aboabo and Mpatuam of Bontefufuo area were studied. A total of forty (40) plots (10 m x 10 m) were studied in order to investigate the distribution of trees, shrubs and herbs. With reference to literature of a Taxonomist (Arbonnier, 2004;Hawthorne and Jongkind, 2006), trees and shrubs were observed. In each community, five (5) plots were studied each for mined and unmined areas. The respective mean numbers of tree, shrub and herb of the unmined areas in all the four communities were determined and compared to mean numbers of plant in the mined areas of the communities.

ANOVA on Microsoft Excel was used to test for significant differences among tree, shrub and herb population. Field observations and photographic images of degraded areas as a result of mining were captured for the study.

The different vegetation characteristics, distribution pattern, land uses related to forest and mining were analysed.

RESULTS AND DISCUSSION

Floristic Composition of Mined and Unmined Areas

The average number of trees and shrubs in the mined area reduced when compared to the unmined (control) area while the average number of herbs increased in the mined areas compared to the unmined area (Figure 3.1).

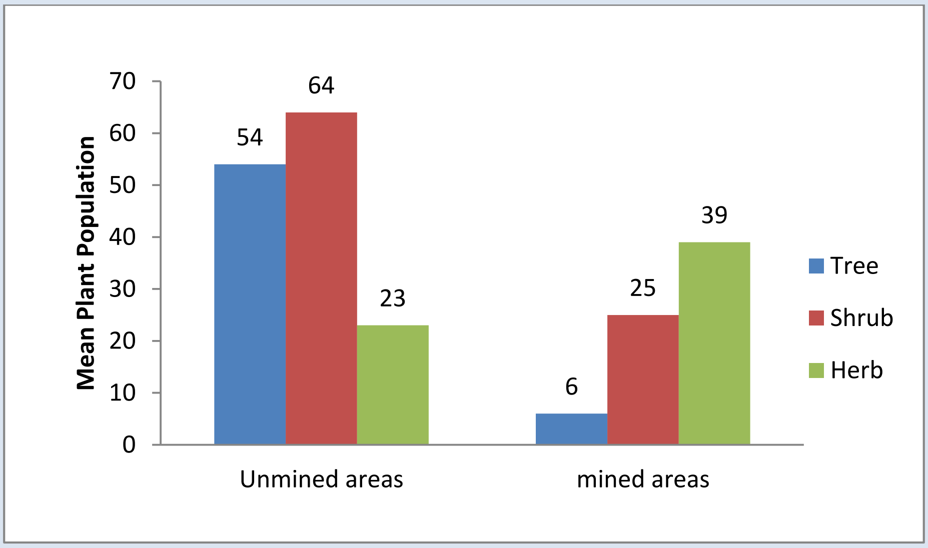

Figure 1: Mean Distribution of Plants in Unmined and Mined Areas

The average number of trees per 100 m^2 in the unmined areas was 54 while the mined areas in the towns recorded 4, 7, 3, and 11per m^2 for Esaase, Manhyia, Aboabo and Mpatuam respectively which were far lesser than the unmined area (Table 3.1). The shrub population recorded 64 per 100 m^2 in the unmined area while the mined areas recorded 19, 25, 22, and 35 per m^2 in Esaase, Manhyia, Aboabo and Mpatuam communities respectively (Table 3.1) which were comparatively lesser than the unmined area. The average number of herbs was 23 per m^2 in the unmined area while the unmined area recorded 39, 41, 40 and 34 per m^2 for Esaase, Manhyia, Aboabo and Mpatuam respectively which were rather higher than the unmined area (Table 3.1).

Table 3.1: Mean Distribution of plants composition in the four different mining towns.

Plant distribution	Unmined Area	Esaase	Manhyia	Aboabo	Mpatuam
Number of trees	54	4	7	3	11
Number of shrubs	64	19	25	22	35
Number of herbs	23	39	41	40	34

Species Composition of Mined and Unmined Areas

Trees and shrubs

The unmined area had greater plant density compared to the mined area. The number of young and middle- sized trees were higher than the older trees since the area they usually mine, show characteristics of secondary forest. The number of trees in the mined area was extremely low as compared to the unmined area. The tree density of 54 per 100 m^2 in the unmined area compared to 6 per 100 m^2 in the mined area is an indication of the level of destruction caused. The rate of degradation was far higher, compared with what was observed in the Talensi-Nabdam district in the north by Tom-Derry et. al, (2012) which was 2.4 per 100 m^2 and 5.6 per 100 m^2 for mined and unmined areas respectively. Small-scale gold mining uncovers the desired minerals by removing the underlying vegetative cover
(Greenwood and Edwards, 1979).

The number of shrubs was also higher in the unmined area than the mined area. The average number of shrubs per 100 m^2 in the unmined and the mined area was 64 and 25 respectively. This shows higher shrub density as compared to 1.6 per 100 m^2 and 2.6 per 100 m^2 for the mined and unmined areas identified in the Talensi Nabdam district in the north. Vegetation density is higher in the southern Ghana than in the north.

Generally, the number of tree species in the mined areas of the four study towns was significantly less as compared to the number of tree species in the unmined area. Again, the number of shrub species recorded in the mined areas was significantly lesser than those recorded in the unmined area. The unmined area had greater plant density compared to the mined areas. Since the mined and the unmined areas had similar climatic features, it was assumed that the density of the plants in the mined areas just before they were cleared for mining activity and that of the unmined area were equal and that the differences in species numbers could be attributed to the mining activities.

The number of herbs was rather higher in the mined area than the unmined area. The average density was 23 per 100 m^2 in the unmined area while the mined area was 39 per 100 m^2. This shows an increase in number even at the mined area. This could be due to the fact that the mining activities had destroyed the tree and shrub species which usually overshadow the herbs and their seeds preventing them from the reach of sunlight. Therefore in their absence, there was maximum exposure to sunlight, allowing more of the herbs to start growing. However, the herbs observed at the mined areas were mostly young and small ones which had comparatively negligible vegetative cover.

It can therefore be said that after clearing the land for mining activities, the land cover was dominated by fresh herbs with a few shrubs and trees remaining. In all the four study towns, the entire mining sites were observed to have more fresh herbs than the unmined sites (Tables 1, 2, 3 and 4).

Table 1: Percentages of Species population at Esaase mining site.

Type of Species	Esaase site		Percentage of mine area (%)	Variation (Increase/Decrease)	Percentage Variation (Increase/Decrease)
	Unmined area	Mined area			
Trees	54	4	7.4	50 (decrease)	92.6 (decrease)
Shrubs	64	19	29.7	45 (decrease)	70.3 (decrease)
Herbs	23	39	169.5	16 (increase)	69.5 (increase)

Table 2: Percentages of Species population at Manhyia mining site.

Type of Species	Manhyia site		Percentage of mine area (%)	Variation (Increase/Decrease)	Percentage variation (increase/ Decrease)
	Unmined area	Mined area			
Tree	54	7	12.95	47 (decrease)	87.05 (decrease)
Shrub	64	25	39.07	39(decrease)	60.93 (decrease)
Herb	23	41	178.2	18 (increase)	78.2 (increase)

Table 3: Percentages of Species population at Aboabo mining site.

Type of Species	Aboabo site		Percentage of mine area (%)	Variation (Increase/Decrease)	Percentage variation (increase/ Decrease)
	Unmined area	Mined area			
Tree	54	3	5.55	51 (decrease)	94.45 (decrease)
Shrub	64	22	34.38	42(decrease)	65.62 (decrease)
Herb	23	40	173.9	17 (increase)	73.9 (increase)

Table 4: Percentages of Species population at the Mpatuam mining site.

Type of Species	Mpatuam site		Percentage of mine area (%)	Variation (Increased/ Decrease)	Percentage variation (increase/ Decrease)
	Unmined area	Mined area			
Tree	54	11	20.37	43 (decrease)	79.63 (decrease)
Shrub	64	35	54.69	29(decrease)	45.31 (decrease)
Herb	23	34	147.8	11 (increase)	47.8 (increase)

Table 5: Average Plant Species Degradation

	Tree (%)	Shrub (%)	Herb (%)
Esaase	92.6	70.3	69.5
Manhyia	87.05	60.93	78.2
Aboabo	94.45	65.62	73.9
Mpatuam	79.63	45.31	47.8
Average	88.42	60.54	67.35

Using ANOVA at significant level of 0.05, there were significant differences among trees, shrubs and herbs found between the mined and unmined areas. P- value of 0.0029 was recorded among trees found between mined and unmined areas while P-values of 0.0096 and 0.0058 were recorded for shrubs and herbs between mined and unmined areas respectively.

Species Diversity

The diversity of species showed that trees and shrub were less in the mined areas as compared to that of the unmined area. Number of trees was drastically reduced in the mined areas. Since the mined and unmined areas have similar climatic and edaphic features, the differences in species composition could be attributed to the mining activities. Sarma (2002), while studying the impact of mining on vegetation characteristics outlined that vegetation reduces in mined areas compared with that of the adjacent unmined areas.

An overview of illegal mining sites in some of the communities showing Species diversity can be seen in Plates 1 and 2.

Plate 1: A mining site at Manhyia

Plate 2: A mining site at Mpatuam

Impact of mining activities on species distribution pattern

Plant population exhibit three pattern of spatial distribution that is clustered, random and regular. The degree to which individuals are aggregated or dispersed is crucial to the understanding of how species should be used as a resource. Ashton (1972) indicated that in the absence of major disturbance, soil and water condition play major roles in controlling species distribution pattern. In the unmined area, most of the tree and shrub species showed clustered distribution pattern. However, in the mined areas the distribution showed dispersed or scattered pattern. Numerous pits dug to win gold from the ore removed numerous plants at the gold rich deposit areas. The dug laterite and washed gravel were also accumulated at the site contributing to the destruction of the plants.

The Effect of Artisanal Mining Activities on Wildlife

Wildlife species in communities depend on each other. Their survival depend on soil condition, local climate, altitude and vegetation. At the mining sites of the four communities, it was observed that the activities caused great destruction and displacement of the wildlife species. Their habitats were destroyed exposing them to unfavourable environmental conditions which impeded their growth and development. Information from the commuters indicated that wildlife species such as deer, antelope, monkeys, grasscutters, rats and tortoise were killed for food or destroyed by the miners while others migrated from the site. Most of these animals have migrated to different communities where there were enough vegetation to support their growth and development. Animals which were found at the mining sites were egrets, pie crow, lizards, owls, bats and some insects. Streams that provided habitat for the aquatic lives have been polluted with mud accumulation.

Degradation of land

Research by (Barry, 1996; United Nations, 1996; Heemskerk, 2002) described small-scale gold mining as gaining global importance both as a source of livelihood for the poor and as a cause of environmental degradation. Mining activities also cause frequent destruction of farm lands without adequate compensation being paid to the affected farmers (Akabza *et al.*, 2005).

One of the major effects of surface mining, according personal observation made at the four communities, is land degradation. Heavy machines were used for the removal of the vegetation, top soils, and subsoil. Anane (2003) alluded to the fact that surface mining in particular involves the clearing of large tracts of forest and agricultural land, resulting in serious land and forest degradation. Changes in the nature of vegetation cover, particularly from forest to non-forest can significantly alter the surface moisture budget and exert further effect on the surface energy budget (Betts et al., 2008). In some areas, land had been covered by rocks, laterites and other debris from mining activities. These have not only impeded plant growth on the land but have also covered the top soil, making it impossible for plant growth and development.

In addition, it was observed that pits and trenches were created and such areas eventually become inaccessible to the people and dangerous to wildlife. Depths of some pits observed ranged from about 10m-20m deep. Even where such pits were backfilled, they were either covered with rocks or gravels. This renders the land infertile and unsafe for agricultural purposes.

Plates 3,4,5, and 6 show the degradation of land caused by the activities Illegal mining.

Plate 3: Heaped Laterites at Aboabo

Plate 4: Open-pit created at Esaase

Plate 5: Heaped Laterites at Mpatuam

Plate 6: Land Degraded at Manhyia

Deforestation and Climate Change

Deforestation is an important factor in global climate change. It is estimated that more than 1.5 billion tons of carbon dioxide are released to the atmosphere due to deforestation, mainly the cutting and burning of forests, every year. However, the impact of activities like artisanal mining that seriously contribute to vegetative cover destruction cannot be overemphasized. Large scale changes in vegetation cover for example reduction in the forest cover would be expected to modify local climate. Reduction in forest cover would contribute to climate change through the release of stored carbon contributing to the rise in atmospheric carbon dioxide (Betts et al., 2008).Therefore the illegal mining in the Bontefufuo that has destroyed large amount of vegetative cover is a contributor to climate change due to buildup of carbon dioxide in the atmosphere. The continuous destruction of the vegetation would reduce the potential of plants to use the excess carbon dioxide while the exposed soil would also increase the release of carbon dioxide into the atmosphere.

Over 30 million acres of forests and woodlands are lost every year due to deforestation; causing a massive loss of income to poor people living in remote areas who depend on the forest to survive (http://www.climateandweather.net). Severe flooding is a result of deforestation due to removal of the forest leaves little vegetative cover to hold heavy rains.

The excess water from land cleared of forest becomes runoff water and enters the ocean instead of seeping downward into the soil to recharge aquifers. Aquifer depletion is already becoming a serious problem in certain areas of the planet and as the human population continues to grow so will the demand for fresh water (Mother Earth News, 2010).

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study showed that mining activities have resulted in the reduction of vegetation cover in Bontefufuo area. Generally, in all the four mining towns, the number of trees and shrubs were reduced compared to those in the unmined area.

The average tree cover in the mined areas of Bontefufuo was reduced by 88.42% in the illegally mined areas.

The average shrub cover in the mined areas of Bontefufuo was reduced by 60.54% in the illegally mined areas.

Though the herb population increased in the mined area, their cover was almost negligible since their sizes were so small to make any impact in terms of vegetation cover.

The accumulated gravels and laterites spread on the soil coupled with compaction of the soil through human movements prevented growth of vegetation.

The forest remove carbon dioxide from the atmosphere through photosynthesis, therefore vegetation degradation through illegal mining in the Bontefufuo would contribute to decline in photosynthetic activity resulting in higher levels of carbon dioxide in the atmosphere.

Recommendations

In order to curb the issue of vegetation degradation through illegal mining, the following recommendations were made:

- The Environmental Protection Agency should institute measures to regulate the activities of illegal mining to avoid further damage to the vegetation as well as the environment.
- The forestry department of Amansie West District should embark on education to sensitize the rural folks about the effects of mining activities to their health and the environment.
- Stringent and rigorous efforts at re-afforestation of affected communities and other measures aimed at restoring degraded lands to their original state after mining activities should be intensified by the Forestry Department in the District. These will make land available particularly to farmers for agricultural purposes.
- Further studies needed to be conducted to estimate volume of vegetation lost per unit area and carbon dioxide released as a result of the loss.

REFERENCES

Akabzaa, T. and Darimani, A. (2001): *Impact of Mining Sector Investment in Ghana: A case study of the Tarkwa Mining Region,* A Draft Report.

Akabzaa, T.M., B.K. Banoeng-Yakubo and J.S. Seyire, 2005. Impact of Mining, Tarkwa, a Mining Community. Bull. Env. Conta. Tox., 79: 377-379.

Anane, M., 2003. Gold Discovered beneath Ghana's Forest Reserve. Environment News Service Article(4/03/2003).

Appiah-Brenyah, F.K. and K. Antwi, (2003). Mining in Ghanaian Forest Reserves.Featured News paper article. Modern Ghana (20/06/2003). In Tom-Dery, D., Dagben Dagben Z.J. and .

Cobbina, S.J. (2012). Effect of Illegal Small-Scale Mining Operations on Vegetation Cover of Arid Northern Ghana. Research Journal of Environmental and Earth Sciences 4(6): 674-679

Arbonnier, M., 2004. Trees, shrubs and lianas of West African dry zones. CIRAD, Margraf Publishers.

Ashton, P.S. (1972): *The quaternary geomorphological history of western Malaysia and lowland forest phytogeography*. Trans. Second Aberdeen Hull Symp. Malaysian Ecology. Pp 35-42.

AWDA (2004): *Demographic characteristic and infrastructure distribution* (Ghana: Amansie West District Profile, 2004) pp 12-26.

AWDA (2010): *General background and analysis of current situation*. (Ghana: Amansie West District Profile, 2010) pp. 1-17.

Barry, M., 1996. Regularizing informal mining. A summary of the proceedings of the International Roundtable on Artisanal Mining. Washington, DC: World Bank, Industry and Energy Department.

Betts R., Sanderson M. and Wooward S.(2008). Effect of large scale Amazon forest degradation on climate and air quality through fluxes of carbon dioxide, water and energy.

Camara, V., Filhote, M.I., Lima, M.I, Alheira, F.V., Martins, M.S., Dantas, T.O., Luiz, R.R. (1997). (1997): *Strategies for Preventing Adolescent Mercury Exposure in Brazilian Gold Mining Areas*. Toxicol Ind Health 13(2-3): 285-97.

Carnegie, J. Katsiaouni, O. and Labonne, B. (2000): *Poverty Eradication and Sustainable Livelihoods*: Focusing on Artisanal Mining Communities. Prepared for the United Nations Development Program and the Government of Ghana. United Nations Department of Economic and Social Affairs (UNDESA), New York: June 2000.

Greenwood, J.N. and J.M.B, Edwards, (1979). Human Environments and Natural Systems. 2nd Edn. Duxbury press, California, pp: 153-162,170

Hawthorne, W.D. and Jongkind, C.C.H. (2006). *Woody plants of Western African forests*. Kew Publishing, Royal Botanic Gardens, Kew.

Heath, M.J., Merefield, J. R., Paithankar, A.G. (1993): *Environmental impact of mining in tropical forest*, Mining Environmental Management, 37, 14-16

Heemskerk, M., 2002. Livelihood decision making and environmental degradation: Small-scale gold mining in the Surinam Amazon. Soc. Nat. Res., 15: 327-344.

Ismi, A (2003): *Canadian Mining Companies Destroy Environmental and Community Resources in Ghana*. Cambridge University Press. USA.

Sarma, K (2002): *Coal mining and its impact on environment on Nokrek Biosphere Reserve,Meghalaya*. North-Eastern Hill University, Shillong. India.

Tom-Dery, D., Dagben Dagben Z.J. and . Cobbina, S.J. (2012). *Effect of illegal small-scale mining operations on vegetation cover of Arid Northern Ghana*. Research Journal of Environmental and Earth Sciences 4(6): 674-679.

http://www.climateandweather.net/global_warming/deforestation.htm. Accessed on 15/08/2013, 5:12pm.

http://www.motherearthnews.com/nature-and-environment/the-effect-of-deforestation-on-the-climate-and-environment. 12/27/2010 7:41:56 AM.

Maximizing Wood Residue Utilization and Reducing its Production Rate to Combat Climate Change

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ABSTRACT

Wood is a renewable natural resource which can effectively reduce climate change. Wood processing operations generate enormous amount of wood residues which need to be efficiently managed. A lumber yield of about 28-64% requires maximizing the economic values of wood. The utilization of wood residue which is deemed as a burdensome waste in many timber industries has the potential of lessening the effects of climate change. This has led to the study of issues associated with the generation and management of wood residues. This research was conducted to examine the rate of wood residue production at the various production lines and its utilization in four selected timber industries in the Ashanti and Brong Ahafo regions of Ghana; and their effects on climate change. Four different timber species, *Cylicodiscus gabunensis* (Denya), *Entandrophragma angolense* (Edinam), *Pterygota macrocarpa* (Koto) and *Triplochiton scleroxylon* (Wawa) were studied. The average lumber recovery percentage at the four sawmills was 38.08% with residue forming 61.92% of the total input volume. It was observed that 9.07% of input volume generated sawdust. However about 60% of this sawdust was not utilized but burnt and/or dumped openly, polluting the environment. It is recommended that the sawdust could be used to manufacture biochar for soil amendment to enhance nurseries, plantations and other agricultural interests.

Keywords: Wood residue utilization, lumber recovery, sawdust, climate change

INTRODUCTION

Climate change is the alteration of the world's climate caused by humans through fossil fuel burning, clearing forests and other practices that increase the concentration of Greenhouse gases (GHG) in the atmosphere. Greenhouse gases are the gaseous components of the atmosphere that traps heat in the air. The forest resource serves as medium for reducing greenhouse gas emissions by absorbing carbon dioxide for photosynthesis and storing carbon in its system (FPAC, 2009). One of the factors that contribute to climate change is forest degradation. The forest resources of any country require efficient utilization to ensure its sustainability so as to reduce its effects on climate change (UNISDR, 2008).

The bulk of Ghana's timber is located in the country's high forest zone. However, most of the original forest in this area has been cleared and the remaining closed canopy forest is now to be found in forest reserves and a few patches of unreserved forests (Cargill Technical Services Limited, 1993). An Annual Allowable Cut (AAC) has been set at two million cubic meters (2,000,000m^3) for round logs. However, the demand for wood is so alarming that this AAC is woefully inadequate to meet the nation's demand for wood. The amount of timbers harvested at 2005 was 2,315,000m^3 giving a deficit of over 300,000m^3 (TIDD, 2010), thus posing a threat on the long term sustainability of the timber industry.

Large volumes of the logs that come into most timber industries are not efficiently utilized leading to high rates of residue generated from logging, wood processing and storage processes (Magin, 2001). The production of high volumes of residue brings the natural forest which is the main source of raw material for the wood industry under threat. Using wood carefully with minimum waste is a vital component of sustainable timber use, but this has been less of a focus to date (Magin, 2001). Wood residues like sawdust, trimmings and edgings are typically viewed as a burdensome disposal problem (FAO, 1990), however, the material has a potential to become a usable resource. Ghana is in a position to take up this advantage since the timber industries have average yield of about 28-64% (Gyimah and Adu-Gyamfi, 2009), with majority of the wood resources going to waste.

To take advantage of the market opportunities that exist for wood residues, information is needed on their availability, quantity and production rates, types of wood residues being produced, current markets and current disposal practices (Alderman, 1998). Wood residue could be decomposed in the soil to improve soil structure and fertility for food crops to enhance food security. Thus, there will be no need to clear more hectares of land for same quantity of food, hence forest maintained. Also, plantation crops could be fertilized with biochar which is a carbonaceous material produced by thermal decomposition of wood with limited supply of oxygen and a relatively low temperature ($<700^oC$). Biochar is produced specifically for the application to soil as part of agronomic or environmental management (Lehmann and Joseph, 2009). Biochar is very stable hence the carbon remains sequestered in the soil for a long time and contributes to the mitigation of climate change (Lehmann, 2007a).

The main objective of the study was to assess the efficiency of production, utilization and environmental effects of wood residue. This study dealt with the maximization of wood residue usage to mitigate climate change.

MATERIALS AND METHODS

This study focused only on the wood processing residues from the sawmill. It did not consider forest residues produced in the process of logging or land clearing. Four timber industries were selected from the Ashanti and Brong-Ahafo Regions of Ghana. Four different timber species (140 logs) were used in the research and this was based on the most frequently processed in the study sites (this was retrieved from the export document of the companies). The species were *Cylicodiscus gabunensis* (Denya), *Entandrophragma angolense* (Edinam), *Pterygota macrocarpa* (Koto) and *Triplochiton scleroxylon* (Wawa).

In estimating the volume of sawn logs, two diameters perpendicular to each other, including the shortest diameter were taken from both the butt and the tapper ends, which excluded the bark. Steel tape was used in the measurement of the diameter while the lengths of the logs were taken with a fibre tape. The average diameter (D_{av}) was given by adding the four diameters and dividing by four. This value and the length of the log were used for the calculation of the log volume in metres cube. Volume calculation of each of the logs, before processing was carried out using the Smalian's formula,

$V_1 = 0.7854 D_{av}^2 L$ (m^3)   **Equation 1** (Brack and Wood, 1997)

Where,

V_1 = volume of log (m^3),

D_{av} = Average diameter of the logs (m),

L = Log length (m)

0.7854 = Constant

The volume of products produced along the various machine centres calculated using the following formula:

The formula for the volume of the fixed lumber was given by;

$V_2 = [L \times W \times T]\, n$ **Equation 2**

Where,

V_2 = Volume of sawn lumbers (m^3)

L = Length (m)

W = Width (m)

T = Thickness (m)

n = Total number of lumber pieces obtained.

The random width lumber was tallied. The length, width and thickness, were measured and the volume was given by;

$V_2 = L \times T \times W_t$ **Equation 3**

Where,

V_2 = Volume of sawn lumbers (m^3)

L = Length (m)

W_t = Total Width (m)

T = Thickness (m)

The total recovery was given by the sum of the volume of the trimmed lumber. The percentage yield or percentage recovery was given by the ratio of the volume of the lumber to the volume of the input log in metres cube expressed in percentage as defined by Tsoumis (1991).

The Recovery Rate was calculated using the formula,

$RR = \frac{V_2}{V_1} \times 100$ **Equation 4**

Where,

RR = Recovery Rate (%),

V_2 = Volume of lumbers obtained after conversion (m^3),

V_1 = Volume of round logs before conversion (m^3)

The total volume of wood residue generated from the conversion of logs was given by the difference between the log volume and the total lumber volume and was calculated using:

$V_R = V_1 - V_2$ **Equation 5**

Where,

V_R = Volume of wood residue (m^3)

V_1= Volume of round logs before conversion {bolt} (m^3)

V_2 = Volume of lumber obtained after conversion (m^3).

The percentage residue was therefore calculated using the formula

Percentage of residue = $\frac{V_R}{V_1} \times 100$ **Equation 6**

The various classes of residues were identified through observations along the production lines. The existing uses of the wood residues at the various sawmills were identified through site observations and questionnaires to the production managers and supervisors.

RESULTS AND DISCUSSION

The findings of the study are presented in tables and charts below.

Table 1. Summary Yield results for all species (*Cylicodiscus gabunensis* (Denya), *Entandrophragma angolense* (Edinam), *Triplochiton scleroxylon* (Wawa) and *Pterygota macrocarpa* (Koto))

Machine Type	Input Volume (m^3)	Output Volume (m^3)	Residue Volume (m^3) Coarse	Sawdust	TOTAL	% of Total Residue
Bandmill	249.895 [a]	190.096	42.009	17.790	59.799	23.93
Edger	190.096	122.735	63.193	4.168	67.361	35.43
Trimmer	122.735	95.150 [b]	26.869	0.716	27.585	22.47
TOTAL VOLUME OF RESIDUE (m^3)			132.071	22.674	154.745	

[a] Log input, [b] Lumber (Final output)

Source: Field Survey, 2012

$$\text{Lumber Recovery \%} = \frac{95.150}{249.895} \times 100$$

$$= \mathbf{38.08\%}$$

Wood Residue % = **61.92%**

Table 1 is a summary result for all the species. The total volume residue generated was 154.745m^3. The band mill was made up of 42.009m^3 coarse residue (slabs) and 17.790m^3 sawdust. The edger was made up of 63.193m^3 coarse residue (edgings) and 4.168m^3 sawdust; and the trimmer was made up of 26.869m^3 coarse residues (trimmings) and 0.716m^3 sawdust. The total sawdust of the production process was 22.674m^3. The production process produced four types of residue: slabs constituted 27.15% of residues, edgings constituted 40.84% of residues, trimmings 17.36% of residues and sawdust 14.65% of residues. The total input volume was 249.895m3 with recovery of 38.08% and 61.92% residue. With reference to the input volume, lumber constituted 38.08%, slabs 16.81%, edgings 25.29%, trimmings 10.75% and sawdust 9.07%.

From Table 1, it is observed that the average percentage recovery for the logs processed was 38.08%, which ranged from 33.27% to 44.91%. This is in line with Noack (1995) who reported that lumber recovery ranged from 36% to 57%. Gyimah and Adu-Gyamfi (2009) after a pilot study on sawnwood conversion efficiency in selected sawmills in Ghana indicated that the mean recovery for small to large scale enterprises ranged from 28% to 64%. Lumber recovery in sawmills is also put at 30-45% of the log input (Nketiah *et al.*, 2001). Between 1909 and 1990, Ghana lost 80% of its forest with 65,000 ha vanishing annually and 115,400 hectares between the years 2000 and 2005 all due to excessive logging and low recovery rates (Dogbevi, 2008; Bank of Ghana, 2004). There is the need to reduce the volume of wood harvested by making maximum utilization of the wood. The effects of excessive logging on climate change can be reduced by utilizing the wood residue. About half of the total mass of wood is made up of carbon which still remains even after harvesting and it is only released when burnt or through decomposition. Hence wood residue usage helps to contain carbon in the wooden product instead of releasing it into the atmosphere to cause global warming (FPAC, 2009; Nabuurs *et al.*, 2007).

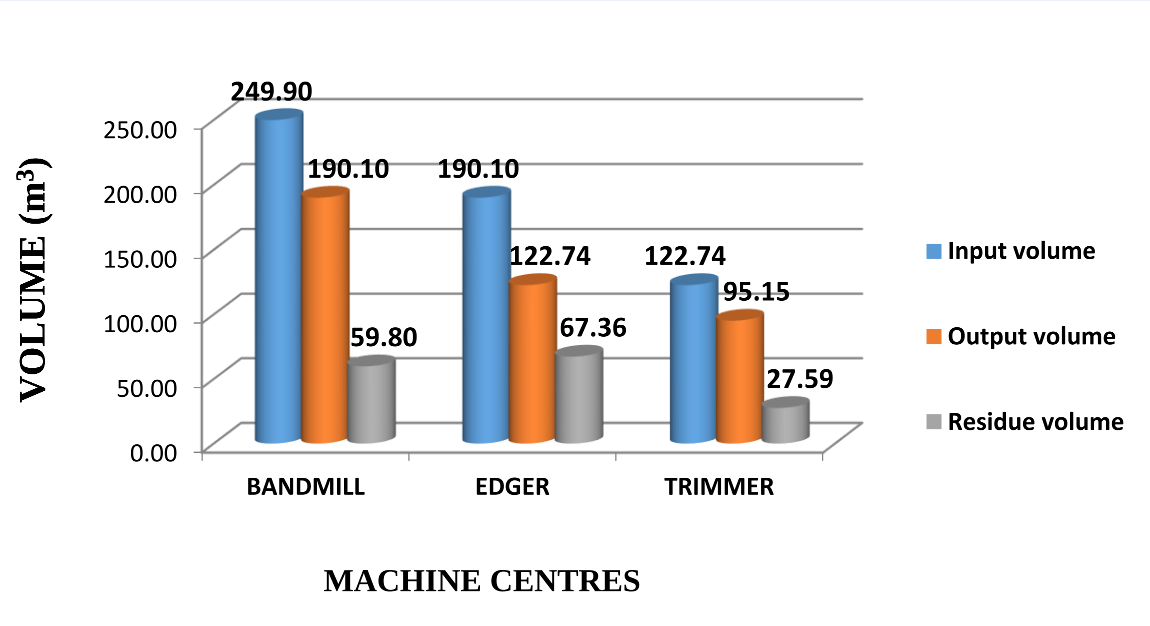

Fig. 1 Summary volume at various centres (*Cylicodiscus gabunensis* (Denya), *Entandrophragma angolense* (Edinam), *Triplochiton scleroxylon* (Wawa) and *Pterygota macrocarpa* (Koto)) for all Companies

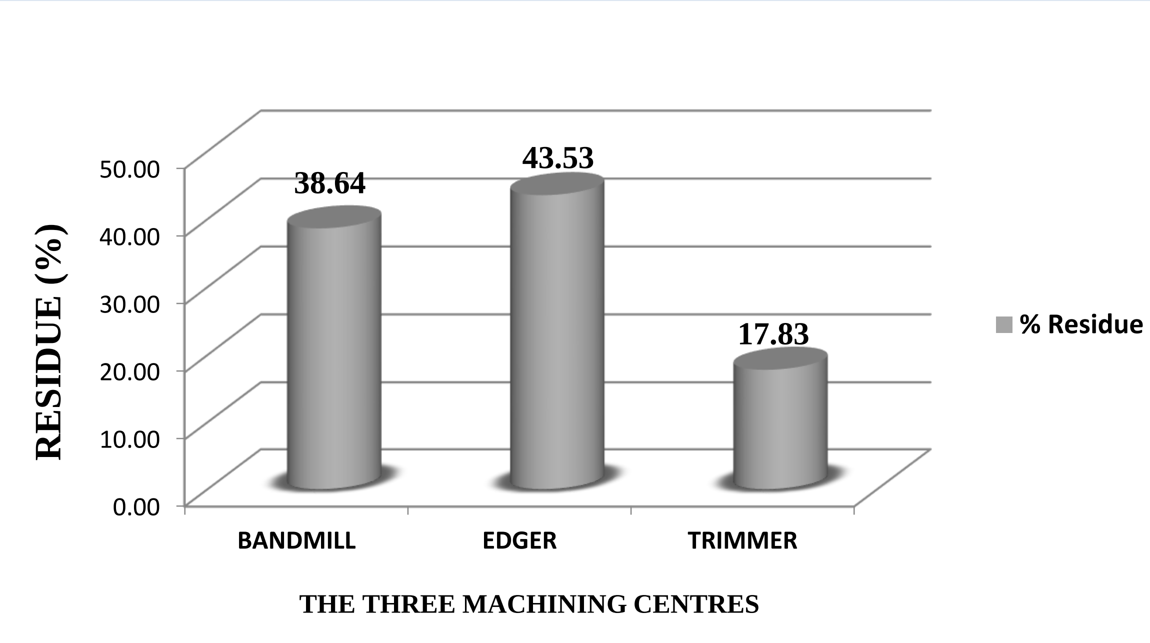

Fig. 2 Bar chart showing residues generated from the machine centres as a percentage of total residue volume for all the companies

Figure 2 which is a summary of the production processes showed that the average percentage residue that was produced as a percentage of total residue volume at the bandmill was 38.64%; that for the edger was 43.53%; and that for the trimmer was 17.83%.

According to Agyeman (1998), a comparison of residues generated as percentage of their total residue volumes indicated that the edger generated the highest percentage residue, followed by the bandmill and then the trimmer. However, in order to offset the effect of the machine centres not fed with the same wood input volume, the percentage input volumes were what was considered for the comparison of the residues generated. This is in line with Figure 2, which shows that the average percentage residue generated as a percentage of total residue volume that was produced at the edger was 43.53%; that for bandmill was 38.64%; and that for the trimmer was 17.83%. In general, the study has revealed that the edger generates the most residues in the sawmilling manufacturing process. It also shows that residues (edgings) generated at the edgers are often more than the slabs (bandmills) which are also more than the trimmings (trimmers) in sawmilling residues (see Fig. 2).

The residues identified in the production process were:

- Sawdust: This is the fine particles of wood that are created when wood is cut with a toothed saw, because the saw creates a path by removing wood. It can range from dust size to clumpy grains. It is a breathing hazard. Sawdust was common along the production lines; the bandmills, edgers and trimmers. Sawdust constituted about 14.65% of the residues generated (Table 1).
- Slabs: Slab is the first and last piece of lumber removed when squaring a log (Martyr, 1972). They are produced at the band mill. Slabs also constituted about 27.15% of the residues generated (Table 1).
- Edgings: These are produced at the edger where lumber is cut to the required width. They formed about 40.84% of the residues generated (Table 1).

- Trimmings: They are the residues produced after lengthwise cutting of the edged boards and they are as thick and wide as the final product. They were produced at the trimmer where length of lumber is cut to contract specifications. They form about 17.36% of the residues generated (Table 1). It should be noted that the defective lumber was added to the trimmings.

Table 2 A summary of residue utilization at the various sawmills

Type of Residue	Volume (m^3)	Recovered (%)	Recovered (m^3)	To Furnace (%)	Sold (%)	Discarded (%)
Slabs	42.009	5.00	2.100	20.00	75.00	0.00
Edgings	63.193	5.00	3.160	90.00	4.00	1.00
Trimmings	26.869	20.00	5.374	75.00	4.00	1.00
Sawdust	22.674	0.00	0.000	40.00	0.00	60.00

Source: Field Survey, 2012

According to Table 2, the Total Volume recovered through further processing was given by the sum recovered from the slabs, edgings and trimmings, given by:

Volume from further Processing = (2.100 + 3.160 +5.374) m^3 =10.634m^3

From Table 1, the volume of the original output was 95.150m^3 and original input was 249.895m^3.

$$\text{Residue recovered \%} = \frac{10.634}{249.895} \times 100$$

$$= \mathbf{4.26\%} \text{ of Input Volume}$$

The New Final recovery is given by:

$$\text{Final Recovery} = \frac{(Original\ Volume\ Output + Volume\ from\ further\ processing)}{Original\ Volume\ Input} \text{ x } 100$$

$$= \frac{95.150 + 10.634}{249.895} \times 100$$

$$= \frac{105.784}{249.895} \times 100$$

$$= \mathbf{42.33\%}$$

New Residue = 100 – 42.33 = **57.67%**

From Table 2 it is deduced that about 27% (35.110m^3) of the coarse residue was sold.

According to Brink (2003), the idea that wood can be recycled or reused and not hauled straight to the landfills, makes sense. This is in line with Table 2, apart from the sawdust which had about 60% being discarded, only about 2% of the coarse residue was discarded. This was confirmed by Bogart (2004) who stated that the least favored option for residue is sending the material to a landfill, however, significant amounts are still landfilled or burned without energy recovery. Dost (1966) defined wood residue as the remnant of the original raw material after the economic value has been removed. This means the 4.26% of Input Volume that was recovered from downstream processing has gained a kind of economic value which will cause the net profit of the sawmill to increase.

Waste prevention and recycling reduces greenhouse gases associated with those activities by reducing methane emission and increasing forest carbon sequestration. The disposal of wood waste produces greenhouse gas emission in a number of ways:

- Anaerobic decomposition of waste produces methane, a greenhouse gas 21 times more potent than carbon dioxide.
- The transportation of waste to disposal sites produces greenhouse gas emissions from the combustion of the fuel used in the equipment.
- The disposal of materials indicate that they are being replaced by new raw materials, hence the depletion of the forest – trees absorb CO_2 from the atmosphere www.epa.gov/climatechange/waste/publications.html

The International Solid Waste Association (ISWA, 2009) has developed a waste hierarchy which is a valuable conceptual and political prioritization tool which can assist in developing waste management strategies aimed at limiting resource consumption and protecting the environment. As a result, priority is given to waste minimization, re-use, recycling, waste-to-energy, and finally landfill.

CONCLUSION

The present study constitutes an attempt to promote the use of abundant but overlooked wood residues in Ghana through providing trustworthy data about the various types, quantities and uses. This huge volume of wood residue (forming 61.92% of the input volume) generated poses environmental and health challenges to the surrounding communities. This might contribute to reduce pressure on the forest by increasing the volume of output (yield) extracted per unit area, making harvesting and processing more financially viable.

RECOMMENDATIONS

- In order to ensure the efficient use of wood residue in Ghana and to protect our forest from deforestation by excessive logging, sawmilling industries would have to educate their staff through research and workshops on recycling a lot more wood residue so as to harvest the forest on a sustainable basis.
- The Government should consider offering investment tax credit, tax deferments or other types of incentives to businesses that are interested in utilizing wood residues in their manufacturing processes.
- Wood residue producers should form partnership which would facilitate the transportation, storage and marketing of wood residues. They could also consider value-added manufacturing processes of solid wood residue such as finger joints, crafts and toys, floorings and garden fencing. Also fines like the sawdust could be used to manufacture bio-char for soil amendment to enhance nurseries, plantations and other agricultural interests.

- There should be laws and regulations governing open burning of sawdust which has a negative effect on climate change.

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REFERENCES

Agyeman, E.K.O. (1998). Economic Assessment of Wood Residue Produced in Sawmilling: A case study. MSc. Thesis, KNUST, Kumasi. Unpublished. Pp113

Alderman, D. R.J. (1998). Assessing the availability of wood residues and residue markets in Virginia. Master of Science thesis. Wood Science and Forest Products. Virginia Polytechnic Institute and State University. 171Pp

Bank of Ghana (2004). Report on the timber industry in Ghana. Research Department. Sector study series.Vol.2 No.1. web: http://www.bog.gov.gh/rpapers/timber-study.pdf. pp1. 01-6-2005.

Bogart, F. D. (2004). Evaluation of Industrial Waste Wood in Tennessee. Tennessee Department of Environment and Construction. Division of community Assistance. Nashville. TN37243-1551. 30pp

Brack, C. L. and Wood, G. B. (1997). Measurement of Logs. Pg1. http://fennerschool-associated.anu.edu.au/mensuration/BrackandWood1998/LOGS.HTM 01-11-12

Brink, R. (2003). Wood Recycling: Can old decks be recycled? TransWorld Skateboarding Business. Pg 1 http://www.robbrink.com/2005/11/11/wood-recycling 03-06-09

Cargill Technical Services Ltd . (1993). Economic Analysis of the potential for enhancing exports of processed products under alternative Government Restrictions on log export,

Dogbevi, K. E. (2008).Ghana's forest reserves under threat. Ghana business news. http://www.ghanabusinessnews.com/2008/12/12/ghana%E2%80%99s-forest-reserves-under-threat/pp 1. 19/04/11.

FAO. (1990). Report: Manual on sawmill operational maintenance. Food and Agriculture Organization, pgs.19, 30.

FPAC (2009). Tackle climate change, use wood (Canadian edition). Forest Products Association of Canada. Web: http://www.naturallywood.com/sites/default/files/Tackle-Climate-Change-Use-Wood.pdf, 19/09/13

Gyimah, R. and Adu-Gyamfi, A. (2009). A pilot study on sawnwood conversion efficiency in selected sawmills in Ghana. A draft report presented at a National workshop in Kumasi, March 2009. 52pp.http://www.epa.gov/climatechange/waste/publication.html 01-09-13

International Solid Waste Association (ISWA) (2009). Waste and Climate Change – ISWA White Paper.

Lehmann, J. (2007a). A handful of carbon. Nature. Vol. 447. Pp 143 – 144.Lehmann, J. and Joseph. S. (Eds.) (2009). Biochar for Environmental Management, science and Technology. Earthscan Publishers. UK and USA. 416Pp.

Magin, G. (2001). An introduction to wood waste in the UK. Fauna and Flora International, Cambridge, UK:40pp

Martyr, N.R. (1973). Introduction to Sawmilling Timber Research and Development Association. Hughen den, Valley High Wycombe, bucks HP14 4 ND. Teaching Aid No.8 pp1-10.

Nabuurs, G.J., O. Masera, K. Andrasko, P. Benitez-Ponce, R. Boer, M. Dutschke, E. Elsiddig, J. Ford-Robertson, P. Frumhoff, T. Karjalainen, O. Krankina, W.A. Kurz, M. Matsumoto, W. Oyhantcabal, N.H. Ravindranath, M.J. Sanz Sanchez and X. Zhang. (2007).

Forestry in Climate Change (2007): Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Nketiah, S. K., Atakora, S. B., and Brew-Hammond, A. (2001). Ghana Sawmill Energy Efficiency Study. Final Report. Intermediate Technology Consultants (ITC) and UK Department for International Development (DFID): xiii.

Noack, D. (1995). Better utilization of tropical timber resources in order to improve sustainability and reduce negative ecological impacts. Volume 1, Part 1. Summary of the project Coordinator's Final Report. ITTO, Japan. pp 50-54.

TIDD. (2010). Annual Report. Timber Industry Development Division. Pg 18.
Tsoumis, G. (1991). Science and Technology of wood; Structure, properties, utilization. Van Nostrand Reinhold, New York, 494pp.
UNISDR (2008). Climate change and disaster risk management, United Nations International Strategy and Disaster Risk management. Briefing Note 1, Geneva.

Impacts of climate change on the coastal environment: A case study of Akwa Ibom State in Niger Delta region, Nigeria

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ABSTRACT
Climate change is globally a menace that has eaten deep into almost all facets of economy and human endeavours and it is considered as a threat to our environments. Akwa Ibom State and Nigeria at large is not left outside this. Akwa Ibom State is a coastal state in the Niger Delta region of Nigeria. There are many coastal rivers and deltas together with its southern part being bounded by the Atlantic Ocean, a region often referred to as the Bight of Benin. The major rivers in the state are lower Cross, Qua Iboe and Imo Rivers. Ikpa and Mbo Rivers are other important rivers in the state because of some important and commercial fish species and the natural resources harvested from them. The impacts of climate change are grievous ranging from coastline destruction to reduction in the aquatic resources themselves. The effects are also felt in both abiotic and biotic environments. There are evidences of global warming and climate change on marine and coastal ecosystems in the state, some of which include increased temperature, coastal erosion, surface water rise (leading to flooding), crop and fish species extinctions, reductions in effort and yield, population density, etc. The livelihoods and the economic well being of the individual fisher and farmer and the fishing and agricultural communities are at stake as floods take over, thus, they are relocating to other places to find alternative employments. It is therefore imperative in Akwa Ibom State, climate change impact on the biota and other natural resources in the coastal aquatic environments be brought to bear as a matter of urgent concern. This review, therefore, aims to present records on the current trends on impact of climate change on the coastal state of Akwa Ibom and to proffer adaptive solutions out of this menace.

Keywords: coastal erosion, temperature rise, low productivity, impact, adaptive, Akwa Ibom State

INTRODUCTION

Global Warming is defined as a natural or human induced increase in the average global temperature of the atmosphere near earth's surface (Botkin *et al*., 1998; Idowu *et al*., 2011) and a change that is permanently changing earth's climate forever (Awosika *et al*., 1992; Intergovernmental Panel on Climate Change (IPCC), 2005). There are several Green House Gases (GHGs) responsible for global warming, and humans (anthropogenic perturbations) emit them in a variety of ways: altering the equilibrium balance between natural GHGs (methane, water vapour, nitrous acid and carbondioxide) and human GHGs (perfluorocarbons – PFCs, hydro-fluorocarbons – HFCs and sulphur hexane floride – SHF_6). The IPCC reported that most of the observed temperature increases since the middle of the 20th century was caused by increasing concentrations of greenhouse gases resulting from human activities such as fossil fuel burning and deforestation (IPCC, 2007) wood burning, wood products and solid wastes, raising of livestock, and the decomposition of organic wastes and fossil fuels in industrial and agricultural activities (Idowu *et al*., 2011). Ekpenyong (2013) revealed that at its current stage of development, Akwa Ibom contributes to global warming more through deforestation than fossil fuel burning.

According to Enete and Ezenwanji (2011) Nigeria is one of the countries expected to be most affected by the impacts of climate change through sea level rise along the 800 km long coastline, intensified desertification, erosion and flooding disasters and general degradation. There is the prediction that Nigeria will lose close to $9 billion as a result of the catastrophe while at least 80% of the inhabitants of Niger Delta will be displaced due to the low level of the oil-rich region (Guardian Newspaper, Monday, September 17th, 2001, p. 80). Gas flaring is one of the major sources of greenhouse gas emission in Nigeria. The cost of climate change in terms of Gross Domestic Production (GDP) is increasingly high. The loss in Nigeria is projected to be between 2 and 11% by 2020 and will rise to 6 and 30% by the year 2050 (Enete and Ezenwanji, 2011; Guardian Newspaper, Monday, 18th July 2011, p. 20). In Nigeria, precipitation extremes such as heavy rain events have become more intense in the past 50 years and are projected to become more frequent and severe (Adefolalu, 2000). Hence, climate change is projected to cause major changes in yearly and seasonal precipitation and water flow, flooding and coastal erosion risks, water quality, and the distribution of species and ecosystems (Adefolalu, 2000; WHO Europe, 2008).

Nigerian coastline has a total shelf area of about 42,000 km^2. Nature has blessed Nigeria with so many great resources; one of such is water and all the natural living resources that are endowed in it. One unavoidable factor that influences these important resources is change. Therefore, changes in the weather and climatic conditions seriously affect water resources. Water resources involve all forms of fresh, brackish and marine waters needed for life's necessities, ranging from domestic needs such as drinking, washing, cooking and cleaning to agricultural needs involving food processing and irrigation,

industrial production, transportation, recreation and the maintenance of natural ecosystems (Ekpo *et al*., 2012 and Enete and Ezenwanji 2011).
The rural poor farmers and fishermen are more likely to suffer more damage from the effect of climate change because they are least endowed with resources to combat the problems, and their economies are based largely on natural resources-dependent sectors that are climate sensitive (Ekpo and Nzegblue, 2012). Climate-related hazards make biogeophysical resources in Itu highly susceptible to climate-related extreme events such as floods, salinity intrusion from Atlantic Ocean, severe wind storm, river bank erosion and excessive rise in temperature.

This paper focuses on climate change in the coastal environment of Akwa Ibom State: its adverse impacts on fisheries, crop production, socio-economic status of the people, and coastline. It also puts in place the different mitigation and adaptive strategies employed in the state. Eka and Udotong (2003) also examined the effect of the 1998 Mobil 40,000 barrels of spill into Akwa Ibom coastal waters and confirmed biodiversity reduction, occurrence of unidentifiable infections, known respiratory diseases and social disharmony in affected coastal communities. Udom (2008) reporting an independent record of Shell oil spills from 1982 – 1992, stated that about 1,626,000 gallons were spilled in 27 separate incidents.

This review adopted descriptive research design where facts concerning the nature and status of a situation, as it exists at the time of the study are presented and conditions, events or systems based on impressions or reactions of the respondents of the research are described (Osuala, 2001 and Enete and Ezenwanji, 2011). Descriptive research design is also concerned with relationships and practices that exist, beliefs and processes that are on-going, effects that are being felt or trends that are developing (Ogbu and Enete, 2006).

Area under consideration
Akwa Ibom State (Fig. 1) is situated in South Eastern Nigeria. Akwa Ibom is a state in Nigeria named after the Qua Iboe River. It is located in the coastal South-Southern part of the country, lying between latitudes 4°321 and 5°331 North, and longitudes 7°251 and 8°251 East. The State is bordered on the east by Cross River State, on the west by Rivers State and Abia State, and on the South by the Atlantic Ocean and the southernmost tip of Cross River State (Wikipedia, the free Encyclopedia). This is the limit of existing cloud free landsat TM imagery for 1986 when the area was not constituted into a state/administrative area. This location is within the tropical rainforest belt where deforestation destroys globally important carbon sinks that currently sequester carbon dioxide [CO2] from the atmosphere and are critical to future climate stabilization (Stephens *et al*., 2007 and Ayoade, 2003). Mean annual rainfall over the area decreases gradually from about 4050mm near the coastal area (the southern part) to about 2100mm in the north. Temperatures are uniformly high throughout the year. The mean annual temperature is 26.9°C. Relative humidity remains at an average of 70 to 80%

throughout the year except for the short period of dry season. Ekpo and Nzegblue (2012) identified communities around Itu bridge-head in Itu Local Government Area (LGA), Akwa Ibom State is within the Niger Delta region of Nigeria. The area is living in a low lying coastal region that is vulnerable to climate change impact.

Aquatic ecosystems

According to Idowu *et al.,* (2011) ocean surges occur as a result of periodic spilling and plunging sea waves extremes that rapidly inundates the seashores. They cause erosion of farmlands, landslides, sand deposition, mud-accumulation, salination of irrigated farmlands and damage generally to soil fertility. High rainfall results in storm water discharges from sewer and surface water overflows, fluvial erosion leading to mobilization of stored chemicals, and run-off of agricultural fertilizers and pesticides, animal wastes and manure (Enete and Ezenwanji, 2011). These impacts will increase due to increased frequency and intensity of storms. Some aquatic organisms may alter their spatial distribution, moving to find the most suitable water quality and temperature, while other species may become extinct. Changing temperature may also cause many plants and animals to migrate pole wards, and species which cannot move easily may be lost.

Fig 1: Map of Akwa Ibom State showing the local Government Areas (Adapted from Wikipedia, free Encyclopedia)

Habitat loss

Each species evolves to thrive in its own particular ecological niche i.e. to live in a particular home with specific living conditions (including temperatures ranges and other plant and animal species). Some species are more adaptable, or opportunistic, than others. Human caused climate change will alter temperatures, precipitation and sea level - wiping out some habitats and shifting others faster than many species can migrate. Unless we drastically reduce our greenhouse gas emissions, we can expect several factors to combine that will make the coming die out astonishingly severe. The climate is changing faster than at almost any time in our planet's history. Many ecosystems are already stressed by human activities - destructive logging, excessive grazing, over fishing, toxic pollution and human development and habitat destruction impedes many species from migrating. A recent major study indicates that if global temperatures increase 1.8-2° Celsius (3.2-3.6°F) which is considered amid-range estimate, a million species would be threatened with extinction over the next fifty years (http://www.nature.com). This can only be avoided by rapid emissions reductions in the next few decades. There is still time to save many species, but it is fast running out. Of course, if temperatures go even higher, more species will be lost.

Aquatic resources

Climate variation is a threat to the aquatic resources in Nigeria. The combinations of over-abstraction and periods of low rainfall result in low flow rivers, lowered ground water and the drying up of wetlands (Enete and Ezenwanji, 2011; Idowu *et al.*, 2011). This has detrimental impact on freshwater ecosystems, worsens water quality and permits intrusion of saline water. Regular water resources scarcity will encourage the use of alternative sources (such as desalination, harvesting of rainwater and recycled water) to supply drinking water, industrial processes and irrigation.

Impacts on macrophytes

The fringing macrophytes in the coastal swamps suffer devastating hazards as long periods of flood water covers their surfaces, hindering the direct solar energy from reaching their photosynthetic parts, thus, carbon synthesis is prevented. The same is also applicable to some fauna. These die and decay, adding organic materials in the form of humid acid to the ecosystems. A study revealed that one of the major causes of agro-biodiversity degradation is oil spillage which occurs on both on and off-shore locations in the state (Bassey *et al.*, 2011). Since the discovery of crude oil in the state, agricultural biodiversity' has been subjected to continuous degradation. The impact of oil spills has ranged from the barely tolerable to utterly disastrous dimensions. The resultant spillage which usually covers extensive areas destroys economic trees, farmlands and cause structural changes, a crust and a pan formation on the soil. Agro-biodiversity of plant source has wide uses. These include utilitarian uses, ornamental uses, medical and biomedical uses.

By loosing 166283ha of secondary forest and 98,733ha of swamp forest between 1986 and 2007, the area lost the forest cover that would have sequestered 188,425.2 tons and 111,880.3 tons of carbon respectively. This estimate was based on the value given by Ong (1993). Furthermore, based on the IPCC estimate in 2006, by loosing 166283ha of secondary forest and 98,733ha of swamp forest between 1986 and 2007, approximately 53,003,200 tons of carbon was released as CO_2 into the atmosphere. It is obvious from the foregoing analysis that deforestation is a serious threat to global warming in the area. After timber, rattans (lignoid palms) provide the second most important source of export earnings from tropical agro-biodiversity of crop source (Ong, 1993). Over-exploitation, habitat destruction of lodging, shifting cultivation and spontaneous settlement has led to the decline of major commercial rattan species and species and species that are valuable in local use (Bassey *et al*., 2011).

Impacts on plankton

Micro-organisms react rapidly to changes in the aquatic environment particularly climate change. Such variability in temperature rise after a certain threshold has a significant effect on this biota and certain processes like reproduction, feeding/food chains, respiration, among others. The growth of phytoplankton depends primarily on the solar radiation and then, on the quality of the system in terms of nutrient load through the process of carbon synthesis. Zooplankton depends directly on phytoplankton and detrital organic matter for their growth. Ekpo and Nzegblue (2012) showed that altered wind patterns may change the spread of microbes such as bacteria and fungi, which are agents of crop diseases and decomposition of dead organic matters which are now abundant in the ecosystems.

Impact on fish and fisheries

Generally, low flows and subsequent heavy rainfall events may lead to fish kills while increased temperature can put cold water fish at risk. Also, as high saline (salt) water from the Atlantic Ocean enters the inland systems, the fish species composition and the type of fish available are affected; hence we have marine intrusive species in our coastal waters (Teugels *et al*., 1992; Ekpo 2012; Onuoha *et al*., 2010; Ekpo and Nzegblue, 2012). Table 2 showed that 23.41% of the respondents accepted that the increased population of fishers into the fishing communities has led to over exploitation of the fisheries resources; all these have led to reduced catch per unit effort. Some fishes may be affected by changes in water level, temperature, oxygen levels, and increased levels of harmful algae (Cheney, 2005). Table 1 shows effects of some of the hazardous impacts of climate change on fishing in coastal area of the state: the most important climate-related hazard is rise in water level (48.24%) while the least is salinity (16.23%). Climate change influences the wind distribution patterns especially caused by storm surges that frequently affect farming communities. Idowu *et al*., (2011) noted that storm surges often result in losses of housing units, lost of postharvest sheds and processed fish, poultry/piggery sheds and farmstead stores. Effects of wind storms have been reported to include: (i) Increase in fuel cost due to the roughness of the sea (ii) Increase in transportation cost to the fishing grounds (iii) Lengthy periods of non-availability of catches (iv) Increased labour cost as a result of harder working conditions (v) Increased maintenance cost caused by damages of the fishing implements and gear (Ekpo and Nzegblue, 2012).

Table 1: Environmental hazards that affect fishing activities in Itu bridge-head, Akwa Ibom State, Nigeria

S/N	Climate-related hazards	Impacts on fishing livelihood (%)
1.	Rise in water level	48.24
2.	Wind storm	37.16
3.	Increased temperature	35.26
4.	Salinity	16.23
5.	Riverbank erosion	22.13
6.	Population	23.41

Source: Adapted and modified from Ekpo and Nzegblue (2012)

In the face of a rise in water level and accompanied by great storm as it experienced recently in the state, many fishers stay away from the waters. This is considered by them to be turbulent water; a condition normally referred to as 'angry water': a lot of fishers are known to lose their lives like it happened a few months ago in Oron and Ibeno. Commenting on this Idowu *et al*., (2011) reported that floods that occur with sea transgressions sometimes with heavy rainfall become the cause of road tracks inundation, house losses, public health hazards and losses of potable water owing to salt water intrusions into wells and seaside beelines, farmland losses and population displacements and ultimate livestock mortality. More so, rise in water level gives an extended surface area since the water now spills into the floodplains and while fishers cannot set nets but can use their traps. Many fish species utilize this opportunity to feed well and spawn in the floodplains. Thus, catch per unit effort from the main channels seem to fall while the fishes are easily caught on the floodplains by the use of simple fishing gear such as gill nets, hooks and traps.

According to Ekpo and Nzegblue (2012) increased temperature may result in increased growth and mortality of most fishery resources. At extremes of whether conditions result in decreased availability of some species of fish, which move to the bottom of the sea when the water is rough (Wilkinson, 1996).

Fig. 2: A fisher at Ibeno, the immediate host community of Exxon Mobil in Akwa Ibom State has continued to count his losses following another round of oil spills reported in the Atlantic coastline of the state (Adapted from Tolani, 2012).

Sea level rise

It is not only small island states that need to worry about sea level rise. Sea level rise increases the risk of both temporary and permanent flooding of coastal lands. Around 23% of the worlds' populations lives in the near coastal zone with population densities about three times higher than the global average (IPCC, 2005). Migration to coastal areas is increasingly common in many countries around the world, developed and developing alike. Settlements and urban centres in coastal regions have expanded more rapidly than elsewhere. Great majority of people live in smaller settlements in the coastal zone. High densities of people are also found in delta regions, which are particularly vulnerable to flooding. Over the 20th century as a whole, sea levels rose by an average of around 1.7mm a year with evidence that in recent years the rate of rise has increased. Latest satellite data put the rise at around 3mm a year. The most recent IPCC (2007) assessment based on the gloomiest scenario puts predictions of 21st century sea level rise at between 26 and 59cm (10-23 inches). There are many variables - including how much the expected increases in precipitation will add to snow packs and, most importantly, our greenhouse gas emissions over the next decades. What we can expect is that even a small amount of sea level rise will have profound and largely negative effects.

Impacts on agriculture

Climate variability effects in the developing countries of the world have been well-documented over the years through scientific researches, statistical analyses in abiotic and biotic components, and monitoring of agricultural production. According to Ekpo and Nzegblue (2012) agricultural activities in communities around Itu bridge-head showed that flood (53.24%) was the most climatic hazard, this was followed by heavy and prolonged rainfalls (45.23%) and then soil erosion (32.19%) (Table 2). This had led to loss of nutrients due to the washing away of the top soil by the surface runoffs, resulting in low crop production and the use of heavy inputs of organic and chemical fertilizers. Hence, the agricultural crops are deficient in essential minerals, this result in low crop yield and income generation (Onwerenmadu, 2007). Ekpo and Nzegblue (2012) further reported that the prolonged rainfall affects the second season farming which served as a source of income and livelihood for the farmers.

Table 2: Environmental hazards that affect farming activities in Itu bridge-head, Akwa Ibom State, Nigeria

S/N	Climate-related hazards	Impacts on farming livelihoods (%)
1.	Soil erosion	32.19
2.	Flooding	53.24
3.	Pests	28.28
4.	Early onset of rainy season	18.12
5.	Late onset of rainy season	37.12
6.	Increased	42.16
7.	Prolonged rain	45.23
8.	Frequent outbreaks of diseases	35.15
9.	Poor yield	50.37

Source: Ekpo and Nzegblue (2012)

Severe drought can degrade or destroy wetland ecosystems through changes in water availability, higher temperature and increased evaporation rates, causing deterioration in wildlife habitats (WMO/UNEP/IUCN, 2009).

Fig. 3: Flooding in Uyo, the capital of Akwa Ibom State. (Modified from Umo, 2011)

Proliferation of insect pests

Prolonged rainfall favours proliferation of insect pests in the tropics; which Akwa Ibom coastal zone is a part of. Higher temperatures also allow insect larvae to hatch and develop faster, thus, causing greater infestation of the crops during the following season. Ekpo and Nzegblue (2012) affirmed that altered wind patterns may change the spread of both wind-borne pests. Increased pests infestations may bring about increased use of chemical pesticides as a control measure, which will further degrade the environment.

Impact on the soil

According to Ekpo and Nzegblue (2012) higher temperatures affect the soil in diverse ways: warmer temperatures speed up the rate of decomposition of organic matter and other soil processes that affect its fertility. Application of fertilizers may be needed to stop these processes in order to enhance crop production; this will increase atmospheric carbon dioxide and hence environmental risk.

Fig. 4: A section of bridge-head at Ayadehe in Itu after the flood of 2012

Impact on air and water quality

Additional uses of chemicals in order to increase soil fertility further impair both air and water quality. Ekpo and Nzegblue (2012) reported that the continual cycling of plant nutrients (carbon, nitrogen, phosphorus, potassium and sulfur) in the soil-plant-atmosphere system is likely to accelerate in warmer conditions, enhancing carbondioxide and nitrogen oxide greenhouse gas emissions.

Fig. 5: Part of Oron Road in Uyo showing collapse of part of the land together with the building belonging to Mr. Edem (Adapted from Wikipedia, free Encyclopedia).

Socio-economic impact of climate change

Climate change affects both the livelihood activities of the farmers as well as sustaining the support activities such as harvesting, processing, fishing, mat weaving, trading, periwinkle collection, etc. According to Idowu *et al*., (2011) climate change has influences on labour investment, occupational health, fish landing distance to smoking sheds, water use/irrigation, transportation/communication access, resources availability, fuel wood, coconut harvest, food crop abundance, reduced fish catches, decline livestock production and subsequent loss of income. The general livelihoods of coastal riverine inhabitants are poor as shown by those of Iko communities which are adversely impacted (Ekong *et al*., 2011). The result of the laboratory analysis shows that the coastal waters of Iko community are polluted and this in turn affects the socio-economic profile of the communities adversely particularly their occupational activities and income/expenditure. OGADEP (2009) reported on the impact of climate change on public health of Nigerian farming communities to include respiratory diseases due to increases in the levels of pollutants, malaria (70% annually), skin aliments (45% annually), heat stroke (4% annually), loss of productivity (40% annually) and portable water shortages (60% annually) due to floods and/or saltwater intrusion.

Adaptive and mitigation measures

Many authors have put forward different adaptive and mitigation strategies (Enete and Ezenwanji, 2011; Ekpo and Nzegblue (2012)). The following recommendations were offered in order to reduce impact of climate change in coastal environment of Akwa Ibom State:

- Implementation, enforcement, compliance and review of existing urban and natural policies.
- Domestication and implementation of disaster contingency plans and other environmental policies.
- Need for the construction of central drainage systems consisting of interconnected flood reservoirs fitted with valves at various levels and discharge pumps (which is ongoing in the State).
- Canalization of the swamps to ease transportation along the channelization of rivers to confine river discharge to their channels.
- Need for the surveying and mapping of flood prone areas so as to reduce vulnerability and the risk of hazards in coastal communities.
- Need for integrated water resources management approach in planning, development and management of water resources in the State.
- Climate change plan of action should take into account sea level rise of over 1 m and storm surges of 2 m.
- More permanent solutions should be found for the active eroding parts of the coastline e.g. building wave breakers further at sea and maintaining.
- Focusing on knowledge and capacity development by improving weather forecasting, water resources monitoring, improving disaster preparedness, investing in appropriate technology development and strengthening capacity for planning and coordination.
- Making adaptation and climate risk management a core developmental component with a particular focus on sustainable water resources.
- Improving water use efficiency, planning for alternative water sources (such as treated wastewater or desalinated seawater), and making changes to water allocation.

CONCLUSION AND RECOMMENDATIONS

A. Agricultural sector

1. Weather forecasting

Crop failure has been linked up with inaccurate and untimely weather information dissemination in the coastal environments. Ekpo and Nzegblue (2012) reported that farmers usually rush to plant their crops with the first rain which may not actually signal the onset of the farming/growing season. Better weather forecasting skills and information sharing by Nigerian Meteorological Agency (NIMET), Maritime Academy in Oron and other relevant research institutes will help farmers to avert and reduce crop failure.

2. **Control of pests and diseases**

Early detection of invasion of pests has been reported as a critical management process to control pests and diseases. Methods of control range from biological, mechanical and chemical: the most effective and environmentally friendly being biological control if carefully selected. This involves the use of natural enemies to control or reduce the populations of a pest.

3. **Use of cover crops**

Legumes are known to be good soil nitrogen-fixers as a result of the nitrogen-fixing bacteria in their root nodules. Thus, the use of cover crops that are nitrogen-fixing ensures the nutrient enrichment of the soil for succeeding cropping season. These creeping crops (potatoes, cowpea, melon, watermelon, fluted pumpkin and groundnuts) can be integrated in the farming system in Itu community to reduce loss of top soil and sustain increased crop production.

B. Adaptive measures in fisheries sector

Freshwater aquaculture is threatened by oceanic (salt water) intrusion into the Cross River, Qua Iboe River, Ikpa River and other freshwater creeks in the State from the Atlantic Ocean. Changes in water variables such as temperature, salinity, wind speed and direction, ocean current and strength of upwelling influence the abundance and distribution of fish populations and fisheries activities. Mitigation and adaptation measures include (1) Protection of water bodies from pollution (2) Farmers should be encouraged to stock salt – tolerant or euryhaline species (3) Waste-waters should be pre-treatment before re-introduction into the natural systems (4) With adequate security enforcement, aquacultural enterprises should be encouraged at the extensive floodplains of the coastal rivers (5) More scientific and environmental researches, workshops and conferences should be mounted sensitize the people (6) Co-operative societies should be established (7) Loans should be sought for the purchase of improved and resistant species.

REFERENCES

Adefolalu, D. O. (2000): An introduction to the challenges of climate change and its impact in Nigeria. A workshop in climate change and natural disasters in Nigeria held at FUT, Minna on 3rd April 2000.

Awosika, L. F.; French, G. T.; Nicholls, R. T. and Ibe, C. E. (1992): The impact of sea level rise on the coastline of Nigeria. O'Callahan J. (ed.). *In:* Global climate change and the rising challenge of the sea. Proceedings of the IPCC workshop of Margarita Island, Venezuela, held on 9th – 13th March 1992. National Oceanographic and Atmospheric Administration, Silver Spring, M. D., U. S. A. pp 690.

Ayoade, J. O. (2003): Climate Change: A Synopsis of its nature, Courses, Effects and Management. VIC Business and Computer Services, Ibadan.

Bassey, C. B., Eni L. I. and Eneji C. O. (2011): Perception of utilitarian values of agrobiodiversity by rural farmers in Akwa Ibom State, Nigeria. African Journal of Agricultural Research, 6(32): 6622-6634.

Botkin, D. B. and Keller, E. A. (1995): Environmental Science: Earth as a Living Planet. New York: John Wiley & Sons.

Cheney, D. D. (2005): Shellfish and climate change: Ecological and economic effects. Washington State Climate Conference.

Enete, I. C. and Ezenwanji, E. E. (2011): Implications of climate variability on water resources of Nigeria: A review. *Journal of Geography and Regional Planning,* 4(13): 678 – 682.

Eka, O. U. and Udotong, I. R. (2003): Effects of incessant oil spill from Mobil Producing Nig. Ltd on human health in Akwa Ibom State. *In*: E. N. Adinna, O. B. Ekop, V. A. Attah (Eds.): *Environmental Pollution and Management in the Tropics.* Enugu: Snaap Press, pp. 201 – 211.

Ekong, F.; Jacob, A. and Uyanga, P. (2011): Pollution levels of coastal water Resources and the socio-economic effects on Iko communities in Akwa Ibom State. *Journal of Human Ecology,* 33(1): 41-46.

Ekpenyong, R. E. (2013): An Assessment of the threats to Global Warming in Akwa Ibom State, Nigeria. *Greener Journal of Environmental Management and Public Safety*, 2(2): 065-074.

Ekpo, I. E. (2012): Diversity and condition factor of fish species of Ikpa River at Nwaniba in Niger Delta, Nigeria. *Federal University of Technology, Akure (FUTA) Journal of Research in Sciences,* 1(1): 36-47.

Ekpo, I. E.; Chude, L. A. and Onuoha, G. C. (2012): The use of multivariate analysis for characterisation and classification of Ikpa River, Nigeria. *Elixir Agriculture*, 49: 9799-9807.

Ekpo, F. E. and Nzegblue, E. C. (2012): Climate change impact and adaptation opportunities on agricultural production in communities around Itu bridge-head in Itu LGA, Akwa Ibom State, Nigeria. *International Journal of Environmental Sciences,* 2(3): 2191 – 2202.

Greenpeace International (2006) Amsterdam

Guardian Newspaper, Monday, September 17th, 2001, p. 80

Guardian Newspaper, Monday, 18th July 2011

http://www.nature.com/nature/journal/v427/n6970/fill/427107a_fs.html

Idowu, A. A.; Ayoola, S. O.; Opele, A. I. and Ikenweiwe, N. B. (2011): Impact of climate change in Nigeria. *Iranica Journal of Energy and Environment,* 2(2): 145 – 152.

IPCC (2005): Global warming: Early signs on climate change. Retrieved online (http://www.climatehotmap.org)

IPCC (2007). Summary for Policymakers. Climate Change 2007: The Physical Science Basis. Contribution of working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC).

Ogbu, S. O. and Enete, I. C. (2006): Fundamentals of Research Methods and Reports in Environmental Studies. Glanic Ventures, Enugu, pp. 12-14.

Onuoha, G. C., Ekpo, I. E., Chude, L. A. and Isangedighi, I. A. (2010): Composite preliminary ichthyofaunal of Ntak Inyang Stream, Ikpa River, Nigeria. *Nigeria Journal of Agriculture, Food and Environment,* 6(1&2): 82-89.

Osuala, E. C. (2001): Introduction to research methodology. African FEP Publishers Ltd, Onitsha, P. 104.

Stephens, B.S. *et al*., (2007). Weak Northern and strong tropical land carbon uptake from vertical profiles of atmospheric carbondioxide. *Science,* 316: 1732–1735.

Tolani B. (2012): Akwa Ibom oil spill: Ibeno fishing communities count their losses.

Umo, I. (2012):

WHO (2008): Global change and Health: National Assessments. http://www.euro.who.int/globalchange/assessment/20020925_1.

Wikipedia, the free encyclopedia.

Wilkinson, C. R. (1996): Global change and coral reefs: impact on reefs, economics and human cultures. *Global Change Biology*, 2: 547 – 558.

WMO/UNEP/IUCN (2009): Factsheet #6: Climate information for a healthy environment. http://www.wmo.int.wcc3/documents/wcc3_factsheet6_environment.EN.pdf.

The Perception of Communities Prone to Environmental Degradation

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ABSTRACT

The activities of man affect the environment which in turn influences the climate. This study assesses these human activities by determining the perceived impact of oil spill and its attendant explosion and fire has on the environment. This study was carried out in Lagos, covering some coastal settlements in Amuwo-Odofin Local Government Area. Landsat 30 m (ETM+) of 2005 and Ikonos 10 m of 2007 were the satellite images used which were subjected to digital image processing and analysed. Also, the study area was divided into 3 strata and convenient sampling technique was used on each stratum to administer 200 copies of questionnaire for data collection which were analysed. The results showed that there was a decline in the high and light forested areas, respectively between 2005 and 2007. Furthermore, the result revealed that educational exposure affected the way the community perceived the impact of oil pipeline vandalization on the vegetation and strategies to prevent pipeline vandalization ($F=2.8-5.9$; $p<0.05$). It was concluded that oil pollution resulted in the reduction of vegetation while educational level affected the way in which the impact of the pollution was perceived.

Keywords: Oil Pollution, Education, Pipeline Vandalization, Vegetation

INTRODUCTION

The environment man lives in comprising of land, water and air is constantly undergoing changes due to natural and anthropogenic activities. These changes alter our environment regularly and can disrupt the sink it provides for green house gases. The oceans stand for the largest pool of carbon near the surface of the Earth, their role is of particular importance in the global carbon cycle; and indeed, the organic matter dissolved in the oceans contains a similar amount of carbon as is stored in the skies as atmospheric carbon dioxide.[1] And mangroves play a major role for the dissolved organic matter (DOM) exchange between continents and oceans and their rapid decline over the recent decades may already have reduced the flux of terrestrial DOM to the ocean, impacting one of the largest organic carbon pools on Earth.[2] So can the organically rich sediments around the tree roots, which support a number of crustaceans and mollusks. Mangroves also provide shelter for organisms, both above ground and underwater. The thick tree roots provide a surface for attachment of sessile marine invertebrates, and the nooks and crannies provide hiding for fish and smaller organisms.[1]

Industrial civilization depends on crude oil and its products which has influenced the way of life of the suburban communities. The challenge of developing countries such as Nigeria to distribute this oil to their populace has led to the laying of pipelines. These pipelines cross vegetated land and water bodies. Pipelines which are high-pressured conduits with varying width and carrying capacity are the main form of transportation for oil across countries and continent, and in many cases, they are also the life-blood of cities and business around the world.[3, 4] Oil when transported can be spilled on water or land if incorrectly handled thereby impacting the ecosystem negatively causing environmental degradation. Illegal fuel siphoning, sabotage and pipeline vandalism as a result of the thriving black market for fuel products has increased the number of oil pipeline explosions in recent years. The transport and fate of spilled oil in water bodies are governed by physical, chemical, and biological processes that depend on the oil properties, hydrodynamics, meteorological and environmental conditions.[5] When liquid oil is spilled on the sea surface, it spreads to form a thin film – an oil slick. Also, oil spilled on land can disrupt soil aeration and biological activities and subsequently lead to negative effects on the growth of forest tress and seedlings.[6] It was also observed that a disruption in the natural vegetation dynamics can occur when a forest ecosystem experiences fluctuating pollution impact over a long period of time.[7]

On the Nigerian Coastal environment, large areas of the mangrove ecosystem have been destroyed and the land/water degraded. Mangrove swamps are an ecological lynchpin. They protect the shoreline integrity and are the nurseries for many shellfish and finfish, providing nutrition and protection from predation. Mangroves are socio-economically important ecosystems, especially for the inhabitants of coastal regions, who depend on them as their primary source of income, fuel, food, medicine, and other basic necessities.[8, 9, 10] Thus oil spills have killed extensive swaths of mangroves. The death of a large portion of a mangrove system can threaten the organisms' dependent upon them for survival.[11] Humans can be affected by oil spills from damage to surrounding plants and animals, and perhaps by direct contamination.[12]

The environmental impact of oil spill can be assessed and monitored over time using remote sensing technology. Remote sensing is a tool useful in several modes of oil spill control, including large area surveillance, site specific monitoring and tactical assistance in emergencies. It is able to provide essential information to enhance strategic and tactical decision-making, decreasing response costs by facilitating rapid oil recovery and ultimately minimizing impacts. Timely response to oil spill requires rapid reconnaissance of the spill site to determine its exact location, extent of oil contamination (particularly the thickest portion of the slick) and verifying predictions of the movement and fate of oil slicks at sea. For ocean spills, remote sensing data can provide information on the rate and direction of oil movement through multi-temporal imaging and input to drift prediction modeling. Observation can be undertaken visually or by use of remote sensing systems. In remote sensing, a sensor other than human vision or conventional photography is used to detect or map oil spills.[13]

Vandalization of oil pipeline and the attendant oil spill, explosion and fire are common occurrences in the coastal settlement of Amuwo-Odofin Local Government, Lagos State while oil pipeline passes through. The effects of these human induced destructive occurrences on the vegetation and its perception by communities are to be monitored, assessed and analyzed using remote sensing in this study.

Study Area

Nigeria has a coastline of approximately 853 km facing the Atlantic Ocean. The coastal area is low lying with heights of not more than 3.0 m above sea level and is generally covered by fresh water swamp, mangrove swamp, lagoon mashes, tidal channels, beach ridges and sand bars.[14] Lagos is a major city on Nigeria's coastal zone with 455 km^2 of the metropolis being water bodies, wetlands and mangrove swamps. The study area covers some coastal settlement in Lagos such as Ifako, Igboejo, Ilado-odo, Akaraba, Sanke, Idimagoro, Okun Igbologun and Igbo-Eseyor in Amuwo-Odofin Local Government Area. The coastal zone of Nigeria could be described based on geomorphology, vegetation, natural resources and socio-economic activities. Geomorphologically, the barrier-lagoon coast extends eastward about 250km from the Nigerian-Benin border to Ajuno village, consisting of narrow beach ridges aligned parallel with the coast and backed up by the Badagry, Lagos, and Lekki lagoons with beach sediments of medium to coarse grained sand and moderately well sort.[15]

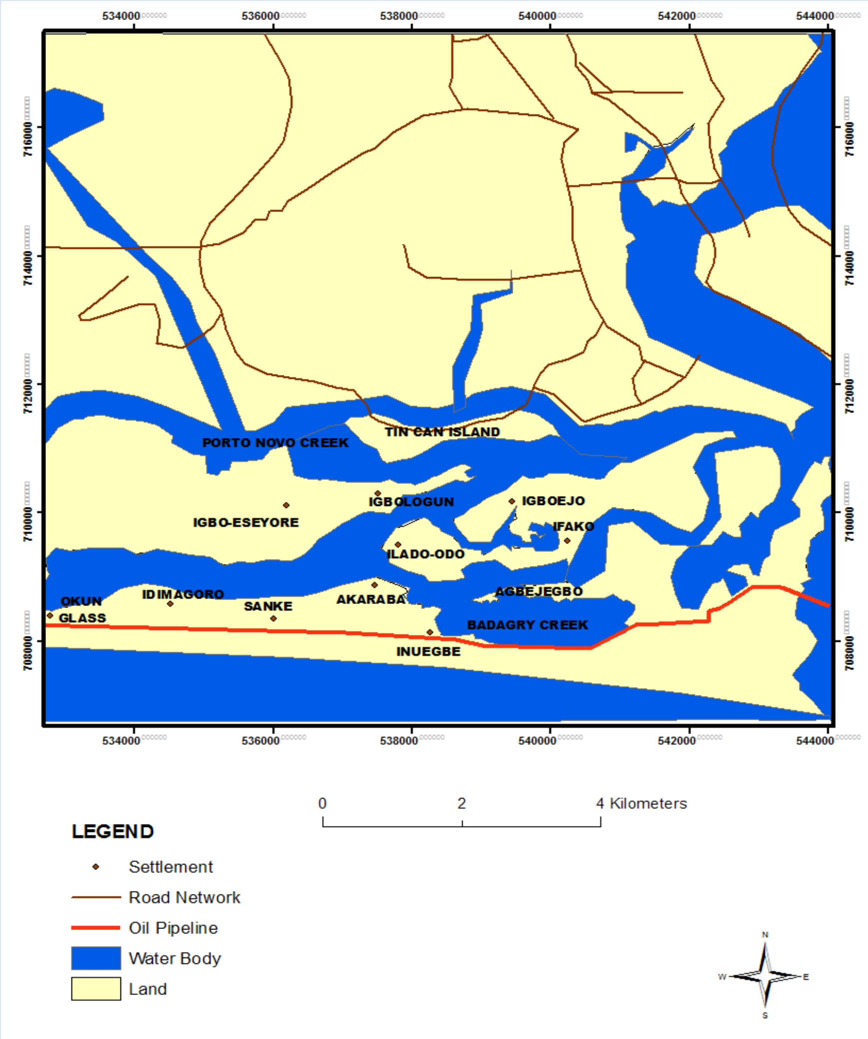

FIG. 1. Map of the Study Area

METHODOLOGY

A subset of the study area was extracted from the satellite imageries of Landsat ETM+ 2005 and Ikonos 2007 using ERDAS IMAGINE sub setting function. The extracted subsets were geometrically corrected. Global Positioning System readings were collected from the field and used in reference to the ortho-photo map to geo-reference and identify features on the image. The images were resampled and subjected to vegetation classification analysis.

Focus Group Discussion was also held with the community leaders and a few of the youth representatives with the view of acquiring information about the perceived impact of oil spill to their environment. Also, structured questionnaire was administered in the study area. To ensure 200 completed questionnaires are obtained, more than 200 questionnaires were drawn and sampled to control for refusals.[16] This was to elicit information on the communities' perception of the impact of oil pipeline vandalization on the vegetation. Stratified random sampling and Random sampling technique were the sampling techniques used. The settlements were grouped into three strata based on their location and proximity and the questionnaires distributed randomly. The first strata included settlement such as Ilado-odo, Ifako and Igboejo, the second included Akaraba, Sanke, Idimagoro and Okun glass while the third strata included settlements such as Igbologun and Igbo-Eseyore. The questionnaires where then administered randomly in each strata. Information obtained from the questionnaire administration was subjected to statistical analysis such as ANOVA.

ANALYSIS AND RESULTS

The image classification analysis revealed that Figure 2, shows that the vegetation type along the coast in areas close to the pipeline in the 2005 image was high forest while that of 2007 shows that the shoreline vegetation of high forest was replaced by light forest. According to the focus group discussion and this is confirmed by these image classification, that the worst affected vegetation were areas where the water flowed across the land i.e. from one end to the other.

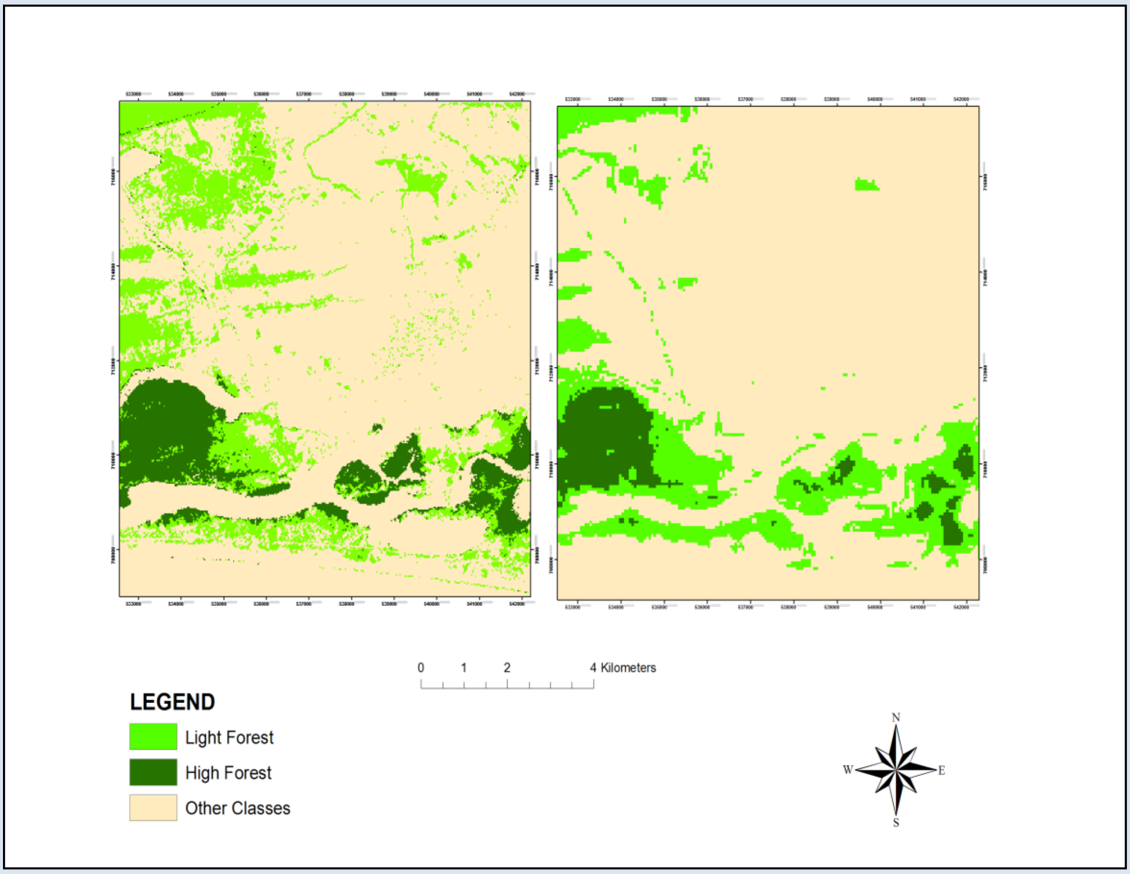

FIG. 2. Vegetation Cover in 2005 and 2007 respectively

The result of the Fous Group Discussion revealed that the oil pipeline in this area was previously monitored by Vigilanty group comparisng of members of the community. They reported that at that time there was hardly any case of vandalizm. They stated that the issue of vandalizing this oil pipeline started when the Police Force took over the security of the oil pipeline. It was stated that among the rubbish gathered from the explosion that police uniforms, hundreds of Jeri-cans among other were discovered.

A total of 200 questionnaires were administered to the respondents in the study areas. The retrieved questionnaires were subjected to statistical analysis. Table 1 shows the frequency distribution of the demographic characteristic of the respondents in the study area.

Table 1. Demographic characteristics of the sampled respondents

Demographic characteristics	Number of respondents	Percentage
Sex		
Male	135	67.5
Female	65	32.5
Occupation		
Civil servant	34	17.8
Student	48	25.1
Driver	14	7.3
Farmer	14	7.3
Trader/Business	64	33.5
Artisan	17	8.9
Monthly Income		
Below N10,000	33	19.5
10,000 - N20,000	41	24.3
N21,000 - N30,000	42	24.9
N31,000 - N40,000	27	16.0
Above N41,000	26	15.4
Education		
Primary	25	12.5
Secondary	77	38.5
Tertiary	52	26.0
Vocational	20	10.3
Others	20	10.3

In table 2, the cross tabulation of the opinions on if they notice any change in their environment (farmlands, water, air) and if they think that vandalizing of oil pipeline is dangerous to their community varies. About 99.3% of those who said they observed changes in their environment (farmland, water and air) also indicated that vandalizing oil pipeline is dangerous to the community, while 96.8% said that they did notice changes in their environment but vandalizing oil pipeline is not dangerous to the community.

About 3.2% did not notice any change and said vandalization is not dangerous to the community.

Table 2. Cross tabulation on the perception of oil pipeline vandalization and the resultant changes

		Do you think vandalizing oil pipeline is dangerous to the community?		
		Yes	No	Total
After the explosion, do you notice any change	Yes	99.3%	.7%	100.0%
in the environment -farmland, water and air	No	96.8%	3.2%	100.0%
TOTAL		98.9%	1.1%	100.0%

The analysis in tables 3 and 4 shows the result of ANOVA. The statistics was used to test the variation in the level of the community's educational exposure to the way they perceive the effect of oil pipeline vandalization on their well-being. The result shows that there is a significant difference in the opinions of the respondents as regards why the pipeline leakage was left unattended to ($F=3.144$, $p < 0.05$), changes in the environment after oil pipeline explosion ($F= 2.811$, $p<0.05$) and strategies to prevent oil pipeline vandalizaton ($F= 5.94$, $p<0.05$). That is their educational level affected the way they responded to these particular questions. For instance, the level of education of the respondents affects the response as to why oil pipeline leakage was unattended to. It was significant at 0.05 probability level. The results indicate that the level of a community's educational exposure affects the way they respond to these questions. It indicates that at $P=0.05$ significant level, educational exposure affect the way the members of a community perceive the impact of oil pipeline vandalization on their well-being.

Table 3. Perception of the respondent to the effect of oil pipeline vandalization based on educational exposure

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
What do you think was the cause of the pipeline leakage?	Between Groups	1.239	4	.310	1.090	.363
	Within Groups	53.715	189	.284		
	Total	54.954	193			
Why did the pipeline leak for this long without being repaired?	Between Groups	8.173	4	2.043	3.144	.016
	Within Groups	122.159	188	.650		
	Total	130.332	192			
After the explosion, do you notice any change in the environment-farmland, Water, and Air?	Between Groups	1.509	4	.377	2.811	.027
	Within Groups	23.491	175	.134		
	Total	25.000	179			
Did the taste of well water and bore hole water change after the explosion?	Between Groups	1.402	4	.350	2.263	.064
	Within Groups	29.116	188	.155		
	Total	30.518	192			
Do you think vandalizing oil pipelines is dangerous to the community?	Between Groups	.048	4	.012	.760	.553
	Within Groups	2.904	183	.016		
	Total	2.952	187			
Are you aware that oil leakage can affect farmland, water and air negatively?	Between Groups	.149	4	.037	1.190	.317
	Within Groups	5.658	181	.031		
	Total	5.806	185			
What do you think is the best way of stopping the vandalization of oil pipelines?	Between Groups	45.814	4	11.454	5.954	.000
	Within Groups	355.896	185	1.924		
	Total	401.711	189			

In table 4, the statistics was used to test the variation in the level of the community's occupation to the way they perceive the effect of oil pipeline vandalization on their well-being. The result shows that there is no significant difference in any of the variables. That is the respondent's occupation did not affected the way they responded to these questions. Therefore, the occupation of members in the community did not in any way influence the way they perceived the oil pipeline vandalization.

Table 4. Perception of the respondent to the effect of oil pipeline vandalization based on occupation

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
What do you think was the cause of the pipeline leakage?	Between Groups	.836	5	.167	.582	.714
	Within Groups	53.144	185	.287		
	Total	53.979	190			
Why did the pipeline leak for this long without being repaired?	Between Groups	2.277	5	.455	.658	.656
	Within Groups	127.387	184	.692		
	Total	129.663	189			
After the explosion, do you notice any change in the environment- farmland, Water,and Air?	Between Groups	1.173	5	.235	1.738	.128
	Within Groups	23.076	171	.135		
	Total	24.249	176			
Did the taste of well water and bore hole water change after the explosion?	Between Groups	.663	5	.133	.837	.525
	Within Groups	29.132	184	.158		
	Total	29.795	189			
Do you think vandalizing oil pipelines is dangerous to the community?	Between Groups	.080	5	.016	1.000	.419
	Within Groups	2.871	179	.016		
	Total	2.951	184			
Are you aware that oil leakage can affect farmland, water and air negatively?	Between Groups	.154	5	.031	.967	.440
	Within Groups	5.649	177	.032		
	Total	5.803	182			
What do you think is the best way of stopping the vandalization of oil pipelines?	Between Groups	20.134	5	4.027	1.964	.086
	Within Groups	371.054	181	2.050		
	Total	391.187	186			

DISCUSSION

This study focused on the perceived environmental degradation of oil spill by impacted communities. Landsat and Ikonos imageries used in this study showed that the mangrove vegetation had had undergone some changes between 2005 and 2007. The assessment and analysis of the 2005 and 2007 satellite images of the area reveals that there was a decline in the high forest vegetation by 1.739% and also a decline in the light forest by 1.642%. Places where the vegetation was dense in 2005 where observed to have been replaced by light forest by 2007. This is because the oil pipeline explosion and the oil spill polluted the water. [7, 18, 19] have shown that oil pollution can lead to the death of mangrove plant.

The Focus Group Discussion revealed that youth living in close proximity to the pipeline where involved in the pipeline vandalization. And vegetation an farmlands were seriously polluted and died faster than those further away. This suggests that pollution concentration reduced with distance from the explosion site. This indicated that oil have been spilled on a regular bases into the environment, hence the gradual pollution of the mangrove vegetation even before the explosion. This agrees with [19] that thousands of barrels of oil have been spilt into the environment through our oil pipelines and large areas of the mangrove ecosystem have been destroyed by oil spill. Some of the reasons noted as to why the pipeline was vandalized include the pipeline being exposed, proximity of the pipeline to their farmlands, pipeline in a hideout where there is little or no security of the pipeline and greed. Other reasons include idleness of the youth. Most of the youth were observed to be less busy and active during the greater part of the day.

The questionnaire analysis reveals that the population in the study area is dominated by males. This could explain why oil spill persist in that environment as vandalization of pipelines entails some rigorous activities of piercing and lifting that may not come handy for the females. Furthermore, increase in the population of unemployed youths and the demands of meeting ones basic needs could be reasons why youths vandalize pipelines. It was reported by 95% of the respondent that vandalizing oil pipeline is dangerous to the environment. The reasons why they noted it is dangerous to the environment were the obvious effect. The short term effects were the foul smell of the air and water from burnt human bodies and aquatic life. While the long term effect was death of the mangrove vegetation and farmlands. This greatly affected the socio-economic of the communities who basically get their goods from the environment (land and water).

The responses of the communities to certain questions were influence by the educational level of the respondent. This was tested by the analysis of variance (ANOVA) statistical technique. Those with a minimum of secondary education perceive the effect of oil pipeline vandalization on their well-being as more severe than the economic benefit some may derived from the sale of stolen oil through vandalization. The occupation of the respondent did not in any way influence the way they perceive the effect of pipeline vandalization. It is obvious that education improve the way an individual perceive things. Those that are educated tend to view things from a different and better perspective than the uneducated. Education is a very useful tool in informing the public of the impact of oil pipeline vandalization on the lives and properties.

CONCLUSION

Oil that is spilled degrades the environment. The degradation of the environment affects the climate of that environment. Hence, this study concluded that oil spill degrades the environment. Also, educational exposure influenced the way the communities perceived the impact of the oil spilled in their environment. Those with higher education knowledge are better informed on the impact oil pollution to man and his environment.

REFERENCES

[1] Moffat, D. and Linden, O. (1995). Perception and reality: assessing priorities for sustainable development in the Niger River delta. AMBIO, J, The human environment. Vol. 24 No 7-8. The royal Swedish society of sciences, 527-538

[2] Freedman, B. (1989). Environmental Ecology, The impact of pollution and other Stresses on Ecosystem Structure and Function. Academic press Incorporated, Harcourt Brace Jovanovich Publishers, San Diego. 4-7, 135-141.

[3] Epstein, P. R. and Selber, J. (2002). Oil, A Life Cycle Analysis of its Health and Environmental Impacts. The Center for Health and the Global Environment, Harvard Medical School. Boston.

[4] Off-shore Technology .com, Pipeline guerrillas- pipeline sabotage and terrorism, (2007). SPG Media Limited a subsidiary of SPG Media Group PLC.

[5] Tkalich P., M.K. Huda, and Gin, K.H. (2003). A Multiphase Oil Spill Model. Journal of Hydraulic Research Vol. 41, No. 2 (2003), pp. 115–125 http://www.iahr.org/publications/assets/JHR41-2/p2171.pdf

[6] Egharevba, R.K. and Osunde, D.O. (2001). The effect of crude oil on seedling growth of two forest fruit trees: Chrysophyllum albidum (Gambaya albida) and Dacroydes edulis G. Don. *Journal of Sustainable Agriculture.* 18(2/3): 25-35.

[7] Imevbore, A.M.A, and Odu E. A. (1985). Environmental pollution in the Niger-Delta In: B.H.R Wilcox and C.B. Powel (Ed). Proceedings of a workshop on the mangrove ecosystem of the Niger delta. University of portharcourt. Nigeria. 19-23 May. 1980, 133-155.

[8] Aksornkoae, S., Paphavasit, N. and Wattayakorn(1993). Mangroves of Thailands: present status of conservation, use and management. Pages 83-132 in International Tropical Timber Organization, Japan International Association for Mangroves, and international Society for Mangrove Ecosystems. *The economic and environment value of mangrove forests and their present state of conservation.* International Society for Mangrove Ecosystems, Okinawa, Japan.

[9] Bandaranayake, W. M. (1998). Traditional and medicinal uses of mangroves. Mangroves and Salt Marshes 2:133-138.

[10] Dahdouh-Guebas, F., Mathenge, C., Kairo, J.G. and Koedam, N (2000). Utilization of mangrove wood product around MIda Creek (Kenya) among subsistence and commercial users. *Economic Botany* 54(4):513-527.

[11] Briggs, K.T., Yoshida, S.H. and Gershwin, M.E., (1996). The influence of petrochemicals and stress on the immune system of seabirds. Regulatory Toxicology & Pharmacology 23(2):145-55.

[12] Campbell D, Cox D, Crum J, Foster K, Christie P, Brewster D, 1993. Initial effects of the grounding of the tanker Braer on health in Shetland. The Shetland Health Study Group. BMJ 307(6914):1251.

[13] Mullin, J. (2008). Offshore Mineral Management, Technology Assessment and Research, Remote Sensing and Surveillance of Oil Spills, US Department for interior.

[14] Dublin-Green C.O., Awobamise A. and Ajao, E.A. (1997). Large Marine Ecosystem Project for the Gulf of Guinea (Coastal Profile of Nigeria). In: Nigeria Institute of Oceanography Encyclopaedia Americana, 1994. International Edition, Grolier Incorporated.

[15] Ibe, A. C and Awosika, L. F. (1986). Sedimentology of beaches of barrier bar complexes in Nigeria. NIOMR Tech. Paper No. 28.

[16] Boynton, P. M. and Greenhalgh, T. (2004). Hands-on guide to questionnaire research: selecting, designing, and developing your questionnaire. *BMJ* 2004; 328:1312-5.

[17] Fagbemi, A.A., Udo, E.J., and Odu, C.I.I. (1998). Vegetation damage in an oil field in the Niger –delta of Nigeria.J.Trop.Ecol.4, 61-75.

[18] Fakpor, M.A., Ero, I.I., and Igboanugo,A.B.I. (2006). Impact assessment of oil effluent on the floral diversity of a mangrove ecosystem in Delta state, Nigeria. The Nigeria Journal of Forest Research and Management.

[19] Nwilo, P.C. and Badejo O.T. (2005). Oil Spill Problems and Management in the Niger Delta. International Oil Spill Conference, Miami, Florida, USA.

Composition, Diversity and Structural Attributes of Lianes in a Moist Evergreen Forest in Ghana

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ABSTRACT

Lianes have gained notoriety as species that suppress and kill desired forest tree species among foresters and silviculturists; a situation that has contributed to their wanton destruction. However, lianes play important ecological roles by contributing significantly to carbon sequestration and forest regeneration. The composition, diversity and structural characteristics of lianes in the Subri River Forest Reserve in Ghana were studied on a 5 ha patch of the forest divided in 50 random 0.1 ha circular subplots each. Eleven species of lianes ≥ 3.2 cm diameter at breast height (dbh, 1.3 m above ground) belonging to 10 taxonomic families were identified. The abundance and diversity of the lianes were low. Relative diversity among the families was low with all but one family being represented by single species. The density, basal area and ecological importance of the species, as determined by the importance value index were low. The results of the study have shown that liane species are rare and less diverse coupled with low structural attributes The need to preserve the lianes in the Subri Forest Reserve is therefore very

crucial, for forest biodiversity conservation, which will in turn contribute to climate change mitigation.

Key words: lianes, ecological, biodiversity, carbon sequestration, climate change.

INTRODUCTION

Lianes are woody vines or woody climbers that climb and grow on other plants and therefore, require supports from their host plants. Lianes are defined as woody plants that begin life on the ground as small self-supporting shrubs and rely on other plants to reach the light-rich environment of the upper canopy [1]. Lianes remain rooted to the ground throughout their lives and often have special adaptations such as stem twining, clasping tendrils arising from stem, thorns and spines, to attach themselves to their host and climb into the forest canopy [2].

Lianes are important components of many forest communities across the world, and are especially conspicuous, diverse, and characteristic in tropical forest [3]. Lianes provide an important contribution to the physiognomy and species diversity of tropical forests [4, 5]. Estimates of their contribution to the vascular plants species diversity of the community range from 12% in Puerto Rico, 25% in Upper Guinea, 31% in Ghana [6], and to over 40% in the Monogaga forest, Ivory Coast [2].

Lianes are also considered to be drivers of a number of forest dynamics aspects [7] and therefore, play and will continue to play vital roles in forest ecosystem functioning and dynamics. For instant, lianes substantially contribute to canopy closure after tree fall, stabilizing the microclimate underneath [8], as well as the provision of arboreal pathways for canopy vertebrates. They also play a prominent role in whole forest transpiration and forest-wide carbon sequestration [2] contributing to the carbon budget of tropical forests [9].

Furthermore, lianes constitute a very important group of non-timber forest products [10]. Lianes are used by local people in many different ways and therefore, considered as an important resource for local communities, particularly for medicinal reasons [2]. They are also used for construction of traditional houses, artisan work, fuel woods, and hunting.

It is obvious that lianes contribute immensely to forest ecosystem structure and services, though, large lianes have some negative impacts such as competition with trees for light, water, soil nutrients, and space and may thus depress the growth and fecundity of trees and increase their mortality [11, 12].

Despite the great importance of lianes to forest ecosystem, many studies on forest ecology are focused on tree species, while lianes received very little or no attention, making information and data on lianes grossly inadequate. The lack of knowledge about lianes is not common only among the general public, but also forest managers, who often advocate extensive liane cutting throughout the forest [13]. Moreover, lianes have been overlooked in most forest studies [2].

This study therefore sought to make a crucial contribution relevant to our understanding of the ecology and the role of lianes in the forest ecosystem, by assessing the composition, diversity and structural attributes of lianes in a moist evergreen forest in Ghana.

MATERIALS AND METHODS

Study area

The Subri River Forest Reserve lies between latitudes 5 ° 30' and 5° 05' north and longitudes 1° 35' and 1° 55' west in the Mpohor-Wassa East Administrative District of the Western Region, Ghana, with its headquarters at Daboase. It is the largest Forest Reserve in the country and covers an area of about 58,793 ha. A total of 824 ha is unproductive, comprising admitted farms and village lands, leaving a net forest reserve area of 57,969 ha. Out of the 57,969.0 ha, 4,062.0 ha have been used for plantation by SIPL, leaving a natural forest area of about 53, 907.0 ha. An area of 5,120 ha of the total area has been designated as a Globally Significant Biodiversity Area by the Forestry Department and this area is strictly protected and access is not allowed.

The reserve is situated within the high forest zone in the southwest of Ghana and lies in the tropical humid climate zone with very high relative humidity of about 85% over the year, with annual rainfall ranging from 1500 to 3000 mm. The topography is fairly undulating, with altitudes in the range 60 to125 m above sea level, but the northern, south-eastern and central parts have steep-sided hills that reach 300 m above sea level. The reserve forms part of the watershed between the Bonsa and Pra rivers and is traversed by tributaries of each, resulting in extensive areas of swampy vegetation which make access difficult even in the dry season.

Some areas of the reserve were subjected to salvage-felling between 1966 and 1976, followed by selective logging since 1978. Timber harvesting rights are given to concession holders including the SIPL [14]. Communal rights to collect deadwood, spices and raffia-leaves for domestic use as well as access to roads and paths are subject to free Forestry Service Division permits. The main non-timber forest products (NTFPs) harvested by the local people on permit are snails, rattan, *Acacia pennata* for sponge, *Celtis mildbraedii* for pestles and (*Garcinia* sp.) for chew stick.

METHODOLOGY

The Subri River Forest Reserve was demarcated into two zones: southern and northern zones; and ecological survey was done in the southern zone. Factors taken into consideration for selecting the site included accessibility, ecological sensitivity and avoidance of obviously disturbed areas. Two sites were demarcated for random sampling; Site 1 was located in the Subri natural forest and Site 2 in the Subri Industrial Plantation. Ten plots were established at site 1 while 40 plots were established at site 2, taking the sizes of the two sites into consideration. The number of plots in each site was chosen, considering the size of each site- this was to give proportionate sampling.

A representative of 0.1ha (radius of 5.64m) circular plots were delimited and in all, a total of 50 temporary plots were randomly established. In each 0.1 ha circular plot, a vernier caliper was used to measure the diameter of all lianes ≥ 3.2 cm at 1.3 m (diameter at breast height) above the forest floor. The plots were demarcated at least 30m away from forest roads and routes to eliminate border effects [15].

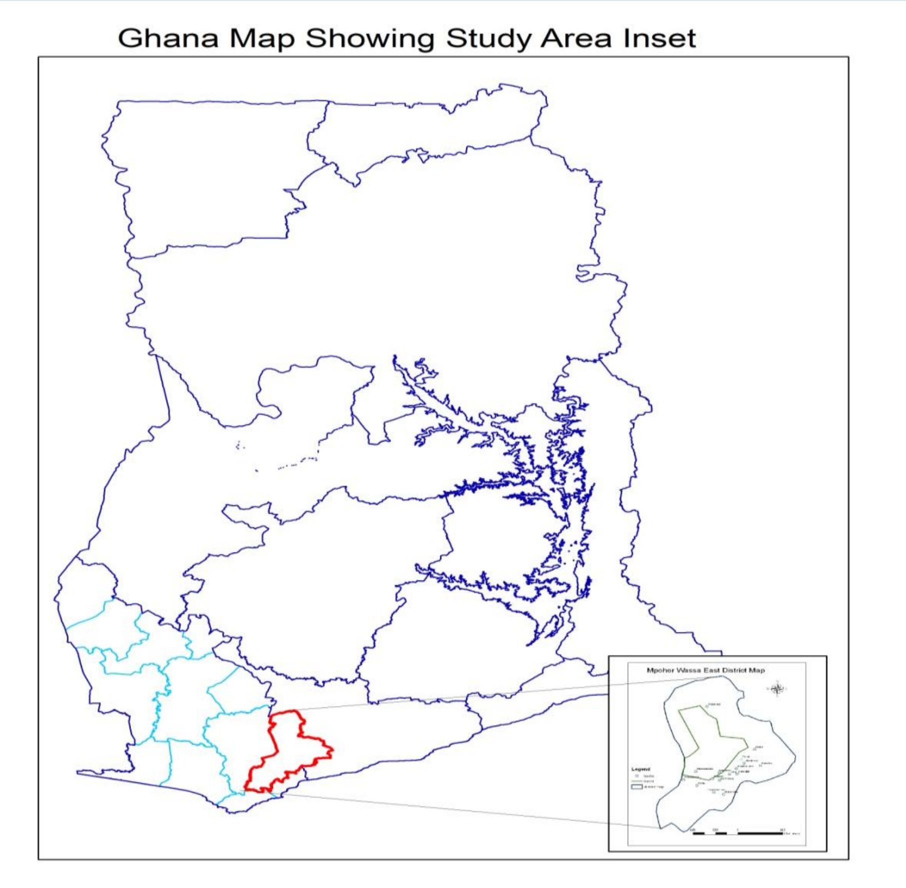

Fig. 1: Map of Ghana showing Mpohor Wassa East District and Study Area

Data analysis

The lianes were identified on the field using plant parts such as leaves, flowers and fruits, and slashing of the bark to look for significant exudates, texture and external characteristics [16]. Voucher specimen of species that could not be identified on the field were collected and identified at the Herbarium of the University of Cape Coast.

Basal area, relative dominance, relative density, relative frequency, species diversity, species evenness and importance value index were calculated, using the formulae given below.

Basal Area (m^2) = Area occupied by plant at breast height

$$= 3.142 \times (DBH/200)^2 \quad (1)$$

where DBH is the Diameter at Breast Height in centimeters

The relative importance of the lianes was calculated as follows:

Relative Dominance (RDo) = $(B_s / B_T) \times 100$ (2)
where Bs = basal area of a single species
B_T = total basal area of all species

Relative Density (RDe) = $(n_i / N) \times 100$ (3)
where n_i = number of individuals of i^{th} species
N = total number of individuals
Relative Frequency (RFr) = $(f_i / F) \times 100$ (4)
where f_i = frequency of a species
F= sum or total frequency of all species

Importance Value Index (IVI) = Σ (RDe + RDo + RFr) (5)
The IVI was used to determine the ecological importance of the species. The Raunkaier's Law of Frequency or valence analysis was used to assess the rarity or commonness of the species [17].

The species diversity of the lianes was calculated using appropriate formulae [18].

i. Simpson's Diversity Index (D),

$$D = 1 - \frac{\Sigma ni(ni-1)}{N(N-1)} \quad (6)$$

where ni = number of individuals of the i^{th} species
N= total number of individuals

ii Shannon-Weiner diversity index (H^1)

$$H^1 = -\Sigma \rho i \ln \rho i \quad (7)$$

where pi = ni / N

iii. Species Evenness (E) = $H^1 / \ln S$ (8)
where S = number of species.

RESULTS

Composition and structural attributes of lianes

A total of 11 liane species belonging to 10 families were encountered in the survey. There is representation of species among the families. With the exception of Mimosaceae which had 2 species, all the families, had only a single species each. The species composition, families and attributes of the lianes are presented in Table 1.

Grewia carpinifolia Juss. had the highest occurrence (40%), followed by *Acacia pennata* Willd. with 14%, while six species of the lianes had least frequency of 2% each. In terms of number of individuals of species, *Grewia* sp. again had the highest mean density of 5.8 ha^{-1}, nonetheless, the density for each species was very low. The basal area of the species were also generally low, ranging from 0.01 to 0.05 m^2, with the exception of *Momordica angustisepala* Harms which had a basal area of 0.07 m^2.

Table 1: Density, Percentage frequency and Basal area of lianes in the forest

Species name	Family	Density /ha^{-1}	Percentage frequency/%	Basal area/m^2
Acacia pennata Willd.	Mimosaceae	1.6	14	0.05
Adenia lobata (Jacq.) Engl.	Passifloraceae	0.2	2	0.01
Dioclea reflexa Hook f.	Papilionaceae	0.2	2	0.05
Entada scelerata A. Chev.	Mimosaceae	0.4	2	0.01
Gouania longipetala Hemsl.?	Rhamnaceae	0.2	2	0.03
Grewia carpinifolia Juss.	Tiliaceae	5.8	40	0.03
Griffonia simplicifolia Bail.	Caesalpinaceae	2	12	0.03
Landolphia calabarica (Stapf) E. A. Druce	Apocynaceae	0.6	6	0.03
Momordica angustisepala Harms	Cucurbitaceae	1	6	0.07
Salacia debilis Walp.	Celastraceae	0.2	2	0.02
Santaloides afzelii (R. Br. ex Planch.) Schellenb.	Connaraceae	0.8	2	0.04

Relative importance and Species diversity of lianes

The importance value indices of the lianes were very low, while the most ecologically important liane in the forest was *Grewia carpinifolia,* which recorded an IVI of 6.27. Species diversity of the lianes in the forest reserve was also relatively low. The Simpson's index and Shannon-Weiner index gave 0.76 and 1.78, respectively. The Species evenness was high (0.74).

Distribution of species according to Raunkiaer's frequency classes

The distribution of the 11 lianes into Raunkiaer's frequency classes showed that almost all the species encountered in the forest reserve were rare, while only one was of low frequency; none was of intermediate frequency; moderately high frequency; or high frequency or common.

Table 2: Distribution of species according to Raunkiaer's frequency classes.

Class code	Percentage Frequency	Number of species	% number of species	Remarks
A	0-20	10	90.9	rare
B	20-40	1	9.1	low
C	40-60	0	0.0	intermediate frequency
D	60-80	0	0.0	moderately high frequency
E	80-100	0	0.0	high frequency (common)

DISCUSSION

Biological communities vary in the number of species they contain and a knowledge of this number is important in understanding the structure of the community. The total of 11 lianes identified in the 5 ha study area is quite low. The seemingly low number of species may be due to past disturbances, for example logging, undergone by the forest [19].

Species diversity in a community comprises the number of species referred to as species richness, and the relative abundance of species. Diversity indices provide important information about rarity and commonness of species in a community and it is the most important aspect of plant distribution. Shannon-Weiner diversity index of 1.78 is quite low, though the Simpson's diversity index of 0.76 as well as species evenness of 0.74 are quite high. Simpson's index is considered a dominance index because it less sensitive to species richness and weights heavily towards the abundance of the most common species. However, the Shannon-Weaver index is affected by both number of species and evenness of their population and it is often more sensitive to environmental disturbance. It therefore gives a true reflection of the species diversity in a community, hence it is the most commonly used index in ecological studies. This may therefore, suggest that the species diversity of the lianes in the forest reserve is low.

The most important tool employed by ecologists in vegetation analysis is the Importance Value Index (IVI), though vegetation can be described in terms of commonest species and/or numbers. The most ecologically important liane in the forest was *Grewia carpinifolia,* largely due to its relative frequency and density. Thus, *Grewia carpinifolia* was the most frequently encountered and the most abundant species in the forest reserve. One advantage of using IVI is that it dampens the effects of single large individuals, or infrequent species which, when present, are very abundant. The Raunkiaer's frequency class distribution of the lianes indicated that almost all the species (90.9%) were rare. The high number of rare species recorded in this study is in agreement with the generally acclaimed notion that most species are rare, rather than being common [20].

Dominant plants are the most noticeable that take up the most room and control some environmental conditions. The most dominant liane in terms of basal area in the current study area was *Momordica angustisepala*, however the basal area of all the lianes encountered was generally low. Even though the low basal area of the lianes cannot be easily attributed to any one factor, light availability and topographic positions differently affect liane growth, mortality and survival [21]. Furthermore, all the taxonomic families were endemic by virtue of the fact that they contain single species except Mimosaceae that had two.

Trellis availability and canopy structure (i.e. canopy openness and tree architecture) together influence the distribution and abundance of lianas in different forest types [22]. Additionally, recent studies have shown that the success of lianas may depend more on the availability of suitable host trees than on soil conditions [23]. Furthermore, tree fall dynamics together with host tree identity and host availability may be important factors determining the abundance and species composition of liana communities [24].

CONCLUSION AND RECOMMENDATION

The results of the study have shown that liane species in the Subri River Forest Reserve are rare and less diverse coupled with low structural attributes. Lianes in this reserve are also harvested by the local people for various uses. It is therefore, recommended that further studies should be done on lianes in relation to their host plants, canopy openings (gaps), microclimatic and edaphic factors.

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REFERENCES

1. Letcher, S. G. and R. L. Chazdon. 2009. Lianas and self-supporting plants during tropical forest succession. *Forest Ecology and Management*, **257:** 2150-2156.
2. Bongers, F., Schnitzer, S. A. and Traoré, D. 2002. The importance of lianas andconsequences for forest management in West Africa. *Bioterre. Revue Internationale de Science de la Vie et de la Terre* N° Spécial: 59-70.
3. Schnitzer, S. A., Dalling, J. W. and Carson, W. P. 2000. The impact of lianas on tree regeneration in tropical moist forest canopy gaps: evidence for an alternative pathway of gap-phase regeneration. *Journal of Ecology*, **88:** 655 - 666.
4. Schnitzer, S. A. and Bongers, F. 2002. The ecology of lianas and their role in forests. *Trends in Ecology and Evolution*, **17:** 223 - 230.
5. Bongers, F., Parren, M .P .E. and Traoré, D. 2005. Forest climbing plants of West Africa: Diversity, Ecology and Management. CAB International, Wallingford, Oxfordshire, UK.

6. Hall, J. B. and Swaine, M. D. 1981. *Distribution and ecology of vascular plants in a tropical rain forest: Forest vegetation in Ghana*. Geobotany 1. Junk Publishers, The Hague. pp 383.
7. Ewango, C. E. N. 2010. *The liana assemblage of a Congolian rainforest: Diversity, Structure and Dynamics*. A PhD Thesis submitted to Wageningen University, Netherlands. Available online: http://edepot.wur.nl/155789, Assessed 17/05/2013.
8. Andrade, J. L., Meinzer, F. C., Goldstein, G. and Schnitzer, S. A. 2005. Water uptake and transport in lianas and co-occurring trees of a seasonally dry tropical forest. Trees 19:282–289.
9. Lewis, S. L., Lopez-Gonzalez, G., Sonké, B., Affum-Baffoe, K., Baker, T. R., Ojo, L. O.,. Phillips, O. L, Reitsma, J. M., White, L., Comiskey, J. A., Djuikouo, M-N. K., Ewango, C. E. N., Feldpausch, T. R.,. Hamilton, A. C., Gloor, M., Hart, T., Hladik, A., Lloyd, J., Lovett, J. C., Makana, J-R., Malhi, Y., Mbago, F. M., Ndangalasi, H. J., Peacock, J.,. Peh, K. S.- H, Sheil, D., Sunderland, T., Swaine, M. D., Taplin, J., Taylor, D., Thomas, S. C.,. Votere, R and Wöll, H. 2009. Increasing carbon storage in intact African tropical forests. *Nature*, **457:** 1003-1006.
10. Van Andel, T. 2000. Non-timber forest products of the north-West District of Guyana. Tropenbos-Guyana Series 8a, Tropenbos Foundation, Wageningen.

11. Nabe-Nielsen, J., Kollmann, J. and Peña-Claros, M. 2009. Effects of liana load, tree diameter and distances between conspecifics on seed production in tropical timber trees. *Forest Ecology and Management*, **257:** 987-993.
12. Ingwell, L. L., Wright, S. J., Becklund, K. K., Hubbell, S.P. and Schnitzer, S. A. 2010. The impact of lianas on 10 years of tree growth and mortality on Barro Colorado Island, Panama. *Journal of Ecology*, **98:** 879-887.
13. Bongers, F. 2001. Methods to assess tropical rain forest canopy structure: an overview. *Plant Ecology*, **153:** 263 – 277.
14. Forestry Commission. 2002. *A Management Plan for Subri River Forest Reserve*, *Western Region, Takoradi*. Regional Planning Team, Takoradi.
15. Alder, D. and Synnot, T. J. 1992. *Permanent Sample Plot Techniques for Mixed Tropical Forest*. Oxford Forestry Institute, Oxford.
16. Hawthorne, W. D. and Jongkind, C. C. H. 2006. *Woody plants of Western African forests: A guide to the forest trees, shrubs and lianes from Senegal to Ghana*. Royal Botanic Gardens, Kew, U.K.
17. Odum, E. P. 1971. *Fundamentals of Ecology*, 3rd edition. W. B. Saunders Company, USA.
18. Magurran, A. E. 2004.*Measuring Biological Diversity.* Blackwell Publishing Company, USA.
19. Pappoe, A. N. M. 1998. *Ecological studies on a tropical moist semi-deciduous forest in Ghana*. M. Phil. Thesis, University of Cape Coast.
20. Greig-Smith, P. 1983. *Quantitative plant ecology*. Butterworth and Co. Ltd, London.
21. Nabe-Nielsen, J. 2002. Growth and mortality rates of the liana Machaerium cuspidatum in relation to light and topography position. *Biotropica*, **34:** 319-322.
22. Balfour, D. A. and Bond, W. J. 1993. Factors limiting climber distribution and abundance in a southern African forest. *Journal of Ecology*, **11:** 93-99.
23. Phillips, O. L., Martínez, R. V., Mendoza, A. M., Baker, T. R. and Vargas, P. N. (2005. Large lianas as hyperdynamic elements of the tropical forest canopy. *Ecology*, **86:** 1250 - 1258.
24. Ibarra-Manríquez, G. and Martínez-Ramos, M. 2002. Landscape variation of liana communities in a Neotropical rain forest. *Plant Ecology*, **160:** 91 - 112.

THEME 10: CLIMATE CHANGE AND POLITICAL INSTABILITY IN AFRICA

Climate change and political instability in Africa

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ABSTRACT

In Africa, the influence of climate change on socio-economic, political and agricultural development is becoming real. Most countries in sub-Saharan Africa depends extensively rain on fed agriculture, transhumance livestock practices and on un-sustainable exploitation of forests resources for both timber and non timber products. The climate record for Africa indicted the temperature to have increased by 0.7°C over most of the continent during the 20th Century and a decrease in rainfall over large portions of the Sahel. In the African dry lands which are home to about 320 million people, climate change is threatening to exacerbate the current level of poverty and existing land degradation problems, thereby, adding to the vulnerability of the dry land inhabitants. In the recent past, about 25% of the fragile Africa dry lands have been degraded by desertification. In Nigeria, environmental degradation occasioned by climate change and misuse of natural resources, led to incessant rains in most parts of the country in 2012. These led to displacement of thousands of people and loss of properties worth billions of naira. Coupled with this, transhumance agriculture has resulted to serious conflicts between Fulani herdsmen and other indigenes in Nigeria. As herdsmen move from the northern to the southern part of the country in search of green pastures, incessant clashes over destruction of farm products have resulted in several deaths and hostilities in several communities. With a total of 330 million people living in extreme poverty, the low technological adaptation and mitigation capabilities make climate change a serious potential for political instability in Africa. Thus, the productivity, sustainability and stability of Africa's environment depend on how climate change is managed. This paper examine the causes of climate change and environmental degradation in Africa. The relationships between environmental degradation, flooding, drought, agricultural production and productivity, livestock rearing and deforestation are highlighted. The impacts of these on livelihoods and their role in armed conflicts in several parts of Africa are examined. The implications of these to sustainable development of Africa are also highlighted.

Keywords: instability, degradation, herdsmen, migration, rainfed

INTRODUCTION

Climate change is one of the major contending issues in this century. Its impact is global, and it is affecting systems of government, trade, transportation, industry and economic development in nearly all the regions of the world. It has also been identified as a leading human environmental crisis of the 21st century. The science of climate change has come a long way since the earth summit in Rio de Janeiro in 1992 and the adoption of Kyoto Protocol in 1997. It is now generally accepted that the climate is changing and even at the best scenario, it is going to have major impacts on global weather patterns and consequently, people's lives, especially the poor.

In 2007, the fourth assessment report on the Inter-governmental Panel on Climate Change (IPCC) presented incontrovertible evidence that the global climate is changing because of human activities. Since the first IPCC report published in 1990, scientific knowledge has been growing and policy responses are being initiated at international, national and local levels.

The problems of understanding and responding to the vagaries of climate change are some of the major challenges confronting Africa. A large number of reports have suggested that climate change is a security threat in Africa [1]. Concerns over the negative impact of climate change have strengthened fears that environmental degradation and demographic pressures will displace millions of people in Africa and create serious political upheavals. However based on the wide expanse of Africa and the different ecological zones that transverse the continent, the impact of climate change may vary within the region. Nevertheless, the low technological capacity, dependence on rain fed agriculture, wide destruction and degradation of forests, the near total dependence on natural resources will greatly exacerbate the impact of climate change in Africa. In view of upheavals that may follow, climate change will pose serious political risk on African population. In this paper, the climate change and political upheavals in Africa are examined. Recommendations capable of mitigating some of the actual and envisaged problems are discussed.

CLIMATE CHANGE AND TROPICAL DEFORESTATION

Since the beginning of the industrial revolution, there has been sharp increase in green house gases (GHG) emission into the atmosphere mainly due to CO_2 from the burning of fossil fuels and deforestation. As a result, mean temperatures are expected to rise at a rate of 0.1 to 0.4^oC per decade during the first half of the century [2]. The greenhouse effect is caused by CO_2 which is growing at 0,5% per year and will double in 2100 [3]. At least 60% of climate change can be attributed to human activities. Burning of fossil fuel alone contribute 6 billion tons of carbon emissions annually [4]. To maintain CO_2 concentration in the atmosphere at current level would require a reduction in global emissions of more than 40%. This will necessitate about 85% cut in fossil fuel utilization.

Forests are vital parts of global efforts to address climate change. FAO estimated that global forests store 286 gigatonnes (GT) of carbon in their biomass [5]. If this is complemented with carbon stored in the deadwoods, litter and soil, it will be up to 762 GT, which is more than the carbon stored in the atmosphere. According to IPCC, the total annual turnover of carbon between global forests and atmosphere (as characterized by gross primary production) ranged from 55 to 85 GT per year [6]. The amount of atmospheric carbon transformed into forest biomass through primary production has been estimated at 25 to 30 GT per year [7]. Trees also act as net sinks for SO_2, NO_2 and other particulate matters [8].

The major factors that limit the potentials of forests from mitigating climate change are deforestation, forest fires and application of unsustainable management methods. Deforestation is the loss of tree cover, usually as a result of forest clearance for other land uses. Deforestation affects carbon fluxes in the soil, vegetation and atmosphere. Tropical deforestation is the most potent as a result of its tendency to release higher quantity of CO_2 at very fast rates. Despite this, tropical deforestation has been going on at a very high rate. In the tropics, the drivers of deforestation vary among regions. Williams categorized direct drivers of deforestation as agriculture, most especially, shifting cultivation farming practices which is predominant in most parts of Africa, timber extraction, fuel wood harvests, road construction and urbanization [9].

According to FAO, about 14.6 million hectares of natural forests are lost annually to deforestation [10]. Of this, 1.5 million hectares was converted into plantations aimed at increasing wood supply [11]. FAO also reported that Nigeria has the highest rate of deforestation in the world [12]. Between 1990 and 2005, Nigeria lost 35.7% of its forest cover or 6, 145,000 hectares of forests [13]. As a result, a lot of damage has been done to Nigeria's landscape. One of this is the advancing desertification in the northern part of the country [14].

Thus, tropical forests of all varieties are disappearing rapidly as humans clear the natural landscape to make room for farms and pastures, to harvest timber for construction and fuel, and to build roads and urban areas. The high rate of deforestation has profound and devastating consequencies. Among these are social conflicts, extinction of plants and animals and climate change. When an area is completely deforested for farming, the farmer typically burn the trees and vegetation to create a fertilizing layer of ash. After this slash-and-burn deforestation, the nutrient reservoir is lost, flooding and erosion rates are high, and soils often become unable to support crops after a few years. If the area is then turned into cattle pasture, the ground may become compacted as well, slowing down or preventing forest recovery.

IMPACTS OF CLIMATE CHANGE IN AFRICA

Africa is one of the most vulnerable regions to climate change. The vulnerability and limitations of the poor countries to adapt to climate change challenges were highlighted in the Third Assessment Report of the Inter-governmental Panel on Climate Change (IPCC) . The historical climate record for Africa shows warming of approrimately 0.7°C over most of the continent during the 20th century, a decrease in rain fall over large portions of the Sahel (the semi-arid region south of the Sahara) and an increase in rainfall in east central Africa. Over the next century, this warming trends and changes in patterns are expected to continue and be accompanied by a rise in sea level and increase frequency of extreme weather events. The general agreement about the trend of changes in temperature, precipitation and extreme event are shown below.

i. Global mean surface temperature is projected to increase between 1.5°C and 6° C by 2100,

ii. Sea levels are projected to rise by 15 to 95cm by 2100,

iii. Climate change scenerios for Africa indicate future warming across the continent ranging from 0.2°C per decade to more than 0.5°C per decade [15]. The warmings will be greatest over the interior of semi arids magins of Sahara and Central Southern Africa

The actual and potential impact of climate change in Africa are large and wide ranging affecting many aspects of people's lives. Climate change will result in higher temperatures, the drying up of soils, increased pest and disease pressures, shifts in suitable areas for growing crops and livestock, increased desertification in the Sahara region, floods, deforestation and erosion. Some of these signs are already showing and represents one of the environmental, social and economic threats facing Africa. As far as development is concerned, climate change will have a strong impact on Africa's ability to achieve Millennium Development Goals in general with increased pressure on agriculture, water supply and demand, health and political stability. The impacts of climate change on processes in Africa are subsequently highlighted.

Agriculture

Most of Africa relies on rainfed agriculture. Africa has seven distinct climate zones and ecosystems ranging from Sahara to the rain forest of central Africa [16]. While Africa is vulnerable to changes in its climate variability, the effects will be variable and variegated as the impacts on agricultural productivity will vary between and within countries. Available climate change evidence for Africa suggests increasing agricultural production in Central Africa and failing agricultural yields in the horn of Africa, encroaching desert like environments in Algeria, Chad and Mali; the destruction of marine and coastal resources and damage to property and infrastructure. These changes are already undermining the carrying capacity of large parts of many pastoral regions in Africa, causing destabilization in population movements and raising tensions over dwindling key resources. For instance the herder-farmer conflicts in parts of Sudan and Kenya and in Nigeria show instances when impacts of climate change increase the risk of violence. The impact of climate change on different agricultural crops remains uncertain. For instance, maize and wheat in southern Africa show negative effects and cowpeas in eastern Africa shows strong negative effects. The areas suitable for agriculture, the length of the growing season and the yield potential are expected to decrease along margins of semi arid and arid areas. While southern Africa is most likely to be affected by crop yields, areas such as Burkina Faso and Mali will show evidence of increased agricultural production (especially millet) of 55% and 35% respectively because of increase in rainfall and could experience improved human welfare [17]. In Chad, agricultural yields are projected to decrease by 50% by 2020 [18].

In West Africa, most countries apart from Mali and Burkina Faso have experienced a year on year reduction in rainfall. In the northern part of the Sahel, the whole year water cycle has been affected with serious consequences for agriculture and food security. The rainfall pattern has changed and the number of natural disasters on the increase. In 2008 for example, torrential rain led to flooding of vast cultivated areas and loss of lives. The dry, cold easterly trade wind that blows along West Africa coast has weakened with Benin and Cote d'ivore affected in particular. The increasing disruption of agricultural calendars and crop seasons by variations in the onset of the wet season militates against proper planning and agricultural activities, resulting in crop failures.

Food Security

The UNDP warns that human development progress achieved over the past decade may be slowed down or reverted by climate change as new threats emerge to water and food security. UNDP observed that impacts of climate change could by 2080 push another 600 million people into malnutrition[19]. In recent years, world food prices have sky rocketed causing severe hardship for poor and vulnerable people throughout the world and in particular in Africa. Between 2005 and 2008, world prices of rice, wheat and maize have doubled, pushing more than 100 million in people into poverty including nearly 30 million people in Africa [20]. Severe and prolonged drought, flooding, loss of arable land due to deforestation, overgrazing and fuelwood gathering that has led to soil degradation are reducing agricultural yields and causing crop failures and loss of livestock which endangers rural and pastoral populations. The horn of Africa pastureland have been severely hit by recurrent droughts, causing livestock losses that have plunged appromately 11 million people who are dependent on livestock for their lilihoods into crises and triggering mass migration of pastoeralists out of drought affected areas (IPS, 2010). The causes of food crises in Africa remained land degradation through outdated farming practices, inadequate power generation capacity and distribution networks, poor quality roads and facilities and lack of water storage and irrigation capacity that limited agriculture, imperil food security and held back trade in agricultural based products [21].

Climate change is affecting all dimensions of food security in Africa. These are food availability, food accessibility, food utilization and food systems stability. It is also impacting on food production and distribution channels as well as changing purchasing power and market flows [22]. Its influence will both be short term, resulting from more frequent and more intense extreme weather events and long term, caused by changing temperature and precipitation patterns [23]. The decline in the availability of wild foods due to scarcity of water or labour resulting from climate change could result in reduced food production. Climate change will also cause new patterns of pests and diseases to emerge, affecting plants and human health. In addition increased incidence of water borne diseases in flood prone areas, changes in vector for climate responsive pests and diseases could affect that both food chain and people's physiological ability to obtain necessary nutrients from the food they consume. It is however expected that food systems may be stable as the technology advances and development of long distance marketing chains that moved produced foods throughout Africa at high speed and at relatively low cost will make food system performance far less dependent on climate. The problems envisaged here are affordability and availability of preferred food in various communities.

To combat the menace, there may be need for adaptation strategies that will help alleviate the pains and growing risks. Agriculture, forestry and fisheries will be seriously affected by climate change, thereby making it difficult to half the number of under nourished people by 2015. Currently out of the 36 countries regarded worldwide, as food insecure, 21 are in Africa [24]. The region has the highest percentage of malnourished inhabitants in the world with nearly 70% of the people living in chronic hunger [25]. The situation is expected to worsen under climate change which could push crops, livestock and farmers out of the livelihood niches.

Water availability

The gradual yet dramatic disappearance of glaciers on mount Kilimanjaro is a result of global warming [26]. An estimated 82% of ice cap that crown the mountain when it was thoroughly surveyed in 1912 is now gone [27]. Other glaciers in Africa (Ruwenzori in Uganda and mount Kenya) are also under similar threat. According to ISS (2012), available statistics on impact of climate change for Africa suggest increasingly scarce water resources in Central Africa and destruction of marine and coastal resources. These changes are already undermining the carrying capacity of large parts of the dry pastoral regions in Africa causing destabilising population movements and raising tensions over dwindling key resources.

Access to clean water is a major problem in many African countries [28]. One third of the people live in drought prone regions and one quater or about 200 million people currently experience significant water stress [29]. Drought account for 31 percent of all disasters in Africa between 1975 and 2002, while floods accounted for 26% [30]. The horn of Africa countries of Ethopia, Somalia and Eriterea have suffered more drought related deaths (estimated 600,000) over the last century than any other part of Africa [31]. The countries have also experienced persistent conflict on internal and regional basis.

FAO's 1985 study of the carrying capacity of land in developing countries compared Africa's projected future population with its food production potential. According to the study, the number of countries unable to feed themselves from home production using the present low level of imputs will rise from 22 out of 49 in 1975 to 32 by the end of the Century and to 35 by year 2025.

Most countries of the sahel and mountainous East Africa will face severe problems. Ethopia's 1983 population of 36 million will more than treble to 112 million in 2025, fourty-four million more than it can feed with immediate inputs. Nigeria's population in 2025 is projected to reach 338 million in excess of its carrying capacity with intermediate inputs. Even with high inputs Kenya's land can only support 51 million people, a total that will be passed by 2010.

Environmental challenges

The consequences of climate change for migration present humanity with an unprecidented challenge. The incidence of storms and floods have increased threefold in the last 30 years with devastating effects in vulnerable communities, particularly in developing countries. In 2008, extreme weather events displaced 20 million persons compared with 4.6 million people displaced within their own countries by conflict and violence over the same period. IOM forcast that bewtween 25 million to 1 billion people will be displaced by 2050 [32].

In Angola, floods hit the southern and eastern parts in 2009, destroying many houses and leaving many displaced. According to IOM, that was the third year in sequence of such occurence affected Angola and caused rivers such as Zambesi to flood [33]. In Egypt, the northern coastal zone, which is characterized by low-lying delta of the Nile is the home to 95% of the countries population and agricultural activity while comprising only 5.5% of the total land area (IOM, 2009). It has been estimated that a sea level rise of 50 cm by 2025 in the delta could displace over 2 million people, flood 1,800 square kilometers or cropland and result in USD 35billion worth of damage to the land, property and infrastructure. In addition , strategic water storage infrastructure such as lake Nasser is likely to be exposed to increased evaporation and more frequent flood risk. Also in the flood affected IDPs in Grambella region of Ethiopia, flooding is a recurrent phenomenon [34]. Flash floods caused by heavy rainfall in the highlands cause rivers and tributaries to overflow overenight, flooding whole villages and leaving communities no option than to flee their settlements. Annual flooding in the last five years alone, has resulted in displacemnets of more than 170,000 people and the loss of more tahn 2,700 livestock. Futhermore, affected communities had experienced significant infrastructural damages and more than 6,500 hectares of cropland had been lost. In 2008, flooding in the region left thousands of households displaced with no shelter, no access to portable water and no basic necessities as many household items were lost due to the flood. In addition to floods, conflict is a major challenge in the first nine months of 2009. More than 40,000 people have been displaced mainly due to cross border cattle raids from Sudan that have severe consequencies such as loss of lives and materials assets, increased exposure to diseases and limited or no access to land and food. In northern parts of Kenya, crop failure due to poor rains and chronic droughts have been aggravating an already unstable situation. Prolonged and cyclic drought is affecting pastoralist communities already strained from loss of pastures, scarcity of water, declining terms of trade for sheep, goats and cattle, high prices of food and farmine [35]. In addition to the low productivity of the rangelands, pastoralists are forced to move frequently to exploit available resources between seasons. This has caused cross border resource based armed conflicts.

In Nigeria, since 2012, incessant rains have led to displacement of hundreds of thousands of people while properties running into billions of naira were destroyed. This necessitated the doling of N17.6 billion by the Federal Government in year 2012 to states and agencies to cushion the effects of flooding that ravaged many parts of the country [36]. The government categorized the states into four groups on the basis of extent of the effect of the flooding. The worst affected states which are in the first category include Oyo, Kogi, Benue, Plateau, Adamawa, Delta, Bayelsa and Anambra received N500 million while the second, third and fourth categories received N400 million, N300 million and 250 million respectively [37].

According to vision 2010 main Committee report of (1997) the major environmental problems being faced by Nigeria include:

i) Population pressure and the continuous exploitation of marginal lands, aggravating the process of drought and desertification in the north;
ii) Severe gully erosion in Eastern and Northern states;
iii) Coastal and marine erosion, and land subsidence in coastal and riverine states;
iv) Flooding in low-lying belt of mangrove and fresh swamps along the coast, the plains of large rivers and short-lived flash floods in the inland river;
v) Uncontrolled logging with inherent problems of the destruction of bio-diversity;
vi) Inappropriate agricultural practices;
vii) Destruction of watersheds;
viii) Soil-crust formation caused by loss of water;
ix) Destruction of vast agricultural lands;
x) Creation of burrow pits associated with bad mining practices and road works;
xi) Oil pollution from spillage and gas flaring related problems;
xii) Urban decay and squatter settlements;
xiii) Industrial pollution and municipal waste generation; and
xiv) Climatic change and ozone depletion.

From the perspectives of physical and cultural landscapes, the natural environment in Nigeria has been seriously bastardized. In addition the cultural landscape which denotes interaction between man and environment has shown that the Nigeria environment have been seriously bastardized by activities such as agriculture, mining operations, sinking of boreholes, wells, tree felling and construction of bridges, houses, road networks and railway among others [38]. Land degradation has assumed a definite pattern in Nigeria

[39]. For example, erosion has ravaged much of the eastern parts of Nigeria. In the area, both active and inactive gullied surface areas range from 0.7km for Ohafia and 1.15km for Abiriba in Abia state. The width of the gulleys ranges from 2.4km for Abiriba and 0.4km for Ohafia. Furthermore, a minimum depth of 120km gullied surface has been recorded at Abiriba. Also, problems of widespread sheet wash erosion have resulted in the failure of agricultural activities. In the Northern and Western axis of Nigeria, erosion is equally serious, especially in places like Shendam and Western Pankshin of Plateau State, Efon Alaaye in Ondo state, Ankpa and Okene in Kogi state of Nigeria. [40]. Generally, the observation of the patterned nature of land degradation reveals that no part of Nigeria is spared from this wreckage [41].

Climate change and security threat in Africa

Burke et al reported that there are strong historical linkages between civil war and temperature in Africa, with warmer years, leading to increasing livelihood of war [42]. Using climate model projections, the authors estimated an additional 393,000 battle deaths by 2030. Using 1981 to 2002 data they indicated that 1^{o}C increase in temperature is likely to result in remarkable 49% incidence of civil war in in sub saharan Africa. Also, a new study has shown that there is a link between climate change and human violence according to researchers at the University of Carlifornia, Berkely and Princeton University [43]. The authors studied data that covers all the major regions of the world and show similar patterns of conflicts linked to climate change such as increased drought and higher than average temperature. Examples include spikes in domestic violence in India and Australia, increased assult and murder in the United States and Tanzania; ethnic violence in Europe and South Asia, land invasions in Brazil, police resulting to force in Holland and civil conflicts in tropics [44]. To perform the analysis, the researchers sifted through hundreds of of studies published across a number of fields including climatology, political science and psychology and eventually settled on 60 studies on subjects related to climate, conflict, temperature, violence, crime and more and re -analysed the data using a more common statistical framework. The study showed that minor departures from normal temperatures or rainfall amounts substantially increased the risk of conflict on a variety of levels, ranging from individual aggression, such as murder and rape, to country level political instability and international wars [45].

Human security and environmental protection are mutually dependent. On the other hand depletion of natural resources undermines livelihoods, increases velnerability to disaster and put human security at risk. For instance the economies of Cameroon, Chad, the Democratic Republic of Congo and Nigeria rely on export of natural resources. The distruption of natural resources development and utilization will have significant impact on the economy of these countries, resulting in inabilities of government to adequately cater for responsibilities and consequently, social upheaveal. Distruption in agricultural production, increase in global food prices, land degradation and extensive poverty will lead to a lot of instability in most parts of Africa. Severe and prolonged droughts, flooding, loss of arable land due to deforestation , overgrazing and fuelwood gathering will compound the already terrible situation and lead to reduction in staple crops yield. These adverse consequencies of climate change seem inevitable as demostrated by the 2012 food situation in the Horn of Africa. This also have the inbuilt potentials of increasing arms conflict in sub saharan Africa [46]. The climate change linked spartial and temporal changes in rainfall patterns and frequent droughts make the survivabilty of African pastoralists in arid environments particularly difficult [47]. The pastural communities in the arid and semi-arid botherlands in Northern Kenya, southern Sudan and Southern Ethiopia are linked in competition over pasture and water, livestock raiding and heavy presence of arms [48]. The widesread use of arms by pasturalists in most parts of Africa, including Nigeria, remains a major concern of security policies [49]. In Algeria, only three percent of the land is arable. The pressure on the arable land and a serious risk of desertification, increased water scarcity and severe food shortages especially in the northern region made worse by rising temperatures and decreasing rainfall are likely to make reconcilliation after civi war difficult [50].

Most conflicts in Africa are attributable to demand for fair distribution of resources, historical greviances, disputes over over access to increasingly scarce resources and weak state institutions [51]. The Albertine Rift in the DRC which is in constant struggle to end an ongoing civil war, is one of the most biodiversity rich and ecologically unique regions of Africa. However, the region is the centre of one of the world's most devastating conflicts in recent history.

In general, it is becoming highly possible that climate change would displace people from their homes. In Nigeria, thousands of people were displaced from their homes in year 2012 as a result of flooding, internal conflicts and poverty. In Sudan also, more than 24% of the population are internally displaced. According to the UN Human Right Commission for Refugees, aroud 67 million people in the world had been forcibly displaced as a result of conflict, persecusion and and natural diasters by the end of 2007 [52].

Another major problem that will increase the impact of climate change on violence in Africa is the issue of population growth. The African population is growing rapidly with high incedence of urbanisation. This is increasing the demand for the limited and reducing resources. Most African states have difficulties in delivering basic services such as education, health care, housing, etc. In addition, Africa's economy is not growing fast enough to keep up with rate of population growth nor economic growth like the rest of the world. The reasons for these include inadequate governance, rampant corruption, disease, inadequate healthcare and near total dependence on natural resources and ongoing conflicts in many countries within the region. Some of these factors have made it difficult for African countries to strategise an adapt to climate change. Against this background, armed conflicts threatens lives and livelihoods and excarbates peoples vulnerability to climate change. Today, Africa is facing an economic loss of one to two percent annually because of climate change variability [53].

POLICY OPTIONS

Climate change has become a very important issue to be contended with in Africa. Unfortunately, most countries in Africa are not putting in place necessary adaptation and mitigation measures to combat the menace. Its impact may be moderated or magnified by underlying conditions of governance, poverty and resource management as well as the impact at local and regional levels. Appropriate climate adaptation policies and programmes are necessary to be instituted and implemented on time to preempt vast destuction of the environment and social factors.

One and perhaps a most important factor is the education the of population on climate change and its possible impacts on country to country basis. Climate information exists that could improve decision making, thereby mitigating the effects of climate change.

Knowledge and access to information are essential for effective environmental management and have significant impacts on people and the livelihood choices that people make. In most African countries, these information are not at present incorporated in policy formulation processes and development decisions [54]. According to IRI a major continent wide effort to integrate climate risk management into climate sensitive development processes at all levels is an urgent and top priority for Africa today [55]. Thus, raising awareness through climate information and providing evidence of its value to decision makers in climate sensitive sectors such as agriculture, forestry, most especially, deforestation and forest degradation are important.

In most parts of Africa, natural resources endowment has turned out to be a source of conflict. As it is not always widespread in availability, it is often the cause for agitation and disagreement with the redistribution of proceeds from such resources to the country as a whole. In Nigeria for instance, the agitation for resource control by the Niger Delta people is an agitation for control of the fossil fuel obtained in the region. This has led to armed struggle by militants against the state. Scholars have long considered the implications of polarity and skewed distribution of natural resource proceeds on the occurence of stife in Africa. In a number of cases, the hijacking of resources by the elevated political leaders have led to rampant corruption, high level of poverty and conflict. Such situations have the tendency to increase violent conflict, displace people internally, and result in forced emigration as has been the case in Dafur [56]. A concerted effort at resource redistribution to redress greviances will be a far more effective means of conflict prevention. Consequently, there is need to initiate good governance policies. Responding to any conflict in an effective and timely manner holds greater potentials for its resolution.

Dealing with climate related shocks in agricultural production and productivity induced by either temperature increase, flooding, etc, will require government initiatives and assistance by donor agencies. In Nigeria, the activities of Nigeria Emergency Management Agency (NEMA) is instructive. NEMA and its states equivalent are the agencies that are mandated to respond to such problems. It is however important that such measures should be upgraded to include participation by mandated research institutes to work on better adapted crop varieties and to provide farmers with the knowledge and incentives to use them. It has also become imperative for African countries to upgrade their technical capabilities and infrastructure in the areas of irrigation and water harvesting technologies.

Closely allied with the above is the need for the establishment of insurance schemes to protect poor households and communities from climate shocks. This could be done through the extension of the recently initiated weather-indexed crop and livestock insurance schemes in Ethiopia, Malawi and Morocco. In this case donor asssitance could be premised on climate risk indicators to augment local assistances when risk of violent is high.

Long term planning for climate sensitive resources should take into account the benefit provided by such resources. At all stages, plans should take into consideration, climate change consequencies. This will make coping with unexpected changes possible and to minimize potential risks.

Indigenous methods of coping strategies should be identified and modified, A compilation of such options may be a cost effective way of identifying feasible options. For example, agricultural practices in the dry lands of the sahel could be used in areas that may become drier. The adaptation options that require long term decisions should be identified and analysed for implementation [57].

Networking and collaboration should be encouraged. The intention of networking should be to build a critical mass of researchers and expertise that is often not available within individual countries and to encourage individual learning among them.

RECOMENDATIONS

Planting and protecting forests will be a crucial part of global response to climate change in terms of both mitigation and adaptation. This should however be approached in a multidisciplinary manner. Communities living in and around the land to be reforested should be involved in land use change proposals. Communities living adjacent to forests should be paid for ecosystem services. Timbers users and farmers should also be compensated for avoiding forests.

The rich and heavily polluting countries should have a comprehensive funding mechanism and compensation package for countries with low historical emmissions.

African countries need to pay more attention to population growth. In most countries existing services and facilities will not be able to cope with continous demand of growing population. It is therefore imperative for government to give more attention to controlling population growth as an importat part of any strategy to adapt to climate change.

International agreements and treaties made on the sharing of trans border water resources by African countries need to be reviewed in the light of apparent regional imbalances. This will require regional negotiation, cooperation and coordination to manage and allocate shared resources equitably [58].

Increased forest-related funding and discouragement of clear felling and financial incentives that offer adjacent population livelihood support may be required to promote afforestation and reduce deforestation. A number of projects that leads to deforestation are relatively low return, short term projects with low finacial returns. This indicated that financial incentives may not be high to reduce deforestation significantly.

African nations depends extensively on fuelwood for cooking. Promotion of clean cooking and the use of biofuels will reduce the current rate of deforestation in Africa. It will also reduce the rate of respiratory diseases which leads to high rate of death among children and women. In most African countries, the use of bamboo will substantially assist in reducing deforestation in view of its high yield, high growth rate and higher heating value compared to wood. The International Network for Bamboo and Rattan is currently promoting this initiative in a number of African countries.

In Africa, the mass media, African based non governmental organisations and the civil society have important roles to play in climate change issues. The media can raise awareness on climate change issues with the general public and local communities and when specific threats arise, they should convey risks and recommended responses. The

NGO's should take an active role in harnessing the continents natural resources for more sustainable development through environment friendly initiatives.

CONCLUSION

Climate change is already affecting countries in Africa. Its role in conflicts and instability in various countries in Africa has been identified and discussed. It is evident that Africa contributes less than 4% of the climate change being experienced globally. However, it will be the most affected region in the world as a result of low technological capacity, dependence on climate influenced natural resources, extensive and widespread povery and corruption. These facts are promoting violence and conflict within countries. The solution to climate change problems within African countries require policy intiatives on adaptation and mitigation. Some of these have been discussed in this paper. There is need for African countries to pursue these at policy level in order to make the fight against climate change sustainable.

REFERENCES

1. Holden, P. (2009). A peaceful environment for a hostile climate?. Journal of Peace Research and Action 14. 23-41.
2. IPCC (2000). Land use, land use change and forestry. Special Report. Cambridge University Press, Cambridge.
3. IPCC (2000). Land use, land use change and forestry. Special Report. Cambridge University Press, Cambridge.
4. IPCC (2000). Land use, land use change and forestry. Special Report. Cambridge University Press, Cambridge.
5. IPCC (2000). Land use, land use change and forestry. Special Report. Cambridge University Press, Cambridge.
6. FAO (2006). www.mongabay,com visited on 1oth February, 2011
7. Fapetu, O.P. (2000b). Production of charcoal from tropical biomass for industrial and metallurgical process. Nigerian Journal of Engineering Management. 1(2): 34-37
8. Williams, J. (2003). Financial and other Incentives for Plantation Forestry. In: proceedings of the International Conference on Timber Plantation Development, 87-101, Quezon City, Department of Environment and Natural Resources.
9. Fapetu, O.P. (2000a). Management of energy and tropical biomass. Nigerian Journal of Engineering Management. (1): 14-19.
10. FAO (2010) Global Forest Assessment Report 2010. Main Report, FAO Forestry Paper. 163. Pp 378
11. Ogunwusi, A.A. (2011a). Potentials of bamboo in Nigeria's Industrial Sector. *Journal of Research in Industrial Development* 9(2): 136-146.
12. FAO (2006). www.mongabay,com visited on 1oth February, 2011
13. FAO (2006). www.mongabay,com visited on 1oth February, 2011
14. Omofonmwan, S.I. and Osa-Edoh, G.I. (2008). The challenges of environmental problems in Nigeria. Journal of Human Ecology 23(1):53-67
15. Hulme, M, (2001). Climate Change in Southern Africa: An exploration of some potential impacts and implications in the SADC Region. Climatic Research Unit, University of East Anglia
16. Brown, O. And Crawford, A. (2009). Climate Change and Security in Africa. A study for the Nordic African Foreign Ministers Meeting. International Instutute for Sustainable Development, Winnipeg, March, 2009.
17. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
18. Heinrich Boll Foundation (2010). Climate change resource migration: securing Africa in uncertain climate. Regional Office, Southern Africa.
19. UNDP (2004). Review and Appraisal of the progress made in achieving the goals and objectives of the programme of action of the International Conference on population and Development , Economic and Social Affairs, 2004.
20. FAO (2008). Climate change and food security: aframework document, Rome:FAO, 2008,8.

21. African Partneship Forum (2007). Climate change and Africa. 22-23, May, 2007.
22. Tadese, D. (2010). The impact of climate change in Africa. Institute for Security Studies Paper220. Nov. 2010.
23. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
24. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
25. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
26. IPCC (2001). Impacts, Adaptation and Vulnerability. IPCC Working Group 11, Third Assessment Report. Cambridge University Press.
27. Desanker, P.V. (2012). Impact of Climate Change on life in Africa. Centre for African Development Solutions. South Africa.
28. Desanker, P.V. (2012). Impact of Climate Change on life in Africa. Centre for African Development Solutions. South Africa.
29. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
30. Brown, S. And Crwford,I (2009). Climate Change and Security in Africa. 2009.
31. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
32. IOM (2009). Migration. International Organisation for Migration.Published 2009.
33. IOM (2009). Migration. International Organisation for Migration.Published 2009.
34. IOM (2009). Migration. International Organisation for Migration.Published 2009.
35. IOM (2009). Migration. International Organisation for Migration.Published 2009.
36. Ogunwusi A.A. and M.A Jolaoso. (2012). Bamboo, Conservation of environment and sustainable development in Nigeria. Advances in Arts, Social Sciences and Education 2(9):346-358.
37. Ogunwusi A.A. and M.A Jolaoso. (2012). Bamboo, Conservation of environment and sustainable development in Nigeria. Advances in Arts, Social Sciences and Education 2(9):346-358.
38. Jimoh, H.I., O.D. Ajewole, S.I. Onotu and R.O. Ibrahim (2012). Implications of land degradation, reclamation and utilizations in the oil producing areas of Nigeria; perspectives on environmental sustainability and development. Environmental Research Journal 6(2): 100-105.
39. Ayoub, A.T. (1994). Human induced soil degradation in Africa. Proceedings of 8th International Soil Conservation Conference, December 4-8, 1994. New Delhi, India pp 34-42
40. Ayoub, A.T. (1994). Human induced soil degradation in Africa. Proceedings of 8th International Soil Conservation Conference, December 4-8, 1994. New Delhi, India pp 34-42
41. Asadu, C.L.A, P.I Ezeaku and G.U Nnaji (2004). Land use and soil management situations in Nigeria: An analytical review of changes. J. Outlook Agric USA., 33:27-37

42. Burke, E. (2009). Warming increases risk of civil war in Africa. Unpublished.

43. Freedman, A. (2013). Climate and Conflict: Warmer World may be more violent. Climate Central. AQAugust 1, 2013.
44. Freedman, A. (2013). Climate and Conflict: Warmer World may be more violent. Climate Central. AQAugust 1, 2013.
45. Than, K. (2013). Wars, Murders to rise due to climate warming?. National Geographic Daily News, Ist August, 2013.
46. Lobell, D.B., Isabella, N. Nyong, A. and Rosamond, N. (2008). Pririotising climate change adaptation needsfor food security in 2030. Sceince 319.
47. Boko, M., Niang, I, A. Nyong, Vogel C. And Pius, Y. (2007). Africa. Climate Change 2007. In Martin L. Parry and Hanson, C.E. (eds). Climate change 2007: Impacts, adaptation and vulnerability. Cambridge University Press. 433-467.
48. Jonah, L. (2009). Pastoralists at war: violence and securityin Kenya-Sudan-Uganda border region. International Journal of Conflict and Violence 3(2):188-203.
49. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
50. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
51. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp

52. UNHCR (2007). Global Trends: Refugees, assylum seekers, returnees, internally displaced and stateless persons. Global view and trend of developmentsin 2007. InternalDisplacement Monitoring Centre. Norwegian Refugee Council, Geneva, April, 2008.
53. World Development Report (2010). Development and Climate Change. The World Bank, Washington, D.C.
54. Tadese, D. (2010). The impact of climate change in Africa. Institute for Security Studies Paper 220. Nov. 2010.
55. IRI (2010). A gap analysisfor the implementation of the global climate observing system programme in Africa. IRI Technical Report 06-01, May, 2010.
56. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
57. Adano, R.W. and Daudi, F. (2012). Links between climate change, conflict and governance in Africa. Institute of Security Studies Paper No. 234. 16pp
58. Bells, C:, Warner,K; Butzengeiger, S. (2007): Insuring the uninsurable design options for a climate change funding mechanism. In : climate policy. Special issue on insurance and climate change

THEME 11: CLIMATE CHANGE AND TECHNOLOGY

A Fuzzy Based Model In Combating Climate Change Threat

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ABSTRACT
Climate change is one of the most complex, multifaceted and serious threats the world faces today. The response to this threat is fundamentally linked to the pressing concerns of sustainable development and global fairness; of economy and poverty reduction. Thus, there is a need for the development of new technologies in terms of new equipment, techniques and skills to combat effects of climate change which poses global threat to sustainable development in Nigeria and Africa at large. Consequently, technology to reduce the sources and build capacity in terms of information network is vital. In view of the above, this paper intends to review various existing technologies in Nigeria to mitigate the effects of climate change. In addition, a fuzzy based model that integrates government tiers and concerned sectors approach is presented. In conclusion, adopting this model will enhance the capacity of policy makers to formulate sustainable developmental policies to mitigate the adverse effects of climate change on the key sectors of the Nigerian economy.

Key words: Climate change, fuzzy model, sustainable development, poverty reduction.

INTRODUCTION

Climate change is regarded by the scholars as a long-term shift in the statistics of the weather variables over a period of time. It could show up as a change in climate normals (i.e. expected average values for temperature, sun shine degree, humidity and precipitation) for a given place and time of year, from one decade to the next (Petit, 2009). Also, climate change is often defined as a change in the state of the climate that are identifiable using statistical tests. This may include changes in the mean and/or the variability of its properties, which persists for an extended period, typically decades or longer (Hegerl *et al*, 2007).

However, it has being established that climate changes have high potential to affect the economic and ecology both positive and negative. This depends on the rapidity, size, and predictability of change. Some of the impacts of past change are evident in shifting agricultural productivity, forest insect infestations and fires, shifts in rainfall, high temperatures, and coastal erosion (Leggett, 2011). Also, the Intergovernmental Panel on Climate Change (IPCC, 2007) confirmed that the warming of the earth's climate system is unequivocal. This warming is attributed to the dramatic rise in human induced greenhouse gas emissions since the mid-20th century

Thus, there is an urgent need to ensure that all policies towards mitigating the effects of climate change achieve the desire result of low carbon, growing economy, with healthy, sustainable, resilient communities, sustainable water and agricultural resources, and thriving and productive ecosystems in the path towards sustainable development. So, there is need for meaningful review of all existing Climate Change Strategic Framework (CCSF). This includes all techniques and skills to combat effects of climate change at all levels of government and stakeholders' level (i.e. Organized Private Sector and International Organizations).

Furthermore, since it has being established that climate change is mostly human induced, consequently, early and effective policy action is required to discourage new high-carbon emission and to encourage policy at all levels of government in Nigeria and Africa to re-direct innovation towards low-carbon growth. This is with the aim of encouraging renewable energy to reduce the carbon emission intensity. In view of the above, this paper intends to review various existing technologies in Nigeria to mitigate the effects of climate change. In addition, a fuzzy based model that integrates government tiers and concerned sectors approach is presented.

EXISTING TECHNOLOGY

Nigeria, one of the developing countries (Odjugo, 2010), of recent has had shift in rainfall patterns, and extreme events such as droughts, floods, and forest fires become more frequent (Zoellick 2009), these result in poor and unpredictable yields, thereby making farmers more vulnerable, increasing poverty because citizen at large suffers food security. The climate change phenomenon has gained increased prominence in Nigeria in recent times mainly as a result of the major flooding we had last year. But it has always formed part of the national conversation on the environmental degradation of the Niger Delta region, and of the increasing desertification in the northern part of the country. The 2012 floods which affected 21 states of the Federation led to the displacement of thousands of our fellow citizens, the destruction of homes and farm lands and infrastructure- particularly roads, electric poles and pipelines resulting in some loss in food production in the second half of 2012. The government intervened with a N21.6 billion flood relief fund that ensure that the impact of the flooding on agricultural GDP was not as severe as it could have been. (Iguisi, 2013; www.climatechange.gov.ng)

Reconciling development with environmental protection and sustainable natural resource management is critical to avoiding the depletion of our natural capital, to mitigating the impacts of climate change and enhancing social cohesion. Thus, the present administration takes the threats posed by climate change very seriously and has taken solid measures to increase resilience to its deleterious impacts. One of the ecological challenges is the massive shrinking of Lake Chad and rapid desertification. On Lake Chad, Nigeria is leading the initiative to re-channel the Ubangi River in Central Africa into the Chad Basin under the Inter-Basin Water Transfer Scheme and provided US$5 million out of the US$6 million required for the feasibility study. In the same manner, to forestall desertification, the Federal Ministry of Environment is at the forefront of the Great Green Wall for Sahara Initiative, which is an integrated approach to check desertification and depletion of natural resources in the Sahel.

The Project aims to plant large acreages of trees and other vegetation to serve as a bulwark against the advance of the desert. Under this programme, over 6,720,000 seedlings have been distributed to the seven frontline states of Adamawa, Bauchi, Jigawa, Yobe, Kebbi, Katsina, Kano, Sokoto and Borno State. It is expected that this will create a 15km wide green shelter belt stretching from Kebbi in the North-West to Borno in the North-East, as part of a larger Trans-African belt, spanning 1,500 kilometres from Djibouti to Dakar in Senegal.
The US$500 million Nigeria Erosion and Watershed Management Project (NEWMAP) is another example of the administration's firm response to climate change effects. It was developed in response to the Federal Government's request to the World Bank Group for urgent help on the challenges posed by soil erosion in the South-eastern part of Nigeria.

The aim is to create an enabling framework for watershed management and erosion reduction in the targeted areas. The project components are: investments in infrastructure to support on-the-ground interventions to help reduce vulnerability to land degradation in the target areas; strengthening institutional and information systems for erosion management and watershed planning; providing project management and coordination support at federal and state levels to help implement the project, including procurement and financial management; social and environmental safeguard management and oversight; strategic project communications and outreach and project Monitoring and Evaluation (M&E). Target States for the first phase of the project are Abia, Anambra, Cross River, Ebonyi, Edo, Enugu and Imo. Phase Two of the project will also fund desertification control efforts in Kaduna, Kano and Sokoto states. In the South-south, oil exploration continues to throw up challenges, which are being met with similar innovative policies. In July 2011, a National Oil Spill Contingency Plan (NOSCP) was unveiled while five Natural Environmental regulations were gazetted in 2011. In addition, a National Oil Spill Compensation Guidelines and Standards for Nigeria was developed (Okonjo-Iweala, 2013).

Nevertheless, with the foregoing, the N22 billion that was appropriated is scarce financial capital that could have been deployed to much needed public services like health and education, which has been the advocate of its stakeholders, or invested in productive sectors of the economy like power or agriculture. Furthermore, the average 7% GDP growth rate witnessed in the past 5 years would soon be a history, if proper measures are not put in place to make our economy more climate-resilient, climate change will likely exacerbate Nigeria's current vulnerability to weather swings making sustainable development difficult to achieve. Furthermore, efforts of non-governmental organization as National Advocacy Campaign on Adaptation in Nigeria (NACAN) Organized by Climate

Change Network Nigeria (CCN-Nigeria) in collaboration with Climate Action Network West Africa (CAN-WA)/ENDA Senegal is a laudable. These organizations create the awareness of the consequences of some actions citizens take that can increase the climate change threat. Central to these efforts is a "green" approach to climate change mitigation. The green growth approach puts human well being at the centre of development, while ensuring that natural assets continue to provide the resources and environmental services to support sustainable development (OECD, 2011a). Although, there is little awareness on Low-Carbon development Opportunities, Nigeria should examine low carbon technologies and management options which can be mainstreamed into Nigeria development.

Presently, there is limited implementation of technology combating the climate change in Nigeria, Mohammed (2013) confirmed with the recent report from the World Bank released two reports addressing and providing solutions to the challenges posed by climate change to Nigeria. The **two** reports titled, "Toward Climate-Resilient Development in Nigeria" and "Low Carbon Development for Nigeria". The reports, which are the results of a two-year collaboration between the World Bank and the Federal Government, detail specific technologies and management practices that could be applied to key economic sectors, including agriculture and land use, water resources, oil and gas, power and transport to build resilience to climate change into the fabric of the economy. Failure to act now on climate change may impact Nigeria's ability to achieve its ambition set out in Vision 20:2020 of becoming one of the world's largest economies by 2020. One of the significant actions offered in the report, which also hinges on the other section of this paper, is integrating climate into the planning and design of other sectors of the economy to promote sustainable development.

A recent report has Nigeria's Climate Fact Sheet that identifies a range of development activities that could be targeted for investment by the Bank in its support to Nigeria's Climate Support Programme for the period 2012 – 2017 (African Development Bank Group, 2013). The purpose is to help reduce Nigeria's vulnerability to many climate change impacts and promote low-carbon, high growth sustainable development. The table below shows these:

Table 1: Proposed Programmes/Projects for the Bank's Intervention

Sector	Activities	Contribution to economic growth	Contribution to low-carbon climate resilient development	Contribution to poverty reduction and sustainable development
Agriculture	Support to Nigeria's Agricultural Transformation Agenda to establish financial mechanisms that link climate finance to agriculture investment for climate-smart agricultural development.	3	2	3
Power	Support the implementation of power sector reforms to unlock the huge economic and environmental potential benefits of the large reserves of gas to generate power	3	3	3
	Investment in small hydro power plants	2	2	1
	Promotion of renewable energy alternatives, particularly solar and biomass (energy crops)	1	2	2
	Energy efficiency programmes in public, industrial and residential buildings	1	2	1
	Reduce transmission and distribution losses	2	1	1
Transport	Urban mass transportation financing	3	3	2
	Improved rail transport system	3	2	2
	Support to the Road Sector Development Project (climate resilient roads)	3	2	3
Water resources	Expansion of efficient irrigation systems	2	1	2
	Water resources conservation	2	1	2
Forestry	Support to the Green Great Wall Initiative	3	3	3

0: no contribution; 1: small contribution; 2: moderate contribution; 3: significant contribution.

CLIMATE CHANGE MITIGATION FUZZY MODEL

Climate change, which is attributable to the natural climate cycle and human activities, has adversely affected agricultural productivity in Africa (Ziervogel et al. 2006, Nwafor 2007; Jagtap 2007) due to their low level of coping capabilities at mitigating the threat posed by this phenomenon.

Slocum et al, 1995; Glicken, 2000; Van Asselt et al, (2001); Gardner (2009) affirmed that Stakeholders involvement in decision making process enhances transparency and inclusiveness; however, this can be quite frustrating if not properly handled. Ravetz (1997), view is adopted in the fuzzy model formulation; the author stated that, policies for managing sustainability will be effective only if they have the moral support of the great mass of people. This process empowers citizens since knowledge is shared with respect to policy making and as advising in decision-making processes. Consequently, in the context of adaptation to climate change local people have valuable knowledge about the locality, the history, which is the most vulnerable and how they have coped in the past. This knowledge does not replace scientific knowledge, however, understanding the human factors, and lay-people's perceptions of the problem, usual proffer a sustainable solution to different challenges in the immediate and long-term that the locality may encounter. The figure below depicts the conceptual diagram of the concerned sectors' integration for mitigating the effects of climate change. The local tier is the danger zone; this is because all climate change inducement activities are invoked at this level. It encompasses all the stakeholders' such that its output is the input at the state level; while the states' output is the input at the federal tier. If each of the country of the continent reaches this level, the continent's vulnerability would be greatly reduced and be "green".

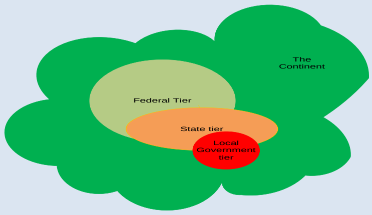

Figure 1: A Conceptual Integrated Approach for Mitigating Climate Change Threat

However, such activities are fuzzy in nature. In a real-world scenario, fuzzy is not a state of confusion, but fuzzy in the real-world is best explained as "sea level rise slightly" or "a bit presence of carbon emission" or "partly cloudy" — these distinctions that are used in decision-making. Computers and other advanced technology have not been able to handle such distinctions. One common thing to the above scenario is that they are all complex, and dynamic, easily characterized by words and shades of meaning than by mathematics. Thus, the fuzzy output is deffuzzified i.e. converted to crisp values.

$$\mu_s(x) = \begin{cases} 1 & if \ x \ \in S \\ 0 & if \ x \ \notin S \end{cases} \qquad 1$$

The fuzzy sets $\mu_s(x)$ is a mapping of X on [0.1], that is the degree of belonging of some element x to the universe x can be any number

$$0 \leq \ \mu_s(x) \leq 1 \qquad 2$$

In Climate change applications, the inverse of discourse U stands for the domain of (factors) input and output variables, i.e. for antecedent and consequent variables, or for the IF and the THEN variables of the rule. Membership functions (possibility distributions, degrees of belonging) of the fuzzy sets are calculated. It is given by

$$S = \{(x, \mu_s(x)) | \mu_s(x) = (1 + (x - N)^2)^{-1}\} \qquad 3$$

N is a natural number of a "tier" sets of climate change indicator

CONCLUSION

The vulnerability of Africa continent to climate change is the cumulative threat from each of the constituent's countries, Nigeria inclusive. The nation has witnessed degradation in the areas of importance to the sustainable development of her citizens. The affected sectors include water resources, agriculture, health, ecosystems and biodiversity, forestry and coastal zones. Nigeria is faced with the adverse impacts of climate change as pointed out by the Africa Partnership Forum (2007). These threats include: changing rainfall patterns affecting agriculture and reducing food security; worsening water security and economic growth prospects; shifting temperature affecting vector diseases; and ultimately, more challenges in reaching the Millennium Development Goals.

According to CERES report (2009), Ghana, Norway and China climate change has different degrees and diversities of threat based on region. This is seen down the tiers too. Thus, government efforts towards combating the climate change threat should not be lobe sided, but it should spread across the nation encompassing all the sectors and regions. Consequently, the fuzzy model presented will assist the policy makers in the decision-making process and facilitate timely implementation of such policy and decision in a way that the least stakeholder understood the concept of climate change and adapt commensurately.

REFERENCES

Hegerl, G.C., F. W. Zwiers, P. Braconnot, N.P. Gillett, Y. Luo, J.A. Marengo Orsini, N. Nicholls, J.E. Penner and P.A. Stott, (2007), "Understanding and Attributing Climate Change. In: Climate Change 2007" The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds s.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Petit, J. R. (2009), "Climate and atmospheric history of the past 420,000 years from the Vostok ice core", Antarctica. Nature 399: 429-436.). Available at http://www.ncdc.noaa.gov/paleo/abrupt/story2.h.

Leggett, J. A. (2011). Climate Change: Conceptual Approaches and Policy Tools. Congressional Research Service, 7-5700. www.crs.gov.R41973

Glicken, J. (2000), Getting stakeholder participation 'right': a discussion of the participatory processes and possible pitfalls. Environmental Science and Policy, 3, 305-310.

Van Asselt, M.B.A., Mellors, J., Rijkens-Klomp, N., Greeuw, S.C.H., Molendijk, K.G.P., Beers, P.J. and van Notten, P. Building Blocks for Participation in Integrated Assessment: a review of participatory methods. International Centre for Integrative Studies (ICIC) Working Paper: I01 – E003.

Mohammed Amina (2013), "Climate change is threat to Nigeria's Vision 20:2020- World Bank" Premium Times Publications, Published:June 10,2013, Accessed August 14, 2013. http://premiumtimesng.com/news/138405-climate-change-is-threat-to-nigerias-vision-202020-world-bank.html

Gardner, J, Dowd, A-M., Mason, C. and Ashworth, P. (2009), "A framework for stakeholder engagement on climate adaptation", CSIRO Climate Adaptation Flagship Working paper No.3. http://www.csiro.au/resources/CAF-working-papers.html. Accessed August 14, 2013.

CERES Report, (2009), STAKEHOLDERS ON CLIMATE CHANGE : North & South Perspectives, Atle Midttun (editor)With national case contributions from: Atle Midttun and HildeNordbø; The Norwegian School of Management; Jin Wang; Sun Yat-Sen University in Guangzhou, China; Joseph Yaro; University of Ghana, Report nr. 3 2009-Creative Responses to Sustainability. www.ceres21.org http://www.ceres21.org/media/UserMedia/Ceres21%20Stakeholders%20on%20Climate%20Change%2014%20des.pdf Accessed August 14, 2013

Africa Partnership Forum (2007), support Unit: Briefing Paper no 1, Sept 2007; http://www.africapartnershipforum.org/dataoecd/57/7/38897900.pdf Accessed August 14, 2013.

Odjugo, P. A. O (2010), "General Overview of Climate Change Impacts in Nigeria", Journal Hum Ecol, 29(1): 47-55.

Zoellick, Robert B. A (2009), "Climate Smart Future", The Nation Newspapers. Vintage Press Limited, Lagos, Nigeria. Page 18

Ziervogel G., A. Nyong, B. Osman, C. Conde, S. Cortes, and T. Dowing (2006), "Climate variability and change: implications for household food security. Assessments of Impacts and Adaptations to Climate Change (AIACC)" Working Paper No. 20, January 2006. The AIACC Project Office, International START Secretariat, Washington DC, USA.

Nwafor, J. C (2007) Global climate change: The driver of multiple causes of flood intensity in Sub-Saharan Africa. Paper presented at the International Conference on Climate Change and Economic Sustainabilityheld at Nnamdi Azikiwe University, Enugu, Nigeria, 12-14 June 2007.

Jagtap, S (2007) Managing vulnerability to extreme weather and climate events: Implications for agriculture and food security in Africa. Proceedings of the InternationalConference on Climate Change andEconomic Sustainability held at Nnamdi Azikiwe University, Enugu, Nigeria. 12-14 June 2007.

Okonjo-Iweala Ngozi, (2013), "Nigeria's Development Prospects in a Changing Climate", A Speech delivered at the launch of World Bank Group Reports on Climate Resilience and Carbon Finance in Abuja, June 10, 2013.

African Development Bank Group (2013), Federal Republic of Nigeria, Country Strategy Paper 2013-2017, Orwa Department, January 2013

Iguisi E.O (2013), Disaster Risk and Adaptation to Climate Change in Nigeria", Centre For Disaster Risk Management and Development Studies, Ahmadu Bello University ZARIA. http://cdrmds.abu.edu.ng/publication.pdf Accessed, August 13,2013.

FAO (2001). Farming systems and Poverty: Improving farmers' livelihoods in a Challenging world. FAO, Rome, Italy.

Absorption Spectra of Some Local Dyestuffs in Nigeria: Implication for Use as Optical Filters to Combat the Impact of Climate Change

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ABSTRACT

Investigations on optical absorption of some local dyestuffs produced in Nigeria were carried out vis-à-vis their use as optical filters. The transmission of the aqueous solution of these dyestuffs was measured with Ultraviolet-visible-Infrared spectrophotometers and their absorbance values obtained. From these measurements, wavelengths at maximum absorption for different solutions of varying molar concentrations were deduced. Spectral bandwidths and absorption edges were also measured. The spectra showed well defined maxima (absorption peaks) over a wide wavelength range. The energies of these bands are reflected in the observed frequencies and/or wavelengths of maximum absorption. Absorption intensity or absorbance values were found to depend on the molar concentration of the salts in the solvents according to Beer-Lambert's law, and shifts in absorption peaks were accordingly deduced. The analyses revealed that these solutions could be used as optical filters. Some were observed to have the properties of cut-off filters, example $CuSO_4$, $Ni(NO_3)_2$ and K_2CrO_4 in the UV-visible region and could be used to block UV, letting through the visible spectrum; while some have the characteristics of band-pass filters ($KMnO_4$ and some dyestuff) in the infrared region. In these experiments, $CuSO_4$, $Ni(NO_3)_2$ and K_2CrO_4 do not absorb at all in the visible region of the spectrum. It is inferred that the intensity of absorption depends on how lightly the electrons are coupled within the molecule. Similarly, the vibration spectra of the dilute aqueous solutions of these metal salts show new broad low frequency bands which can be assigned to cation-water vibration. Thus, in the aqueous solution containing these salts, bands appear at approximately 2740-3340nm; 2750-3350nm; 2740-3400nm and 2750-3850nm respectively. Practical applications of the solution filters are suggested.

Keywords*:* Absorption spectrum, Optical filter, Local dyestuff, Spectrophotometer

INTRODUCTION

The Earth's atmosphere contains many types of gases, including those known as "greenhouse gases." Some greenhouse gases occur naturally in the atmosphere. They regulate the Earth's climate by holding warmth in an atmospheric blanket around the planet's surface; a phenomenon referred to as "greenhouse effect." In this way, greenhouse gases help control global temperatures. Greenhouse gases (GHG) absorb and retain heat from the sun [1]. Naturally occurring greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, and ozone. However, certain human activities release additional greenhouse gases, upsetting the natural atmospheric balance. The manufacture, distribution, and use of products—as well as management of the resulting waste—all result in emissions of greenhouse gases in excess that affect the Earth's climate [2]. This rising levels of greenhouse gases in the atmosphere raises global temperatures. Some of these emission increases can be traced directly to some manufacturing processes notably the dye and textile industry [1]. Both methane and carbon dioxide are major constituents of the world's problem GHGs. Methane is emitted during the production and transport of coal, natural gas and oil; dye and textile; the decomposition of organic wastes in municipal solid waste landfills; and the raising of livestock. Carbon dioxide is released to the atmosphere when fossil fuels (oil, natural gas, and coal), wood and wood products are burned [3]. Others are Nitrous oxides emitted during agricultural and industrial activities, as well as during the combustion of solid waste and fossil fuels. [4] [5]

Besides, several classes of halogenated substances are also human-activity greenhouse gases.
Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6) are potent greenhouse gases that primarily result from industrial activities. Sources of HFC emissions include foams, refrigeration, air-conditioning, solvents, aerosols, and fire extinguishing sectors. PFCs and SF6 are predominantly emitted from industrial processes, including magnesium casting, aluminum smelting, semiconductor manufacturing, and electric power transmission and distribution systems. Research has also shown that each greenhouse gas differs in its ability to trap heat in the atmosphere. SF6 is the most heat absorbent, trapping 23,900 times more heat than carbon dioxide. Methane traps over 21 times more heat than carbon dioxide, and nitrous oxide absorbs 310 times more than carbon dioxide [2].

Appraisal of Nigeria's GHG emissions scenarios reveals that Nigeria is a high carbon dioxide (CO_2) emitting country and as such, she is one of the most vulnerable countries to the impact of climate change. This is because as a developing nation, a large part of its economy depends on natural resources which are vulnerable to climate change. Besides, Nigeria has become an increasingly urbanized and urban-oriented society. The resultant impact on the environment, flora and fauna, and peoples' safety and health has been an increased global warming, depletion of ozone protective cover from harmful UV radiation, contamination of land and water ways due to release of toxic chemicals by industries, reduction in non-renewable resources such as petroleum, destructions of forest cover due to acid rains, increased health problems, and industrial accidents resulting in loss of lives and property [6] [7]. Resource extraction and processing industries such as coal mining, solid mineral/petroleum (hydrocarbon) extraction, which are common in Nigeria, emit dust or hazardous fumes with attendant exposure to air pollution resulting from outdated technology [8]. Almost every step of resource management in Nigeria can contribute to the emissions of GHG. Consequently, the management of these resources/ increased volume and variety of solid waste resulting from increased flow of goods and services, changed lifestyle and consumption pattern has become a major challenge.

Current management crisis of the natural resources in Nigeria is predominant in the manufacturing sector; particularly in the management of the raw materials of these industries and the waste stream which accrues from its production processes. In particular, unmanaged dyestuffs waste disposal sites are high potential sites for anaerobic degradation of organic matter which occur causing GHGs emissions. Hence, current approaches at mitigation and adaptation to climate change in Nigeria have focused on restricting emissions of greenhouse gases specifically, combustion of fossil fuels associated with manufacturing, transporting, using, and disposing the product or material that becomes a waste. Thus, management of natural resources and the evolving waste from the production/manufacturing sector of our economy present many opportunities for GHG emission reductions. This contribution holds that lowering greenhouse gases emitted during manufacturing and product use can make a significant contribution to reducing our nation’s greenhouse gas emissions which is critical to stopping climate change. Preventing or reducing waste at the source through design of innovative processes is envisioned to be much more profitable. [8]

However, current knowledge on greenhouse gases emissions in Nigeria is characterized by dearth of serious studies .This is partly due to the scientific constraints on the African climate science which lacks reliable data [6]. Besides sufficient data for green house gas emission calculation is not available in Nigeria. Yet, such pieces of information are necessary for understanding the likely impact of greenhouse gases on our climate.

The current contribution takes a cursory look at the contribution of the dyestuffs produced in Nigeria and their use/management to the generation of greenhouse gases and how it contributes to climate change as well as its usefulness at mitigation and adaptation to climate change in the Nigerian context.

Contribution of the Dye and Textile Industries to Climate Change: A cursory look at Contribution of the Dye and Textile Industries to Climate Change reveal that approximately 10,000 different dyes and pigments are manufactured worldwide [9] [10] [11] ; of several structural varieties such as acidic, reactive, basic, disperse, azo-, diazo-,

anthraquinone-based, and metal-complex dyes. All absorb light in the visible region. Dyes are used primarily in the production of consumer products, including paints, textiles, printing inks, paper, and plastics. They add colour and patterns to materials.
These dyes are manufactured out of a number of different chemicals, but most notably, sulphuric acid, chromium, copper and other metallic elements are used. Along the way many other additives, solvents and chemical compounds are used to instigate reactions. [9] The textile industry is one of the largest sectors [2]. These sites can be the optimal candidates for Landfill gas emission; which produces significant amount of methane (CH_4) and Carbondioxide (CO_2) for emission into the atmosphere. Dye is the most difficult constituent of the textile waste water to treat. Principal pollutants in the textile effluent are recalcitrant organics, colours, toxicants and inhibitory compounds, surfactants, soaps, detergents, chlorinated compounds, and salts. [4]

Concepts of Optical Filtering/ Filter Optics

An optical filter is an optical device that partially absorbs or reflects incident light. [12] The visible spectrum of electromagnetic (EM) radiation ranges from red light through the colours of the rainbow to violet. The optical range of the spectrum also extends or overlaps into some portion of the ultraviolet and the infrared ends of the EM spectrum. The absorption may be selective with respect to wavelength, in which case the optical filter 'purifies' the incident light in the sense of making it more nearly like that of the pure spectrum; or non-selective, in which case the optical filter merely reduces the light flux without change in spectral composition. This is achieved by either passing the beam through or reflecting it off a material with the required filter properties. [12] Thus, a filter is a device that absorbs or transmits; reflects or deviate certain frequencies of radiation incident on it from a certain path except for one band or region.

Filters are classified in terms of region of wavelength required to attenuate or pass. One type is the band pass filter that provides a 'window' for a narrow range of frequencies and strongly attenuates or completely stops others [13]. Those frequencies in a narrow band around the resonant frequency are transmitted or passed and others rejected or absorbed. Much more commonly, band-pass filters discriminate against a narrow band centered about a characteristic frequency, fo. Cut off filters, on the other hand, highly attenuate frequencies either below or above a selected value. Under this we distinguish between high-pass filter which attenuates low frequencies and pass high ones; and low-pass filter which attenuates high frequencies and pass low frequencies. [12]
Similarly, optical filters can be classified according to the type of their spectral absorption, for example neutral (spectrally non-selective), diffuse cutting (gradual change in absorption with wavelength), sharp cutting or simply cut-off (absorbing one end of the spectrum and transmitting nearly all of the remainder), band-pass (absorbing all incident energy except that of a stated wavelength range). This last type is classified as either narrow band-pass (absorbing all incident energy except that of a narrow wavelength range) or large or wide band-pass. Similarly, optical filters may deviate or reflect all frequencies from an optical path except for a chosen spectral region. Thus,

band-pass filter is valuable in separating an emission line or isolating a narrow spectral band from the output of any continuous source while the cut-off filter is useful in blocking a portion of the spectrum. [12] On the other hand optical filters tend to be given descriptions which vary with their purpose; as they are used in photography, optical instruments and illuminating devices – to control the amount and spectral composition of incident light: for example, the filter used to make red traffic light is always called red though it actually filters out blue, green and yellow light. On the other hand photographers often use filters which they call UV to absorb the blue and ultraviolet wavelengths which tend to produce a haze on photographs of distant scenes, though the filter may be light yellow.

Some wavelengths are more easily absorbed than others: It is particularly difficult, for example, to make a filter which will absorb only red light, transmitting only blue. Blue-coloured filters tend to absorb a little of all colours. When a band of colour is removed, the remaining colour will predominate. Thus, white light passed through a filter which absorbs blue and green light will contain yellow, orange and red light, and will have an overall orange colour.

A sharp-cutting yellow filter is illustrated below:

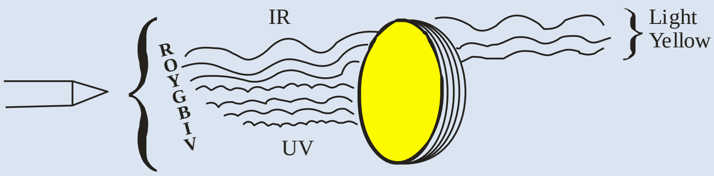


FIG. 1.1 Characteristic yellow filter

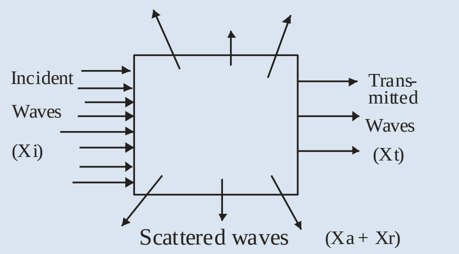


FIG. 1.2 Absorption, transmission and scattering of an em wave incident on a medium.

FIG.1.1: Characteristic yellow filter. [12]

This filter transmits infrared, red and green while it absorbs blue and ultraviolet. The apparent colour is yellow.

Thus, when electromagnetic radiation is incident on a medium, it may pass through unhindered, a phenomenon called *transmission*; it may be partially or totally *absorbed*, or it may be *scattered*. The relative magnitudes of these effects depend on the nature of the medium involved as well as on the frequency of the incident electromagnetic radiation. When the light encounters molecules of certain materials, the photons or 'packets' of light energy of particular wavelengths may force these molecules to resonate. According to classical electromagnetic theory, electromagnetic waves (or simply radiation) are produced whenever a charged particle is in accelerated periodic motion. The resulting electric and magnetic fields then undergo a perturbation which travels in vacuum with the velocity of light and in all other media with a somewhat lesser velocity [13]. Quantum mechanics adds to this picture the important condition that radiation can be emitted only when a system goes from a *state of higher energy to a state of lower energy,* the energy difference becoming the energy of the emitted photon [14]. *Absorption* is the reverse of *emission*, the energy of the absorbed photon being used to take the system from a state of lower energy to a state of higher energy. Thus, in bound systems only certain energy values are permitted. In both cases the frequency of the photon is related to the energy difference by the Bohr's formula: [15]

$$\Delta E = E^1 - E^2 = hv \qquad (1)$$

Where, E^1 and E^2 are respectively the energies of the higher and lower energy states. This expression interprets the primary fact of *spectroscopy:* the existence of discrete *lines* or *band spectra* – of atoms and molecules. The light is re-emitted but at a longer (infrared) wavelength, at which the photons have less energy. This means that the beam of light has lost energy at one wavelength, or in practice a band of wavelengths. This is the principle of absorption filters– a concept employed in this work.

An electron so excited may immediately return to the ground state by re-emitting the energy just absorbed. Alternatively the energy may be re-emitted at different frequencies if the excited electron passes through intermediate energy state during its return to the ground state. In either case, the direction of emission is random so that the intensity of the transmitted wave is reduced by this *scattering process* [Fig. 1.2]. The scattered waves will interfere with each other in such a way that in a homogenous medium they are only propagated in the forward direction, but at the limit of two different media with a smooth interface they give rise to *reflection* and *refraction*, and when passing through narrow slits to *diffraction.* The angle of *refraction* or *diffraction* as the case may be, is frequency dependent. If the incident light is not *monochromatic* it will undergo *dispersion*. Based on these facts *spectrographs* and *spectrometers* can be constructed with either prisms (refraction) or gratings (diffraction).

The above effects can be summarized as:

$$xr + xa + xt = xi,$$

Or:

$$\frac{xr}{xi} + \frac{xa}{xi} + \frac{xt}{xi} = 1$$

Where, the first term is called the *reflection coefficient* R; the second term is the *absorption coefficient,* α, and the third term on the left is called the *transmission coefficient* Ʈ. That is,

$$R + \alpha + Ʈ = 1 \qquad (2)$$

1.2 Absorption Mechanisms: Theoretical Considerations

(4a)

If a beam of light of initial intensity Io is incident upon some absorbing medium the intensity I of the beam after traversing a thickness, x of the medium is known to satisfy the relation:

$$I = Io \exp(-ax) \qquad (3)$$

Where, a, the optical absorption coefficient, is dependent on frequency (or Energy) of the photons in the beam, I is the intensity of the transmitted light or the beam after it has penetrated a thickness x of the medium.

or $\ln I = -ax + c$ (

Its unit is m^{-1}.This is known as Lambert's law [15]. It states that equal paths in the same absorbing medium absorb equal fraction of the light that enters them.

For a homogenous solution where the solute molecules are assumed to absorb, the concentration and path length play the same role and we have

$$I = Io\ 10 - Ecx \qquad (4)$$

(8)

Where, c is the concentration in moles per litre and x is the path length in metres. The last equation is the well known combined Beer-Lambert law. E is the molecular or molar absorption coefficient (molar absorptivity) of the solution. Its unit is litre $mole^{-1}$ m^{-1}. Thus the absorption of the solution is in general proportional to the concentration of the solute. The absorption of a quantum of incident light may, depending upon its size and particular molecule, simultaneously promote transitions in one or several categories of motion:

$$E_{molecule} = E_{translation} + E_{rotation} + E_{vibration} + E_{electronic} + E_{nuclear\ orientation}. \qquad (5)$$

(9)

Thus the energy of a molecule is usually characterized as being distributed among motions of sufficiently different energy that each can be treated separately. Quantum-mechanical selection rule describes the combinations allowed.[14] Thus, transition from low energy states to higher energy states within a molecular or atomic system occurs as a result of absorption of electromagnetic radiation.

Optical Filter Materials, Types and Design Considerations

Fil**ter Materials**

The most common types of filter use the absorptive properties of various materials like minerals and dyes. These may be mixed with the transparent filter materials, which may be glass, plastic, gelatin or cellulose ester; or they may be coated on to a surface of material and then protected by sandwiching them in glass. [19]

Optical filters are usually made of ***glass*** for maximum permanence, of dyed gelatin or plastics for maximum convenience combined with excellent flexibility and often satisfactory performance. *Plastic optical filters* are supplied cemented between glass sheets for greater toughness and durability and greater scratch resistance than bare plastic. To this list the present contribution postulates that filters can also be made of local dyestuffs either dissolved with an appropriate solvent into solutions or gelatin confined to cells with transparent faces for maximum flexibility or gasified for use as sprayers.

The types of filters which can be made depend on the materials just considered. In this section the design of these filters are considered.

Solution Filters: For homogenous solution Beer-Lambert law states that the proportion of light absorbed by a transparent medium is independent of the intensity of the incident light and is proportional to the number of absorbing molecules of the solution in the light's path:

$$\log \; I_0/I = A = acx \qquad (6)$$

()

where, I_0 is the intensity of the incident light, I is the intensity of the transmitted light, a the absorptivity (the coefficient of absorption), c the concentration of solute in the solution (given in gramme per litre or mole per litre), and x is the path length (cell thickness) (in centimeters). A is the absorbance, also called optical density or extinction coefficient, ϵ [17] [18].

When c is expressed in moles per litre, the molar absorptivity or molecular extinction is denoted by ϵ and $A = \epsilon c x$; or $\epsilon = A/cx$

Thus, ϵ is a measure of the absorbance of the solution at a concentration of 1 mol/litre in a 1 cm cell.

This paper therefore contends that optical filters can also be made of solutions and substrates confined to cells with transparent faces for maximum flexibility, control and convenience. Other advantages it has is that it is easy to fabricate; one only needs cuvettes of different thickness, and the solutions are made of different concentrations to achieve the desired absorption or control of the amount of spectral composition of light in specified wavelength range.

There are usually several processes that contribute to absorption coefficient at a given frequency so that the absorption coefficient is really a sum of several coefficients, each referring to a specific absorption process. This work investigates these effects.

MATERIALS AND METHODS

Instrumentation

The Ultra-visible-Visible grating spectrophotometer Model CE-303(Cecil Instruments) and Perkin Elmer double beam rotating prism (electrical null) Model 710B Infra-red Spectrophotometer were used for this work. [15] The optical features of these instruments are schematically illustrated in FIG.2.1a and FIG.2.1b respectively. The equipment are available for all ranges of the current analytical optical spectrum extending from the vacuum ultra violet to the far infra-red end (about 50nm to 1000 μ m). However, the spectrophotometers used for the current work are restricted to one or two spectral range-the IR and the UV-VIS. The essential components of these or any spectrophotometer are a source of radiant energy (a monochrome or monochromatic source), a cell (sample compartment), a detector and an amplifier for measuring the radiant energy; and in the more expensive modern instruments as those used in this

work, a recorder is also included. No details of the actual operations of these instruments will be given here because of space.
The IR spectrophotometer produces a continuous record of the transmittance (the ratio of the energy transmitted by the sample to the energy incident upon the sample) as a function of wavelength.
The instrument is provided with a flat chart recorder which permits visibility throughout the scanning period. Similarly, the UV-VIS spectrophotometer covers both the ultraviolet and visible ranges of EM -within a range of 300nm to 1000nm which correspond to the UV - through near infrared spectrum. Radiation from the source is passed through the sample contained in a cell which holds the sample to be scanned. The cell is transparent to light in the given region. [15]

Filter Materials: Considerations and Choice of Samples
The choice of the materials/samples for this research work was based on chemical as well as physical considerations. First was the ability of the compounds to form aqueous solution in the most readily available solvent. The *solvability* of a salt in a particular solvent is determined by the distance between the ion and the adjacent solvent molecule, the strength of ion-solvent interaction and the delocalization of charge from ion into the adjacent solvent. [18] Further, a variety of the chemical characteristics of the salts formed by the elements of the periodic table in solution were considered. [16] For example, groups IA and IIA elements give aquo-cations $M^{+}aq$ and $M^{2+}aq$ respectively, example, k^{2+}. Group IIB elements Zn, Cd and Hg also give M^{2+} aquous species. But only salts of anions which are weakly complexing (example Nitrates) can be used to generate reasonable concentrations of Hg^{2+}. The first row transition elements form M^{2+} aquous cations in aquous solutions; of these Cr^{2+} is air sensitive, several stable Chromium (IV) compounds are known in the solid state; for example, salts of CrO_4^- , Co^{3+} and Mn^{3+} oxidize water. With group IV, the predominant character of the elements has changed to non-metallic and there is no report of the existence of simple aquo-cation and by the time group V is reached evidence for simple aquo-cation is almost non-existent. [16 [18]

These considerations then explains why salts of Cu^{2+}, Ni^{2+}, K^{2+}, MnO_4^- and KrO_4^- were found suitable for the purpose at hand. Thus, Copper (II) Sulphate, Nickel Nitrate, Potassium Permanganate and Potassium Chromate were chosen for this work to serve as control to the experimental salts-the locally produced dyestuffs since the chemical analyses or characterization of these dyestuffs are outside the scope of the current study. Besides, these salts form complexes which give them their characteristic colour. For example, the formation of $(NO_3)_2^-$ in Nickel nitrate gives it its characteristic green colouration; and the strong colouration of these compounds as well as those of the dyestuff suggest their absorbing characteristics. On these notes, some pH indicators were also chosen for this work. However, the dyestuffs were arbitrarily selected as representatives of the colours of the visible spectrum– red through violet –to investigate their absorptive properties. We guessed that since these all formed coloured solutions they could thus, filter radiations.

METHODS

Preparation of Samples

A given salt was first weighed and transferred to a volumetric flask. The solvent was then measured and poured into the flask and stirred to make a homogenous solution. The solvents used for this work had good spectroscopic qualities and so had little or no absorption in the region of the EM spectrum under study. Among those commonly used were water, methanol, alcohol and sodium hydroxide.

The following procedures were used in the preparation of Potassium Permanganate, Potassium Chromate, Nickel VI Nitrate, Copper II Sulphate solutions and all of the dyestuffs: One gram (1g) each of the solute were dissolved in a hundred millilitres (100 ml) of water. This gave a concentration of 1g/100ml. To investigate the effect of solute concentration on the absorbance of these solutions, the solutions were respectively diluted in steps of 10.

Preparation of pH Indicators: The various methods by which these were prepared are outlined below:

Methyl Red: 1g of this indicator was dissolved in 60 ml of alcohol and then diluted with 40 ml of water to make up the required 100 ml.

Methyl Orange: 1g of this indicator was dissolved in 100 ml of boiling water.

Alizarin Yellow: 1g of the solute (powder) was dissolved in 100 ml of rectified spirit. Methanol could also have been used.

Bromothymol Blue: This was prepared by dissolving 1g of the indicator in 16 ml of 0.1N solution of Sodium Hydroxide and made up to 100ml with water. This last procedure was taken only for solubility purpose. The gain secured is that ions or molecules dissociate sufficiently to be essentially independent and for Beer's law to be applicable.

Production of Spectrographs

In the IR spectrophotometer a pair of flat demountable blocks of rock salt constitutes the sample cell. When fully assembled this has a fixed path length of about 1mm and takes up to 0.3 ml of the sample when full. A small drop of the solution was then transferred to the cell by means of a hypodermic syringe. This assembly was fitted to the sample compartment of the instrument and then operated by a switch labeled 'Scan' at the control panel. Another switch controls the scanning speed. A scan speed of about 15 minutes (a quarter of an hour) per range was selected.

When sample and reference beam intensities were equal a dc signal was presented to the amplifier. When the intensities were unequal, a13 Hz signal appeared, was amplified and converted by the demodulator-filter circuit or module to a60 Hz signal. It powered the attenuator motor that drove an optical wedge in or out of the reference beam until the intensities were again equal. This is called a null point and here the compensating comb was fully withdrawn from the reference beam. The wedge position was relayed mechanically to the transmitting potentiometer. Its output was directed to the servo amplifier that powers the pen motor and was recorded as a transmittance. The strong difference signal from the detector amplifier reduced the speed of the scan and recorder motors. Thus, the movement of the comb was a measure of the absorption by the sample; and the pen of the recorder to which it was linked drew out a plot of the intensity of the transmitted light versus the reciprocal of the wavelength (or wave number in cm-1) and wavelength in microns (A^0). The positions of the observed bands extend from 2500nm to 8000nm.

In the UV-VIS spectrophotometer the samples were handled in a rectangular container called cuvette of one centimeter thickness which was light-proof. The instrument had an external control that could bring each cell into the beam in turn. This made the work with it easier than the other instrument as four different measurements could be taken before demounting the cells to change the sample. Another advantage of this instrument is that the absorbance values were read off directly. The ultra-violet spectrum was recorded over wavelength range of 300 nm to 400 nm. The 400nm to 800 nm region records absorption in the visible region. The spectra were plotted on a graphical data sheet specially prepared for this purpose (FIG.3.1).

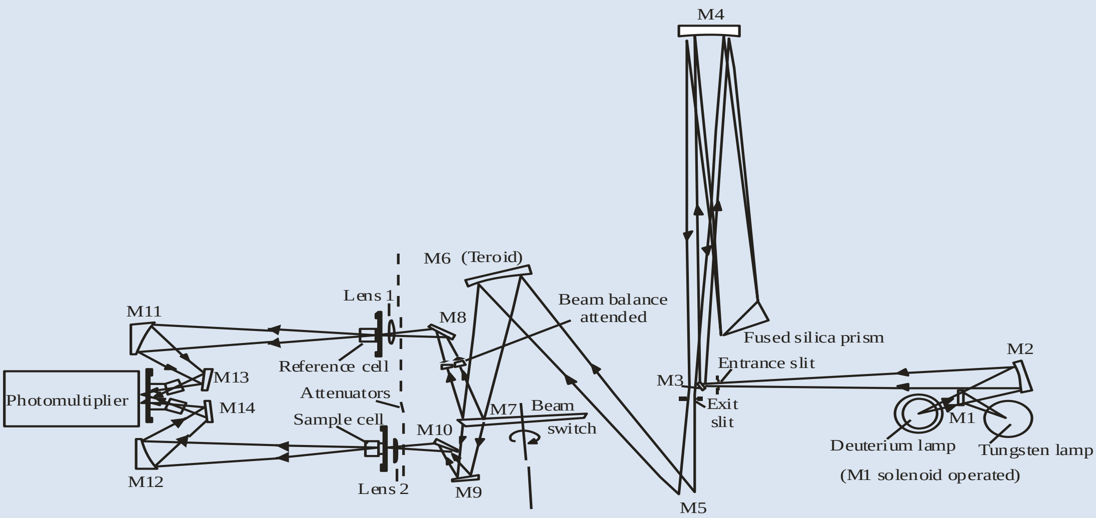


FIG. 2.1a Ray diagram of a CE 303 UV-VIS grating spectrophotometer

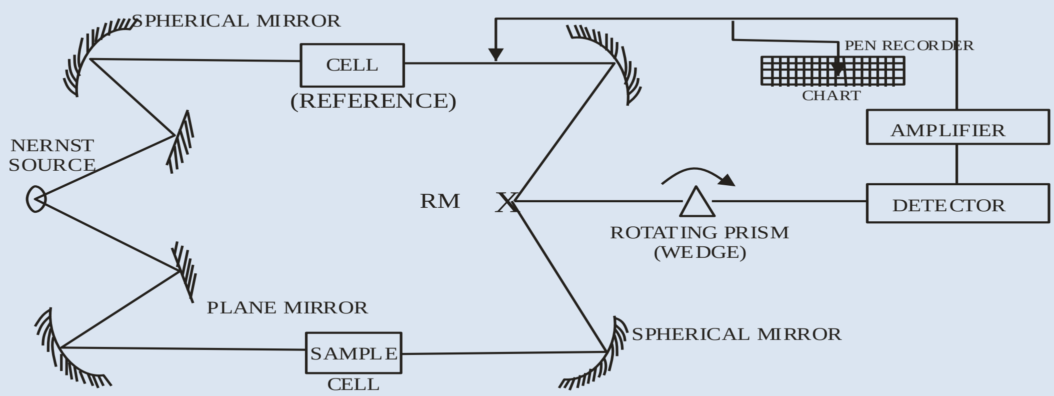


FIG. 2.1b Simplified schematic of a 710b perkin Elmer double beam, electrical null infrared spectrophotometer

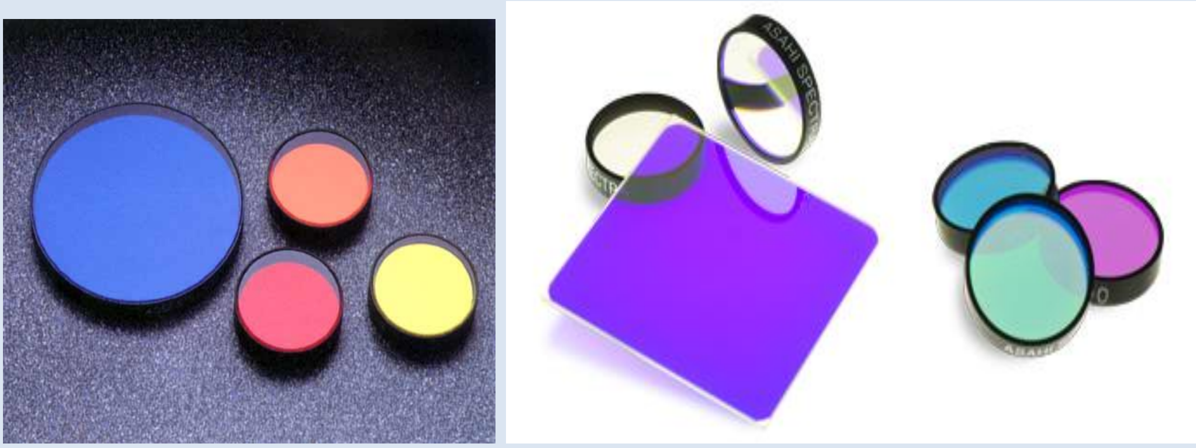


Plate 1: (a) Local dyestuff samples (b) standard optical filters [19]

RESULTS AND DISCUSSION

Summary of Results

The IR spectra are plots of the percentage of the incident light transmitted versus the wave number and wavelengths. The spectra show maxima over a wide range of wavelengths. There is at least one absorption band in each spectrum. FIG.3.1 shows a representative transmission plot of potassium chromate solution recorded directly by the instrument. Since the emphasis is on the absorption (the two, A and T being inversely related), these spectra were re-plotted with a change of axes from T versus $\frac{1}{\lambda}$ (cm^{-1}) to A versus the λ (nm). The resulting absorption curves are depicted in FIGs 3. 2 – 3. 7.

Other results obtained from the analyses of the IR scan of the different samples are summarized on the spectral plots.

The IR spectra of the pH indicators and dyes were also obtained and are shown in the curves of FIGs. 3.6 and 3.7. Here bands appear at 2775 – 3325 nm for methyl red indicator, 2700 – 3450; 6100 – 6300 nm for methyl orange and 2775 – 3600 nm for Alizarin yellow. The Bromothymol blue indicator did not indicate any specific absorption band but recorded a fairly constant absorbance value throughout the spectrum. Similarly the effective band width for the red dye stuff is 2800 – 3400 nm, 2750 – 3200 nm for the green dyestuff and 2725 – 3325 nm for the violet. Again the deep blue dyestuff almost did not show any characteristic band.

The corresponding maximum Absorbance at maximum wavelength of these samples were deducted to be $1.4nm^{-1}$ at 3000nm for methyl red, $1.5nm^{-1}$ at 3000nm, and $0.850nm^{-1}$ at 6150nm for the two bands of methyl orange, and $1.1nm^{-1}$ at 3025 for Alizarin yellow. A maximum for Bromothymol blue ≈ 0.398nm. The concentration of this later group of samples was fixed at 100g/ml for each spectrum.

Other spectral data obtained from the UV – VIS of the samples are listed on the spectral plots. Again the spectra were obtained for four different concentrations for the ionic salts and one of the pH indicators – methyl orange; for a fixed concentration for the various dyestuffs.

K_2CrO_4, $CuSO_4$ and $Ni(NO_3)_2$ did not record any absorption in the visible region of the spectrum. They respectively had their absorption edge at 330nm, 350nm and 350nm.

Discussion

The spectra show maxima over a wide range of wavelengths. There is at least one absorption band in each spectrum. The energies of these bands are reflected in the observed frequencies or wavelengths of maximum absorption/absorption peaks. They reflect the strength of the interaction between the metal ion, non-metal and the organic substances and solvent. [18] The infrared spectra of the solutions show bands which can neither be assigned the individual ions present nor the solvent. This may be due to the occurrence of molecular vibrations at certain quantized frequencies and when infrared radiation of this frequency is incident upon the molecule energy is absorbed and the amplitude of that vibration is increased. [14] [16]

In the vibration spectra of the dilute (i.e. a low concentration) aqueous solutions of the metal salts – $KMnO_4$, K_2CrO_4, Ni $(NO_3)_2$, $CuSO_4$ – new broad, low frequency bands are observed which can be assigned to cat-ion-water vibrations [16]. The intensity of absorption depends upon how lightly the electrons are coupled within the molecule as a whole. [14] 18] Thus, in the aqueous solution containing these salts bands appear at approximately 2740 – 3340nm, 2750 – 3350nm, 2740 – 3400nm and 2750 – 3850nm respectively when the concentration was reduced to 1g/200ml.These are shown in Fig. 3.2 – Fig. 3.6.

Values shown here indicate that the wavelengths depend much on the nature of the solvent. [3] It can be observed that many solutions give rise to absorption bands in approximately the same part of the spectrum, irrespective of the nature of the molecule, although small deviations brought about by the interaction between adjacent groups of atoms, may slightly alter the location of a band. Also when the spectrum of the solution is compared with that of the pure solvent, significant wavelength shifts arising from the perturbation of a solvent vibration mode by an interacting ion [16] [18] are also revealed. The sub-peaks in the IR spectra mark the presence of traces of some other substance as observed in FIG. 3.3

The bands also show decrease in width in going from high to low concentration. Wavelengths of maximum absorption and absorption edges corresponding to these bands have been deduced for these salts. Considering only results from the solutions in which ion-pairing is thought to be minimal, the respective absorption maxima are 3000nm for $KMnO_4$, 3050nm for K_2CrO_4 and 6130nm for its second band; 3100 for $CuSO_4$ and 2880nm for Ni $(NO_3)_2$ and 6100nmfor its second band at solute concentration of 1g/100ml of solvent. The absorption edges corresponding to these are as listed in the various plots.

The absorption wavelengths of the substances change somewhat when the concentration is varied although these changes are small. This is due to the difference in the Van Der

Waal's forces. [13] We infer however, that if the specific substance – solvent interactions are altered (for example, a change of substance from one phase to another or transfer from one solvent to another) the shift would be much larger.

Some representative absorption values of molar chemical shift for water derived from the IR spectra of the ionic solutions of $KMnO_4$, $KCrO_4$, Ni $(NO_3)_2$ and $CuSO_4$ are also listed in the plots. FIGs. 3.2 – 3.6 show the dependence of shift on concentration for two such well behaved systems – solutions of $KMnO_4$ and Methyl orange in water. Here the shift in absorption area is a linear function of salt concentration and can be ascribed to interactions during random collisions. [16] Such shifts in wavelengths and intensity of absorption can be commonly considered in terms of balance between two opposing contributions. The first is polarization of water molecules. The second arises from hydrogen-bond breaking in the solvent as a consequence of the introduction of the cat-ion, even though it is difficult to establish precisely the relative importance of these two effects. [18] Varying the concentration causes a slight, difficult to detect, wavelength shift but has a marked effect on the absorption intensity. The observed shift in wavelength is found to be 60nm for $KMnO_4$, 50nm for K_2CrO_4, 60 and 30nm respectively for the first and second absorption bands of $Ni(NO_3)_2$ and 100nm for $CuSO_4$ solutions (in water), and the corresponding change in absorption maxima are respectively 0.82, 1.02, 0.20 and 0.23 and 0.50nm^{-1}. Samples I and II exhibit blue shift (shift towards shorter wavelengths) and samples III and IV exhibit red shift (towards longer wavelengths) as revealed in the plots. Thus, bond or structure formation leads to increased half-width and structure breakers decreases the half-width or band widths at half the absorption maxima. The high values of absorption maxima for the water molecules also show that the later is opaque to infrared radiation (i.e. they absorb strongly just as ordinary glasses). Hence water may be considered an unsuitable solvent for this study.

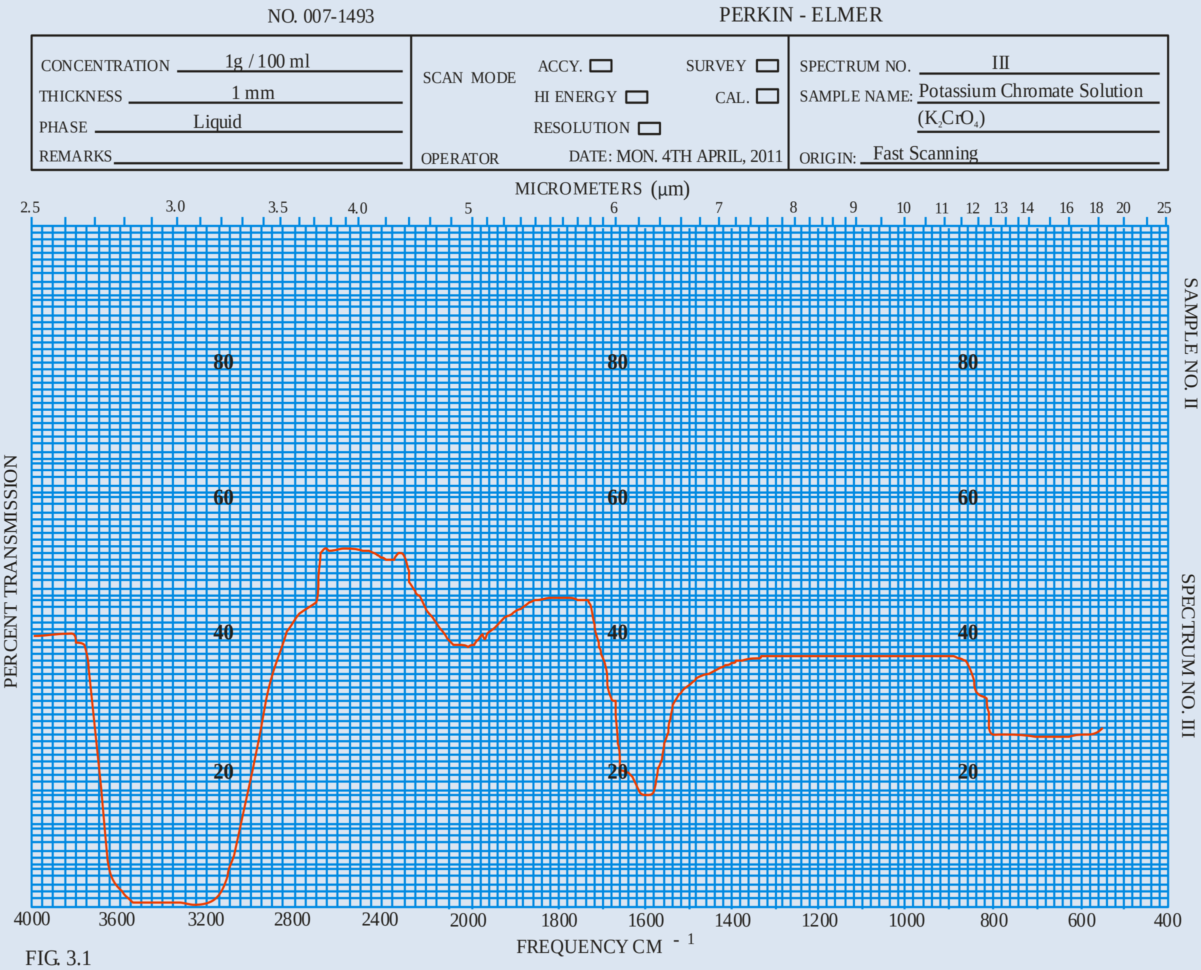
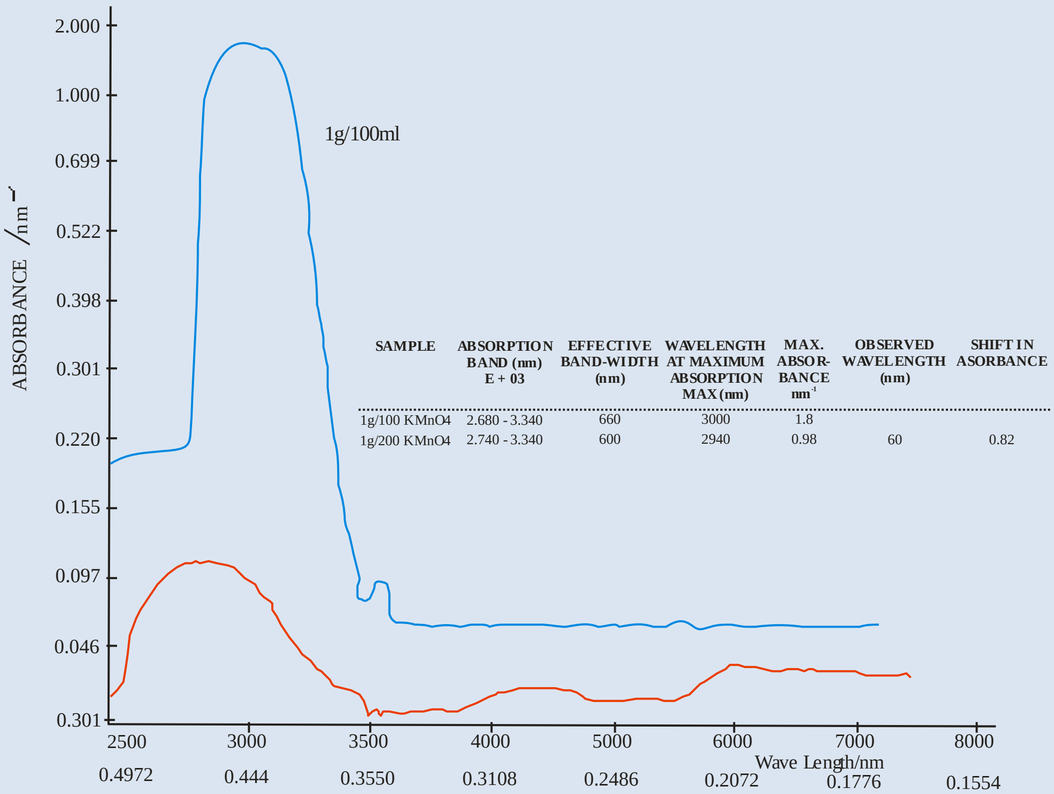
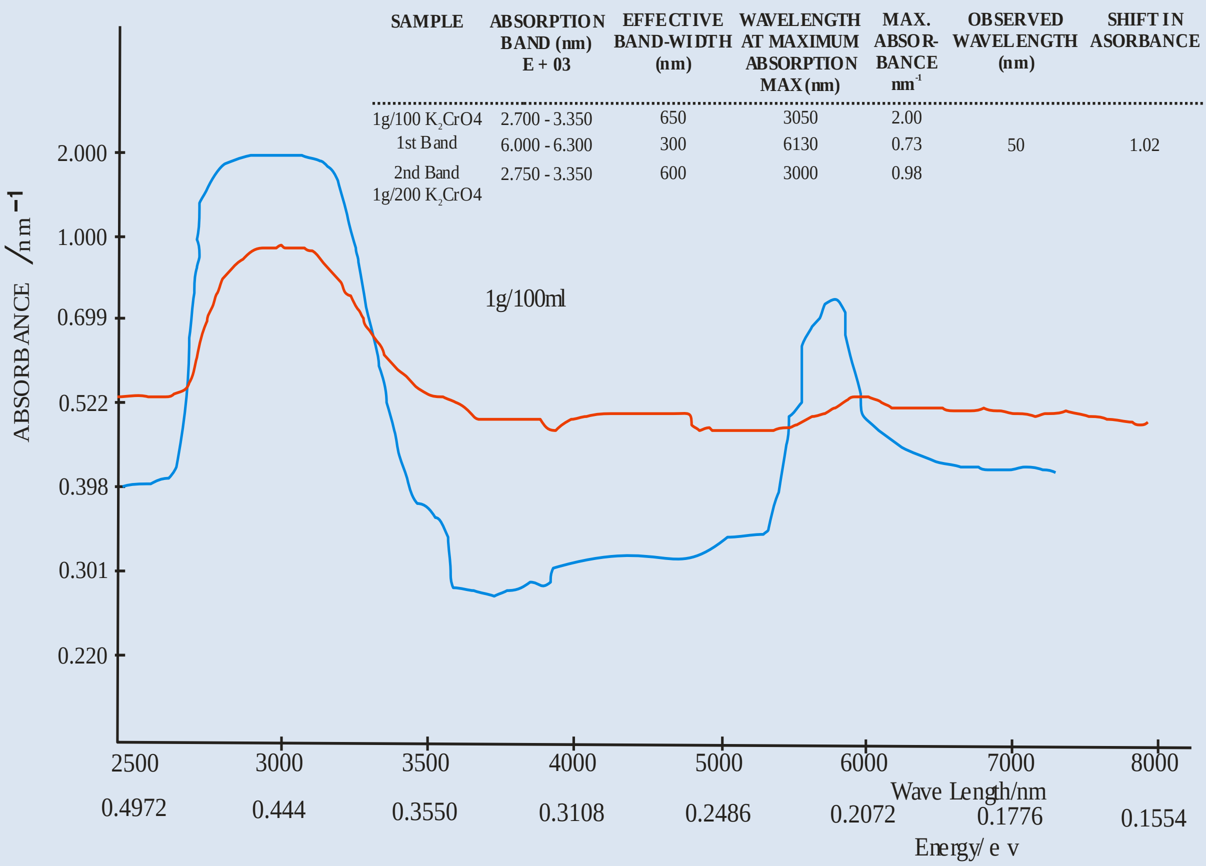

NO. 007-1493
PERKIN - ELMER
CONCENTRATION 1g / 100 ml
THICKNESS 1 mm
PHASE Liquid
REMARKS
SCAN MODE
ACCY.
SURVEY
HI ENERGY
CAL.
RESOLUTION
OPERATOR
DATE: MON. 4TH APRIL, 2011
SPECTRUM NO. III
SAMPLE NAME: Potassium Chromate Solution (K_2CrO_4)
ORIGIN: Fast Scanning
MICROMETERS (µm)
2.5
3.0
3.5
4.0
5
6
7
8
9
10
11
12
13
14
16
18
20
25
80
60
40
20
PERCENT TRANSMISSION
SAMPLE NO. II
SPECTRUM NO. III
4000
3600
3200
2800
2400
2000
1800
1600
1400
1200
1000
800
600
400
FREQUENCY CM - 1

FIG. 3.1



SAMPLE	ABSORPTION BAND (nm) E + 03	EFFECTIVE BAND-WIDTH (nm)	WAVELENGTH AT MAXIMUM ABSORPTION MAX (nm)	MAX. ABSOR-BANCE nm^{-1}	OBSERVED WAVELENGTH (nm)	SHIFT IN ASORBANCE
1g/100 KMnO4	2.680 - 3.340	660	3000	1.8		
1g/200 KMnO4	2.740 - 3.340	600	2940	0.98	60	0.82

FIG. 3.2 IR plot of absorbance vs wavelength for aquous solution of $Kmn0_4$ for two different concentrations.



SAMPLE	ABSORPTION BAND (nm) E + 03	EFFECTIVE BAND-WIDTH (nm)	WAVELENGTH AT MAXIMUM ABSORPTION MAX (nm)	MAX. ABSOR-BANCE nm^{-1}	OBSERVED WAVELENGTH (nm)	SHIFT IN ASORBANCE
1g/100 K_2CrO4	2.700 - 3.350	650	3050	2.00		
1st Band	6.000 - 6.300	300	6130	0.73	50	1.02
2nd Band	2.750 - 3.350	600	3000	0.98		
1g/200 K_2CrO4						

FIG. 3.3 IR absorption spectra of aquous solutions of K_2CrO_4 for two different concentrations.

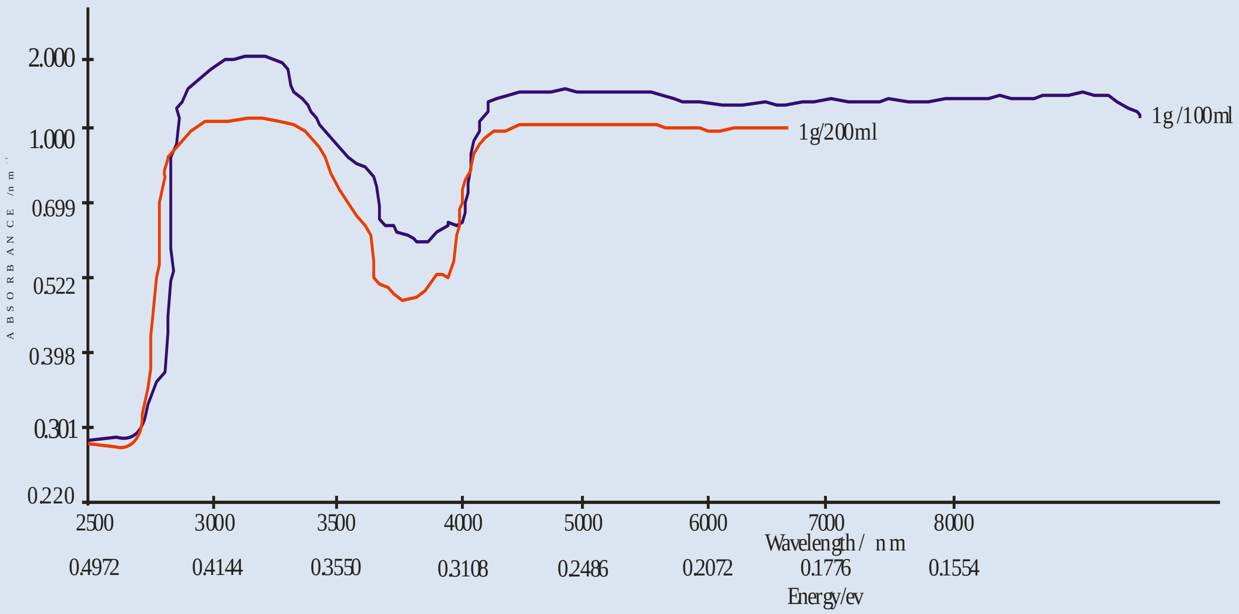


FIG. 3.4 1R absorption spectra for aquous solution of $CuSO_4$ for two different concentrations

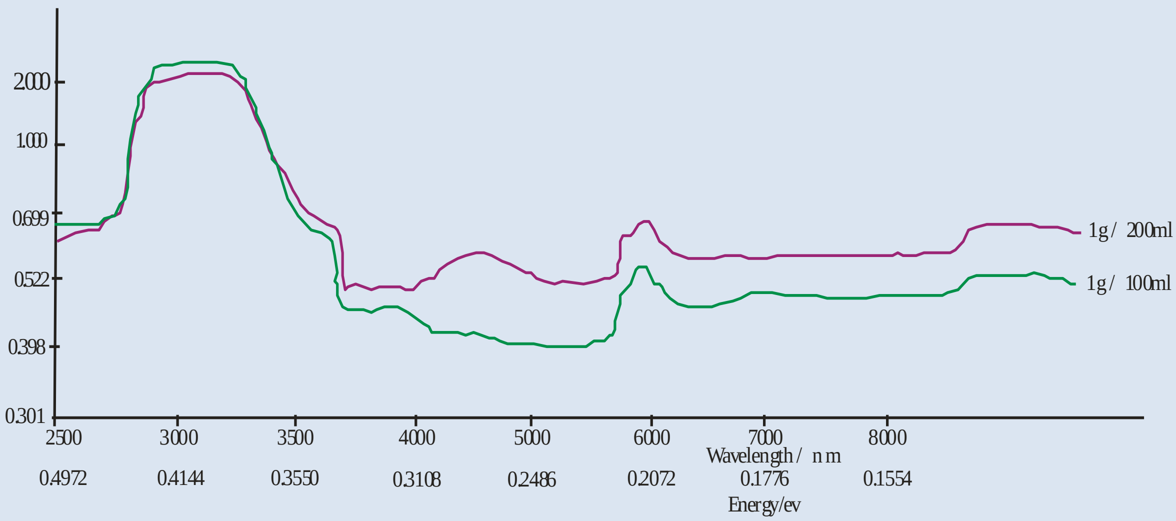


FIG. 3.5 1R absorption spectra for aquous solution of $Ni(NO_3)_2$ for two different concentrations

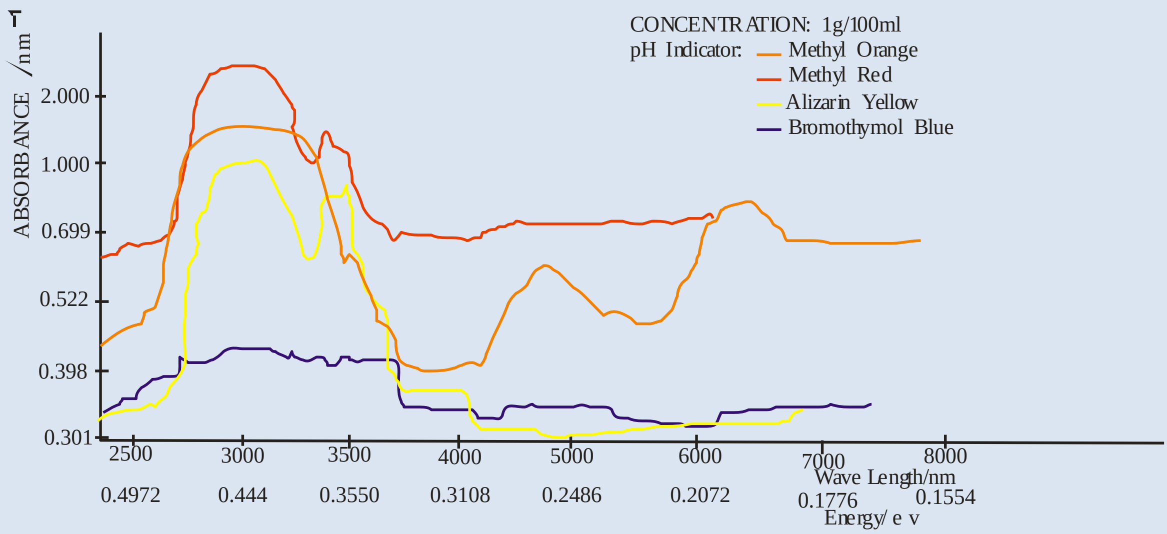


FIG. 3.6 IR spectra of aquous solutions of pH indicators at a concentrations of 1g/100ml.

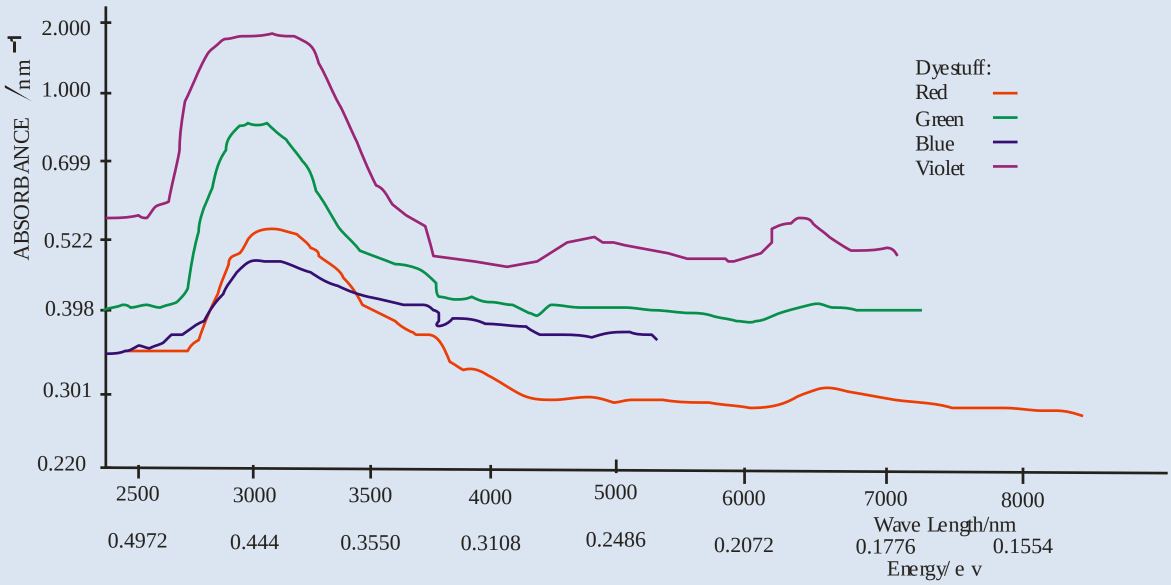


FIG. 3.7 Infrared absorption spectra of the solutions of different Dyestuff in water at the concentrations of 1g/100ml.

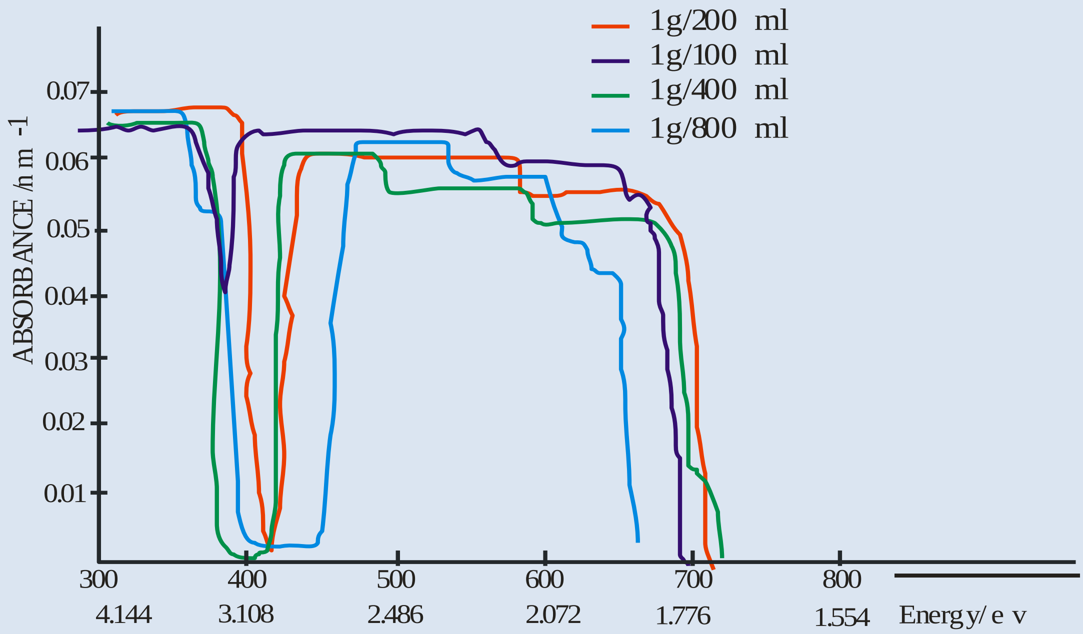


FIG. 3.8 VU-VIS absorption spectra of KMn04 in water for different concentrations

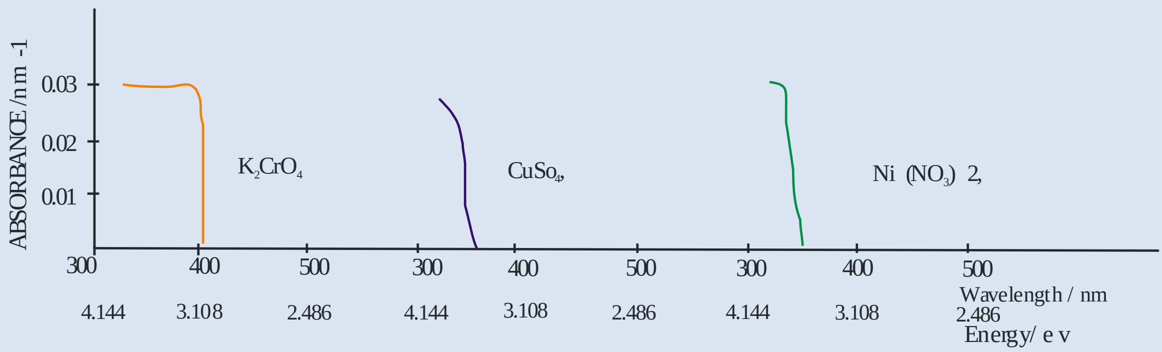


FIG. 3.9 VU-VIS absorption curves for aquous solutions Ni (NO_3) 2, $CuSo_4$, K_2CrO_4 of different concentrations

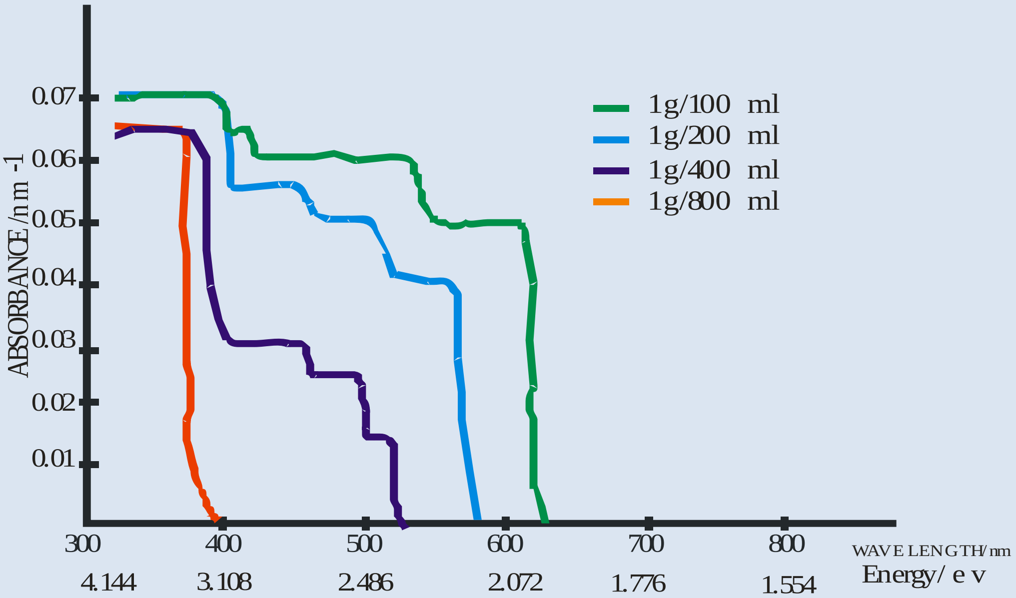


FIG. 3.10 VU - VIS absorption spectra of methyl orange in water at different concentrations

In the UV – Visible regions of the spectrum series of the spectra at different concentration exhibit isobestic point. This study makes it possible to establish some sort of solute-solvent interaction order. The resonance stays at a constant position but its area changes according to solute concentration. For example, the UV-VIS spectra of $KMnO_4$ and methyl orange studied for different concentrations show isobestic points. Here maximum absorption wavelengths stay at a constant position but the areas change according to concentration. This implies that wavelength shifts are not observed in these spectra; they all have the same absorption pattern but varying absorbance values. These properties indicate that they can be used as interference filters since they reveal many incomplete absorption bands corresponding to different wavelengths. [20] They can also be used as standard filters in the filter photometers otherwise called colorimeters. [21] They are comparators in action. These filters could be calibrated in terms of concentration for the path length of the sample cell where the solutions are confined. [20] Since they have an inherently large band-pass, a filter photometer is ideal for quantitative analysis of a substance that has a broad absorption band in the visible or near ultra-violet. On the other hand, K_2CrO4, $CuSO_4$ and $Ni(NO_3)_2$ could be used as cut-off filters since they could only let through the visible spectrum, blocking the ultra-violet. These could be used as radiation filters or sun screens in shade covers and tents. [19]

On the whole, on inspection of the absorbance versus wavelength curves it is apparent that the absorptions of the solutions vary with concentration in accordance with Beer-Lambert law.

Near the centre of a range of wavelengths the $dA/d\lambda \sim 0$, but at the ends of the range the slopes have large values. This type of variation in absorption is contrasted with the nearly constant absorption obtained in the UV-VIS spectrum of Potassium Chromate, Blue and

Violet dyestuffs; and the IR spectrum of Bromothymol blue indicator. Here absorption is non-selective with respect to wavelength. Thus, the blue dyestuff and bromothymol blue indicator can serve as neutral or non-selective optical filters because they merely reduce the light flux without change in spectral composition. Red, green and orange dyestuffs as well as methyl orange indicator exhibit the character of diffuse cutting filter at higher concentrations (by their gradual change in absorption with wavelength). While blue and violet dyestuffs and K2CrO4 exhibit the character of sharp cutting (cut-off) filters (-absorbing at one end of the spectrum and transmitting nearly all of the remainder).

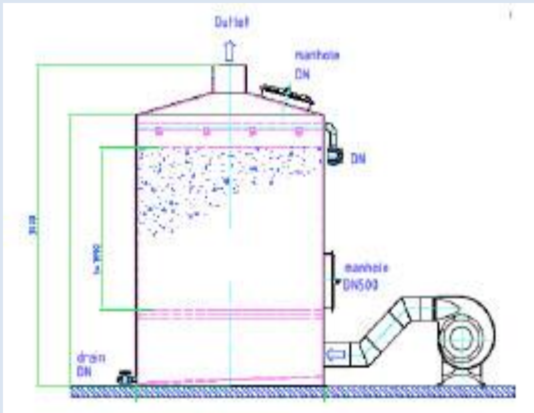
Suggested Applications and Design Considerations of Solution Filters

Solution filters can be useful in a number of ways: They could replace the conventional plastic, glass or gelatin filters) - as wavelength isolation device in optical instruments - (used for laboratory purposes). These will act to absorb some wavelengths and let through some others. The desired wavelengths to be absorbed or transmitted can be obtained through analyses as done in this work. It can also be useful in spectroscopy as a monochrome. Here, the required wavelength at a particular absorbance could be selected. They can also be used as standard filters in colorimeters. [13]
Solution filters also have medical applications as in radiation protection. They could be used in as special screening material to shot off continuous radiation from the non affected part of the patient's body. Also, protective eye glasses (or goggles), lamp shades, window glasses, can be sandwiched with these radiation absorbing solutions for more effective filter output of these devices in a bid to combat the adverse effects of climate change in homes and offices. It can also be used in fibre optics for remote illumination. The absorbing solutions will absorb light of different colours and are capable of transferring the energy of the light they absorb to photographic grains. Thus, these solutions can be used to sensitize the grains to light of any required colour throughout the visible spectrum and even to near infra-red radiation.
Applications can also be found in stage illumination in theatres, street lighting and traffic light. It can also be used in indicator light in automobiles.
In all these applications, solution filters confined to cells with transparent faces is preferred since they offer maximum flexibility, satisfactory permanence and is easier to fabricate. One only needs a solution of predetermined concentration in a specified cell thickness and the required (unwanted) wavelength is filtered out of the continuous radiation.
Municipal wastes are sometimes disposed of using waste combustors. This involves the burning of the waste at extremely high temperatures to reduce waste volume, control bacteria, and sometimes generate electricity. [5] However, air pollution from the waste combustion and other air pollutants (usually classified into suspended particulate matter (PM): dusts, fumes, mists, and smokes); gaseous pollutants (gases and vapours); odours and other types of suspended PM including diesel exhaust particles; coal fly ash; wood smoke; mineral dusts, such as coal, asbestos, limestone, and cement; metal dusts and

fumes; acid mists (for example, sulphuric acid); and pesticide mists) is sometimes a concern with this type of waste disposal as they are among the major sources of greenhouse gases in the Earth atmosphere. Scrubbers (devices that spray liquids on smoke to reduce pollution) [22] and filters (screens to remove ash and pollutant particles) [23] [24] commonly used today can be made with these dyestuffs since they have been shown to posses filter characteristics.

Furthermore, much of the secondary pollutants consisting of PM created by the condensation of gaseous pollutants—for example, sulphur dioxide (SO_2) and nitrogen dioxide (NO_2); [20] gaseous pollutants including sulphur compounds such as SO_2 and sulphur trioxide; carbon monoxide; nitrogen compounds such as nitric oxide, NO_2, and ammonia; organic compounds such as hydrocarbons; volatile organic compounds; polycyclic aromatic hydrocarbons and halogen derivatives such as aldehydes and odorous substances as well as volatile organic compounds including such chemicals as benzene released from burning fuel (gasoline, oil, coal, wood, charcoal, natural gas, and so on); solvents; paints; glues; and other products commonly used at work and at home and emissions of nitrogen oxides and hydrocarbons which react with sunlight to eventually form another secondary pollutant, ozone, at ground level (ozone at this level creates health concerns, unlike ozone in the upper atmosphere, which occurs naturally and protects life by filtering out ultraviolet radiation from the sun) could all be controlled using solution filters made of these locally produced organic dyestuffs.

(a) Fibre glass Carbon Filter



(b) Carbon Filter Sketch

Plate2: Activated Carbon Filter by Likusta [24]

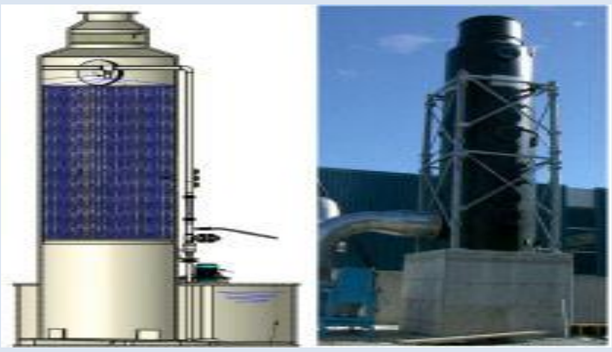


Plate3: Wet Scrubber Systems for Pure Air Filtration by Sentry. [23]

Outdoor air pollution caused mainly by the combustion of petroleum products or coal by motor vehicles, industry, and power stations and the combustion of wood or agricultural waste; as well as pollution which originate from industrial processes that involve dust formation (for example, from cement factories and metal smelters) or gas releases (for instance, from chemicals production) which can create extremely high levels of air pollution as well as catastrophic emissions of organic chemicals as occurred in Bhopal, India, in 1984, with the attendant health implications on the human populace can also be scrubbed with the use of these organic dyestuffs (see plates 2 and 3).

However, as earlier discussed in the introductory section, the solution filter as any other chemical manufacturing process should use inherently environmentally safer substances. The form of substance used in a chemical process should be chosen to minimize the potential for environmental hazard, including releases, explosions, and fires.
On the whole, process improvements will never end. The issue of paramount concern to climate change is that while industries may weigh all actions with respect to profit and cost reduction, it is the duty of the governments of various nations to take the larger view and weigh the long-term benefits to society. Unless the governments are committed nothing can be achieved; the world has to be left untarnished by the present generation for the future generation to also live and draw the benefits. Unless the governments of various nations take interest, greenhouse gas emission reduction will never be a reality, instead remain an academic exercise.

CONCLUSION

The transmission of aqueous solutions of some dyestuffs has been measured with IR spectrophotometer, and the absorbance values read off. The spectral absorbance of the solutions in the UV-visible range of the electromagnetic spectrum was read directly from the UV-visible spectrophotometer. From these measurements wavelengths at maximum absorption for the different solutions were deduced. Spectral bandwidths and absorption edges were also read off. Absorption intensity or Absorbance values were found to depend on the molar concentration of the salts in the solvent according to Beer-Lambert law, and shifts in absorption maxima were accordingly deduced.

The analyses reveal that these solutions can be used as optical filters. Some were seen to have the properties of cut-off filters example $CuSO_4$, Ni $(NO_3)_2$ and K_2CrO_4 in the UV-visible region and could be used to block UV letting through the entire visible spectrum; band-pass filters as in $KMnO_4$ and the dyes in the infrared spectrum. $CuSO_4$, Ni $(NO_3)_2$ and K_2CrO_4 do not absorb at all in the visible region, of the electromagnetic spectrum.

REFERENCES

[1] IPCC (2000).Intergovernmental Panel on Climate Change. Special Report on Emissions Scenarios. Nakicenovic N, Swart R (Eds.). Cambridge.

[2] "Sector Programs: Chemical Manufacturing". U.S. Environmental Protection Agency. 2011. Available at: http://www.epa.gov/sectors/sectorinfo/sectorprofiles/chemical.html

[3] IEA (2005).CO_2 Emissions from Fuel Combustion (1971-2003). 2005 Edition. Paris, France: IEA

[4] Blacksmith Research Institute (2012) Top Ten Toxic Pollution Problems/2012 www.worstpolluted.org/projects/display/105,106

[5] Bennett, R.L.;K.T. Knapp, D.L. Duke (1984).Chemical and Physical Characterization of Municipal Sludge Incinerator Emissions; Document # EPA-600/S3-84-047.U.S Environmental Protection Agency, Research Triangle Park, NC.

[6] Nicholson, S. E. (2001) Climatic and Environmental Change in Africa during the last two Centuries. In P. Desanker (Ed.): Africa and Global Climate Change. *CR SPECIAL 8. Climate Research*, 17:123–144.

[7] Hulme, M.; Conway, D.; Kelly, P.M.; Subk, S. & Downing, T.E. (1995). The Impacts of Climate Change on Africa. *CSERGE Working Paper GEC* 95-12.

[8] Ekanem, C.H.; Ekanem, H.E.; Eyenaka,F.D. & Isaiah, E. A.(2013) Zero Waste: An Innovation For Less Polluting Emission Processes, Resource Management Practices & Policies; Presented at the 2nd International Conference on Environmental Studies and Research, Umunze, Nigeria. 1-4 July.

[9] "Dye Manufacturing", Pollution Prevention and Abatement Handbook. World Bank Group. 1998

[10] Parvath, C. (2009) Environmental impacts of textile industries. Indian Textile Journal. November, 2009. Available at: http://www.indiantextilejournal.com/articles/FAdetails.asp?id=2420

[11] Kant, R. "Textile dyeing industry and environmental hazard." Natural Science 4 (1): 22-26; 2012.

[12] Illustrated Encyclopedia of Science and Technology; How It Works. Volume 8.

[13] ARMSTRONG, R.L and J.D. KING Electromagnetic Interaction, Prentice Hall, Inc, Engle wood cliffs, New Jersey (1973).

[14] SANDORFY, C. Electronic Spectra and Quantum mechanics Prentice Hall Incorporated. (1982)

[15] DENNEY, R.C. A Dictionary of Spectroscopy (Perkin Elmer) Macmillian Press Limited. – London (1973).

[16] CRIDDLES, W. J. & ELLIS. G. P. A Laboratory Handbook on spectral and Chemical characterization of organic compounds. 2nd Edition. John Wiley, New York (1988).

[17] Bergstrom, R. W. (1973). Extinction and Absorption Coefficients of the Atmospheric Aerosol as a Function of Particle Size*; Contributions to Atmospheric Physics*. 46: 223-234.

[18] BURGESS, J., Metal ions in solution, Ellis Howard Limited, Chichester, England. Low price Edition (1980).

[19] www.asahi-spectra.com/opticalfilters/index.html?gcld=CJeFhl7E4rgCFQLtAod7mEAaw

[20] Clarke A.D. (1983). Light Absorption Characteristics of the Remote Background Aerosol -Methods and Measurements, University of Washington, Seattle, WA.

[21] Chow, J.C & Watson, J.C, (1998). Guideline on Speciated Particulate Monitoring www.epa.gov/Hnamti/files/ambient/PM/25/spec/drispec.pdf

[22] R.W. Bergstrom, T.P. Ackerman, L.W. Richards (1982). The Optical Properties of Particulate Elemental Carbon, in *Particulate Carbon: Atmospheric Life Cycle*. G.T. Wolff, R.L. Klimisch,(Eds.), Plenum Press, New York, NY, pp. 43-51.
[23] www.pureairfiltration.com/sentry.htm Scrubber; Gasabsorber.
[24] Environmental technology with innovative solutions – Waste Gas Treatment – Biofilter www.likusta.com/en/abluftbehandlung/aktivkohlefilter.html

Biochemical Properties of Microrganisms Isolated from selected African Traditional Frmented Foods

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ABSTRACT

We investigated the dominant lactic acid bacteria (LAB) from African traditional fermented foods (*ogi, fufu, dawadawa, ugba*) and their biochemical properties. Seven (7) species of LAB were isolated from the various traditional fermented foods. The isolated organisms were *Lactobacillus acidophilus*, *Lactobacillus fermentum*, *Lactobacillus plantarum, Bacillus subtilis, Bacillus licheniformis, Bacillus pumulis, Staphylococcus spp* which were characterized according to their differences in morphological and biochemical properties. The biochemical changes, bacteriocin production and proteolytic activities were investigated. The LAB strains produced inhibitory substances against *E. coli* (25 mm – 38 mm inhibition) and *S. aureus* (18 – 35mm inhibition) and also exhibited medium (pH 3.6) to low (pH 4.3) acidification activity. *Bacillus* spp. isolated in this study showed proteolytic activity (clear zone of 35mm – 45mm in diameter). These properties of the LAB associated with the African traditional fermented foods would help in the selection and development of beneficial strains as starter or adjunct culture.

Key words: African traditional fermented foods, Lactic acid bacteria, Biochemical properties, Bacteriocin production, Proteolytic activity.

INTRODUCTION

Fermented foods are usually products of desirable microbial biochemical activities. Fermentation of food is a common and cheap way of traditional food preservation process. Mensah (1997) indicated that fermentation is not only cost effective but also improves the shelf-life and ensures microbiological safety of the food product. Other roles played by fermentation include food enrichment through diversity of flavour development, improved aromas and textures of the food. Organic acids such as lactic acid, acetic acid, then alcohol and alkaline type of fermentation all enhance food preservation. Fermentation process can also increase biological enrichment with proteins, fatty acids, vitamins and essential amino acids. Steinkraus (1996) noted that fermentation of foods remove toxins from the foods and reduces cooking time which invariably minimizes fuel requirement.

Of all the organisms involved in African traditional fermentations, lactic acid bacteria (LABs) are the most commonly used. LABs maximize their substrate utilization resulting in highly efficient metabolic ability and probiotic characteristics. LABs have a long history of use and commonly occur in most African traditional fermentations. Many workers have indicated the general acceptance of LABs in foods for human consumption because they are generally regarded as safe (GRAS) (Silva et al., 2002). Since LABs contribute significantly to the properties of most fermented foods, research interest in their functional, metabolic and biochemical contributions in relation to their environment is highly important especially as it concerns African traditional fermented foods. Some of the biochemical properties of LABs have been highlighted (Calo-Mata *et al*., 2008). They indicated the main groups of LABs in this regard as *Lactobacillus*, *Leuconostoc*, *Pediococcus* and *Streptococcus*. A further insight into the nature of LABs contributions indicated that some LABs are homofermenters producing only lactic acid while others are classified as heterofermenters (Blandino et al., 2003). The heterofermenters contribute significantly to taste and aroma of the fermented food products due to the influence of volatile compounds they produce.

LABs isolated from traditional fermented food ecosystem have been found to have divergent metabolic activities different from similar strains used as starters in the industries (Klijn *et* al., 1995). They show differences in growth rates and competitive growth in mixed culture. Rapid adaptation to environmental conditions and production of microbial inhibitory substances such as bacteriocins has been reported (Ayad *et al*., 2002).

The search for new product development has necessitated the use of new strains with desirable biochemical properties. To achieve this, exploration of the biodiversity of microbial ecological niches to locate natural floras without perfectly defined application is an option. This is in addition to the expansion of knowledge and understanding of the known organisms in use. In a study by El soda *et al*., (2003), some of the properties to look out for are production of (1) antimicrobial compounds (2) proteolytic activity (3) exopolysaccharide synthesis (4) high and predictable acid production.

Knowledge is still evolving in the characteristics of the biochemical reaction of microorganisms implicated in African traditional fermented foods. This is directly related to their nutritional quality, safety and acceptability of the final food products. A strategic action plan can be initiated to further develop the quality of African traditional fermented foods from the local fermentation to a standardized fermentation process. A comprehensive understanding of the microbiological processes is a step in the right direction. This idea has been seen to improve the important qualities of the end products (Simpson *et al*., 2001; van Beek and Priest, 2002). This study aimed at determining the biochemical properties of microorganisms in African traditional food fermentation.

MATERIALS AND METHODS

Traditional Fermentation

Cassava roots were peeled, cut into pieces then washed 3 times in water and were submerged in water for a period of 3 days at ambient temperature (30 ± 1^{o}C). The cassava was then processed according to the method of Oyewole and Odunfa (1990).

The maize grains were cleaned and steeped in water for 2 days in a locally made earthenware pot. Fermentation was carried out for 2-3 days by natural flora of the grains as described by Odunfa and Adeyele (1985). Oil Bean Seeds were fermented as described by Nwamarah and Madueke (2010). African locust Bean Seeds were cleaned and sorted manually; then cooked for 24 h and allowed to cool. The cooked locust bean seeds were dehulled and spread thinly in local container usually lined with leaves and fermented for 24-36 h. Sample was collected and analysed every 12 h (Odunfa, 1983; Achi, 2005).

Analyses

Ten gram of each sample was homogenized in 90 ml sterile distilled water containing 9% (w/v) sodium chloride, using a stomacher laboratory blender (Model 80, Seward Medical, London). Aliquots of the serially diluted sample were mixed with molten MRS Agar and nutrient agar medium and pour-plated in duplicates. Counts on MRS plates, were obtained after incubation for 48 h at 30^{o}C. Replicate of MRS were inoculated and incubated under aerobic and anaerobic conditions. Pure cultures were made by repeatedly streaking the isolated colonies and incubated as previously described. The culture plates were flooded with lugol's iodine to detect starch hydrolysis. Amylolytic strains were routinely maintained on MRS starch agar slants at 5^{o}C, with successive transfers every 2 weeks. Biochemical tests were used in the characterization of the isolates.

Carbohydrate Fermentation: Fermentation of carbohydrate was determined according to Sharpe (1979) on microtitre plates (Sterilin, Staffordshire, UK) as described by Jayne-Williams (1976). Sterile solutions of the sugars tested (Sigma-Aldrich), maltose, fructose, glucose, etc were obtained by filtration through 0.22µm filters (Millipore S.A., Molsheim, France) which was added to the basal medium (MRS without glucose and meat extract but contained 0.004% [w/v] of chlorophenol red used as pH indicator) to a final sugar concentration of 2% (w/v). Plates were anaerobically incubated at 37^{o}C for 48 h. Production of gas was determined with a Durham tube. Gas produced during fermentation of the sugar was trapped at the top of the Durham tube and appeared as bubbles.

Bacteriocin Production: It was determined by the agar well diffusion methods of (Varadaraj *et al.,* 1993). The plates were checked for zones of inhibition surrounding the producer strain colonies (Geis *et al.,* 1983).

Acid Production: Acidification activity of the organisms isolated was measured by change in pH during time (Ayad *et al.,* 2004). Strains were investigated for acid production using MRS broth as described by Koskinen *et al.,* (2007).

Proteolytic Test: was carried out according to the method reported by Thomas and Pritchard (1987).

RESULTS AND DISCUSSIONS

Isolation of Organisms: Several traditional fermented foods serve as reservoir for lactic acid bacteria. Microorganisms isolated from each product, and their morphological characteristics used for identification are shown in Table 1. The predominant LABs isolated from various traditional fermented foods (TFF) were characterized as *Lactobacillus, Bacillus,* and *Staphylococcus* species. *L. acidophilus* from maize and cassava; *L. fermentum* from maize and cassava; *L. plantarum* from maize, oil bean seeds and cassava; *Bacilli* were also isolated from African Locust bean and oil bean seed. These *Lactobacillus* spp. are similar to those earlier identified from closely related fermented food products by Oyewole and Odunfa, (1988); Johansson *et al*., (1995); Teniola and Odunfa, (1995). Other African fermentation in which *Bacillus* spp.predominate are the production of Nigerian fermented melon seeds (*Ogiri*) and sesame seeds (*Ogiri-saro*), pumpkin or castor oil seed fermentation from Sierra Leone. Previous work has also indicated the predominance of *Bacillus* species in fermenting African locust bean and oil bean seed, leguminous seeds such as *anyi* (fermented *Samanea saman* seeds) into condiments (Okonko, 2002).

Table 1: Morphological characteristics of lactic acid bacteria isolated from traditional fermented foods

Strains	Fermented foods	Colony morphological and characteristics	Cell shape
Bacillus ugba, pumulis	*dawadawa*	large flat and pale yellow, wide spreading, dull surfaced colonies	short rods in single and in pairs
B. subtilis	*ugba, dawadawa, fufu*	large flat and creamy white, wide spreading , dull surfaced colonies	short rods
B. licheni-formis	*ugba, dawadawa*	large flat and creamy, wide spreading, dull surfaced colonies	short slender rods in pairs
Staphylo-coccus	*ugba, dawadawa ogi*	small non-spreading, glistering yellow colonies	cocci in cluster
Lactobacillus plantarum	*Ogi, fufu*	very small flat, cream to yellowish colonies	rods in chains
Lactobacillus acidophilus	*ogi, fufu dawadawa*	red, smooth colonies	rods
Lactobacillus fermentum	*ogi, fufu*	small greenish yellow colonies	slender rods

Biochemical Characteristics of Organisms: Biochemical properties of the isolates are shown in Table 2. Most isolates are Catalase positive except for *Lactobacillus* species that are Catalase negative. Some species showed oxidase, coagulase and urease positive while negative for other species as indicated in Table 2. Coagulase production was described as one of the most reliable criteria for the identification of pathogenic *Staphylococcus* species, although *Staphylococcus* did not seem to play a major role in the fermentation (Oyarekua, 2011). The results in this study showed that coagulase positive *Staphylococcus* spp. occurred in the fermenting medium. This may be due to lack of hygienic measures in the preparation of the fermented foods.

Table 2: Biochemical characteristics of organisms isolated from traditional fermented foods

Strains	Catalase	Oxidase	Coagulase	Urease
Bacillus pumulis	+	-	ND	-
Bacillus subtlis	+	-	ND	-
Bacillus licheniformis	+	-	ND	-
Staphylococcus spp.	+	-	+	+
Lactobacillus plantarum	-	-	ND	-

Lactobacillus acidophilus	-	-	ND	-
Lactobacillus fermentum	-	-	ND	-

+ Positive; - Negative; ND Not determined

All the isolated organisms were further confirmed by sugar tests and the results are presented in Table 3. The result indicated that *L. acidophilus* produced acid/gas with glucose, it produced acids only with maltose, galactose and lactose but did not ferment mannitol, sucrose and arabinose; *L. fermentum* followed the same pattern except that it also fermented sucrose with the production of only acid, showed delayed fermentation with arabinose; *L. plantarum* produced acid/gas with maltose, glucose and lactose. It produced only acids with galactose and arabinose, but did not ferment mannitol and sucrose. Most of the Bacilli were acid producers except *B. subtilis* that neither produced acid nor gas with galactose as indicated in Table 3. These characteristics were used to identify probable organisms since the genetic characterization could not be determined to confirm their identity (Okoro *et al.,* 2011). These results are similar to the sugar test for LAB reported by Abu-Tarboush, (1994).

Table 3: Characterization of Isolated Organisms based on Sugar Fermentation

Sugar fermentation	B.P	B.S	B.L	S.A	L.P	L.A	L.F
Fructose	+	+	+	+	±	±	±
Galactose	N	+	+	+	+	+	+
Glucose	+	+	+	±	±	±	±
Lactose	+	+	+	+	±	±	±
Mannitol	+	+	+	+	N	N	N
Maltose	+	+	+	+	+	±	±
Sucrose	+	+	+	+	N	N	+
Arabinose	ND	ND	ND	ND	+	N	DG

+ acid production; - gas production; ± acid/gas production; ND - not determined; N - no fermentation; DG - delayed growth; B.P - *B. pumulis*; B.S - *B. subtilis* ; B.L - *B. licheniformis*; S.A - *Staphylococcus aureus*; L.P - *L. plantarum*; L.A - *L. acidophilus*; L.F - *L. fermentum*.

Bacteriocin Production: Inhibition of the indicator organisms *Escherichia coli* and *Staphylococcus aureus* by LAB used in this study are presented in Table 4. *L. fermentum* with an inhibition zone of 38 mm exhibited the highest degree of inhibition for *E. coli* while *L. acidophilus* with inhibition zone of 25 mm exhibited the lowest degree of inhibition for this organism. The same pattern of inhibition was observed for *S. aureus* (*L. fermentum* showed the highest inhibition level). Inhibitions by the cell free supernatant of the overnight broth of the organism (control) were similar but slightly lower in each case.

Table 4: Bacteriocin production by isolates

	Inhibition zone for pathogenic bacteria (mm)			
Isolates	*E. coli*	control	*S. Aureus*	control
Lactobacillus plantarum	28	25	25	20
Lactobacillus fermentum	38	35	35	30
Lactobacillus acidophilus	25	20	18	15

Control – cell free supernatant of the overnight broth of the test organism.

Acid Production: There was significant increase in pH during fermentation mainly between 0 and 48 h, ut to final values of 8.5 – 9.0 as seen in Table 5. However, simultaneous increase in pH and titratable acidity has been reported in the fermentation of similar foods (Ikenebomeh, 1989). Certain bioconversion activities probably not yet understood could be the reason for the acid production in those fermented foods.

Table 5: Acid production by some isolated organisms

		pH	
Strains	6 h	24 h	48 h
Bacillus subtilis	5.3	5.4	7.6
Bacillus pumulis	5.3	6.1	8.3
Bacillus licheniformis	5.3	7.5	8.4
Lactobacillus spp.	3.6	4.1	4.3

Proteolytic Activity: The proteolytic activity was determined by observing the presence of the clear zone which varied between 35 mm and 45 mm as presented in Table 6. The organisms are composed of *Bacillus subtilis, B. licheniformis and B. pumulis* which were isolated from African locust beans and oil bean seeds. *Bacillus* spp. showing highest protease activity comprised of *Bacillus subtilis. B. licheniformis* isolate did not show any proteolytic activity in casein agar. Vuillemard and Amiot, (1985) reported a threshold value of 20 mm for the diameter of clear zone of proteolytic bacteria in casein agar after 72 h of fermentation. Based, on this, it can be consider that 62% of the investigated organisms from fermented legume foods were highly proteolytic, even after 24 h of fermentation (Azokpata *et al.,* 2006). In addition, the entire *Bacillus* spp. investigated in this study showed high proteolysis than those identified in *Soumbala* (Ouoba *et al*., 2003). Proteolytic activity has been reported to be abundant in the fermentation of similar protein rich foods (Omafuvbe *et al*., 2002). This is probably due to a consistently active proteinase activity resulting in rapid amino-acid production (Ogunshe *et al.,* 2007). The high proteolytic activity observed in this study may also be due to high protein content of African locust and oil bean seeds.

Table 6: Proteolytic activity of organisms isolated from traditional fermented foods

	Diameter of clearing zone (mm)		
Strains	24 h	48 h	72 h
Bacillus subtilis	29.2 ± 0.04	40.1 ± 0.05	45.2 ± 0.02
Bacillus licheniformis	35.5 ± 0.15	42.7 ± 0.22	45.5 ± 0.20
Bacillus pumulis	30.9 ± 0.10	41.3 ± 0.22	43.2 ± 0.15

CONCLUSION

Microorganisms isolated from traditional fermented foods under test possessed important biochemical properties. These biochemical properties were carbohydrate fermentation, bacteriocins production, enzyme production, acid production and proteolytic fermentation, which are required as prerequisite for the understanding of the properties of the organisms in fermentation. Organisms isolated from the sample during fermentation produced high level of acidity which is required for the retting of cassava to *fufu*, and in the fermentation of maize to *ogi.* The *Bacillus* spp. produced high level of proteolytic activity - a condition necessary for the fermentation of oil bean seed and legumes. These properties are quite outstanding and necessary for the performance of the organisms in the fermentation.The findings concerning the succession within the lactic flora in the spontaneous fermentation of Nigerian traditional foods would assist in the selection of suitable cultures for use in controlled fermentations.

REFERENCES

Abu-Tarboush, H.M. (1994). Growth behavior of *Lactobacillus acidophilus* and biochemical characteristics and acceptability of acidophilus milk made from camel milk. Dept. Food Sci., College of Agriculture, King Saud University, Riyadh, Saudi Arabia.

Achi, O. K. (2005). The potential for upgrading traditional fermented foods through biotechnology. Afr. J. Biotechnol., 4 (5): 375-380.

Ayad, E. H. E.; Verheul, A.; Wouters, J. T. M. and Smit, G. (2002). Antimicrobial-producing wild *Lactococci* isolated from artisanal and non-dairy origins. International Dairy Journal, 12: 145–150.

Ayad, E.H.E.; Nashat, S.; El-Sedek, N.; Metwaly, H. and El-Soda, M. (2004). Selection of wild lactic acid bacteria isolated from traditional Egyptian dairy products according to production and technological criteria. Food Microbiol., 21: 15-725.

Azokpota, P.; Hounhouigan, J.D.; Nago, M.C. and Jakobsen, M. (2006). Esterase and protease activities of *Bacillus* spp. from *afitin*, *iru* and *sonru*; three African locust bean (Parkia biglobosa) condiments from Benin. African Journal of Biotechnology, 5 (3): 265-272.

Blandino, A.; Al-Aseeri, M. E. ; Pandiella, S. S.; Cantero, D. and Webb, C. (2003). Cereal-based fermented foods and beverages. Food Research International, 36 (6): 527–543.

Calo-Mata, P.; Arlindo, S.; Boehme, K.; De Miguel, T.; Pascoal, A., and Barros-Velazquez, J. (2008). Current applications and future trends of lactic acid bacteria and their bacteriocins for the biopreservation of aquatic food products. Food and Bioprocess Technology, 1(1): 43–63.

El Soda, M.; Ahmed, N.; Omran, N.; Osman, G. and Morsi, A. (2003). Isolation, identification and selection of lactic acid bacteria cultures for cheesemaking. Emir. J. Agric. Sci., 15 (2): 51 – 71.

Geis, E.; Singh, J. and Teuber, M. (1983). Potential of lactic *Streptococci* to produce bacteriocin. Appl. Environ. Microbiol., 45: 205-211.

Ikenebomeh, M.J. (1989). The influence of salt and temperature on the natural fermentation of African locust bean. Int. J. Food Microbiol., 8: 133-139.

Jayne-Williams, D. J. (1976). The application of miniaturized methods for characterisation of various organisms from the animal gut. J. Appl. Bacteriol., 40: 189–200.

Johansson, M.L.; Sanni, A.; Lonner, C. and Molin, G. (1995). Phenotypically based taxonomy using API 50CH of *Lactobacilli* from Nigerian *ogi*, and the occurrence of starch fermenting strains. Int. J. Food Microbiol., 25: 159-168.

Klijn, N.; Weerkamp, A. H. and de Vos, W. M. (1995). Detection and characterization of lactose-utilizing *Lactococcus* spp. in natural ecosystems. Applied Environmental Microbiology, 61: 788–792.

Koskinen, P.E.P.; Kaksonen, A.H. and Puhakka, J.A. (2007). The relationship between instability of H 2 production and composition of bacterial community within a dark fermentation fluidized-bed bioreactor. Biotechnol. Bioeng., 97 (4): 742-758.

Mensah, P. (1997). Fermentation - the key to food safety assurance in Africa. Food Control, 8 (5-6): 271-278.

Nwamarah, J.U. and Madueke, U.O. (2010). Graded fermentation effects on nutrient content of oil bean seeds (*Pentaclethra macrophylla*) consumed in Umuagom village, Awka. JHER, vol. 13: 16-23.

Odunfa, S. A. (1983): Biochemical changes during production of *ogiri* a fermented melon (*Citrullus vugaris* Schrad) product. Plant Foods for Human Nutrition, 32 (1): 11-18.

Odunfa, S.A. and Adeyele, S. (1985). Microbial changes during traditional production of *ogi*-*baba*, a western Africa fermented sorghum gruel. J. Cereal Sci., 3: 173–180.

Ogunshe, A.A.O. Omotosho, M.O. and Ayansina, A.D.V. (2007). Microbial Studies and Biochemical Characteristics of Controlled Fermented *Afiyo*- a Nigerian Fermented Food Condiment from *Prosopis africana* (Guill and Perr.) Taub. Pakistan Journal of Nutrition, 6 (6): 620-627.

Okonko, I.O. (2002). Microbial Studies on *Anyi*-A fermented food condiment from *Samanea saman*. HND Thesis. Microbiology/Virology Unit, Laboratory Technology Training School, University of Ibadan, Ibadan, Nigeria p. 120.

Okoro I. A., Ojimelukwe P. C., Ekwenye U. N., Akaeru B., Ogbonna I. L. and Offia-Olua B. (2011). Comparative evaluation of the bacteriocin producing characteristics of lactic acid Bacteria from selected traditional fermented foods. Continental J. Food Science and Technology, 5 (1): 1 – 5.

Omafuvbe, B.O.; Abiose, S.H. and Shounkan, O.O. (2002). Fermentation of soybean (Glycine max) for '*soydaddawa'* production by starter cultures of *Bacillus*. Food Microbiol., 19: 561-566.

Ouoba, L. I. I.; Rechinger, K. B.; Barkholt, V.; Diawara, B.; Traoré, A. S. and Jakobsen, M. (2003). Degradation of proteins during the fermentation of African locust bean (*Parkia biglobosa*) by strains of *Bacillus subtilis* and *Bacillus pumilus* for production of *soumbala*. J. Appl. Microbiol. 94 (3), 396-402.

Oyarekua, M. A. (2011). Biochemical and Microbiological changes during the production of fermented pigeon pea (*Cajanus cajan*) flour. African Journal of Food Science and Technology, 2(10): 223-231.

Oyewole, O. B. and Odunfa, S. A. (1988). Microbiological studies of cassava fermentation for '*lafun'* production. Food Microbiology, 5: 125-133.

Oyewole, O.B. and Odunfa, S.A. (1990). Characterization and distribution of lactic acid bacteria in cassava fermentation during *fufu* production. J. Appl. Bacteriol. 68: 148-152.

Sharpe, M. E. (1979). Identification of the lactic acid bacteria. In: Identificative methods for microbiologists. Skinner PA, Lovelock DW (eds), Academic Press, London, pp. 233–259.

Silva, J.; Carvalho, A. S.; Teixeira, P. and Gibbs, P. A. (2002). Bacteriocin production by spray-dried lactic acid bacteria. Letters in Applied Microbiology, 34(2): 77–81.

Simpson, K.L.; Petterson, P. and Priest, F.G. (2001). Characterization of *Lactobacilli* from Scotch malt whisky distilleries and description *of Lactobacillus ferintoshensis* sp. nov., a new species isolated from malt whisky fermentations. Microbiology, 147: 1007–1016.

Steinkraus, K. H. (1996). Introduction to indigenous fermented foods. In K. H. Steinkraus (Ed.), Handbook of indigenous fermented foods, New York: Marcel Dekker, pp. 1–6.

Teniola, O.D. and Odunfa, S.A. (1995). Indigenous microflora of *ogi* and their role as spoilage microorganisms. The third Biennial Seminar of African fermented foods, Ghana. pp. 71-76.

Thomas, T.D. and Pritchard, G.G. (1987). Proteolytic enzymes of dairy starter cultures.
FEMS Microbiol. Rev., 46: 245-268.

van Beek, S. and Priest, F.G. (2002). Evolution of the lactic acid bacterial community during malt whisky fermentations: a polyphasic study. Applied and Environmental Microbiology, 68: 297–305.

Varadaraj, M. C.; Devi, N.; KeShava and Manjreker, S.P. (1993). Antimicrobial activity of neutralized extracellular cultured filtrates of lactic acid bacteria isolated from a cultured Indian milk products (*dahi*). Int. J. Food Microbial, 20: 259-267.

Vuillemard, J.C. and Amiot, J. (1985). Hydrolysis of food proteins by Bacteria. Microbiological Aliments Nutrition, 3: 333–343.

Biogas Production from Cow Dung and Chicken Droppings

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ABSTRACT

An investigation was carried out on the production of biogas, a low natural gas, from cow dung and chicken droppings each supplemented with *Pennisetum purpurem (*elephant grass) and chicken feed respectively. Each waste was mixed in different ratios with the supplements, depending on the moisture content of the waste. The wastes mixtures were charged into six (6) prototype stainless steel bioreactors of 4litres for 35 days. The bioreactors were operated at a mesophilic temperature range of 28^0c to 35^0c. Biogas production was measured on a weekly basis. It was observed that biogas production started on the 9th day in cow dung alone, and on the 7th day in both cow dung with elephant grass leaves, and cow dung with elephant grass stalk. Biogas production was detected on the 4th., 3rd. and 7th. day in chicken droppings alone, chicken droppings with feeds and chicken droppings with cow dung respectively. Cow dung alone, cow dung with elephant grass leaves and cow dung with elephant grass stalk yielded biogas with mean values of 19.43dm^3/day, 25.43dm^3/day and 23.00dm^3/day respectively. The mean values of biogas yield in chicken droppings with cow dung were 2.43dm^3/day, 28.14dm^3/day and 22.54dm^3/day respectively. There is a significant difference between the biogas yield in cow dung and chicken droppings at $P < 0.05$ with chicken droppings giving the higher biogas yield.

Keywords: Cow dung, chicken droppings, supplements, bioreactors, biogas

INTRODUCTION

Biogas, mainly methane, is a renewable energy source and a high quality fuel applicable for generating power and replacing the use of petroleum and coal. Biogas is a combustible mixture of gases produced by microorganisms during the degradation of livestock manure and other biological wastes under anaerobic condition. Being a renewable gas, it helps to reduce the need for fossil consumption which in turn reduces emission of the greenhouse gas, Co_2 [1]. For countless years, fuel supplies have been used and misused at will.

In United States alone, the average petroleum consumption equates to three gallons per day [2]. That is, for every man, woman and child of the population, making an annual consumption of over two billion gallons! The pressure of population has also reduced Indian's forests to few shrubs. Other countries are not left out [3, 4, and 5]. These lands are made impossible for agriculture and human habitations. Carbon (IV) oxide emission and environmental pollution also give rise to several diseases. The advantages of using excreta (both humans and animals), and of course other agricultural and industrial wastes cannot be over-emphasized [6]. High energy generation, high quality fertilizers produced from spent slurry of the wastes, reduction of carbon emission and prevention of disease transmissions are some of such advantages [7].

In Nigeria, there is a marked increase in deforestations, environmental pollution due to CO_2 emission and loss of large expanse of land due to crude oil spills during oil drillings. In quest for alternative source of energy, hence this research aims at producing biogas (methane) from microbial degradation of cow dung and chicken droppings.

MATERIALS AND METHODS

Sample Collection

The wastes were collected from different parts of Awka metropolis, Anambra State, Nigeria. Cow dung samples were collected freshly from an abattoir in Amansea, a small town near Awka urban with big sacks. One-day old chicken droppings were also collected from a poultry farm in Awka metropolis. Elephant grass leaves and stalks were collected in a nearby bush beside the Biotechnology Research Center of the University. Chicken feed was bought from Awka Main Market.

Sample Preparation

3kg of cow dung was weighed and mixed thoroughly with equal volume of water for optimum gas production. 2kg of cow dung were weighed and mixed with 1 kg of shredded elephant grass stalk and leaves each and equal volume of water added respectively. The bioreactors for cow dung, cow dung with elephant grass stalk and cow dung with elephant grass leaves were labeled reactors A_1 A_2 and A_3 respectively. 3kg of chicken droppings was weighed and mixed with half volume of water. It was labeled reactor B_1. Reactors B_2 and B_3 were filled with equal volumes of chicken droppings with poultry feed and chicken droppings with cow dung respectively. The wastes were then loaded to three quarter of the digester volume.

Bioreactor Setup

Each of the 4 litre-stainless steel bioreactors were connected via their gas outlets on top to plastic gas collecting apparatus using a 9-12mm plastic flexible connectors. The bioreactors were also connected to a mechanical agitator to ensure even mixing of the slurry and intimate contact between microorganisms. Sampling ports were also provided at the sides of the reactors tanks. Both ports on the tops and sides of the reactors were tightly sealed to exclude oxygen. The volume of biogas yield was measured and recorded on a weekly basis for 35 days. The experimental setup was as reported by [8]. Samples were also taken during these periods for analysis. Temperature, pH, moisture content and total microbial counts were recorded. The bioreactors were finally connected to three containers with $CaCl_2$ and Ca (OH_2) and iron fillings to remove water vapour, carbon (IV) oxide and corrosive hydrogen sulphide respectively.

Temperature Determination

The thermometer (mercury in glass) was dipped into the bioreactors at 7 days intervals and the temperatures recorded.

Plate 1: Experimental Set- Up for Biogas production from Chicken Droppings Samples.

Plate 2: Experimental Set Up for Biogas production from Cow Dung Samples

Plate 3: Experimental Set up for Biogas Purification

pH Determination

The calibrated indicator papers were dipped into the bioreactors at interval of 7 days during which the colour changes and appropriate values were estimated.

Moisture Content Determination

Known weights of the samples were collected from the bioreactors and dried in an oven at 103°C for 1 hour. Drying continued at 80°C until the sample attained consistent weight. Moisture contents were calculated and expressed in percentage as:

$$\% \text{ moisture content} = \frac{\text{amount of water loss}}{\text{Initial total weight}} \times \frac{100}{1}$$

Carbon Determination

Carbon-content were determined according to the standard method for examination of water and wastewater. Known weights of dried samples of the slurries
A were placed in a crucible and burnt up in a furnace to charring. Thereafter the samples were re-weighed. The difference in weight i.e. carbon content were calculated in percentages as% carbon =

$$\frac{\text{Burnt carbon}}{\text{Initial total weight}} \times \frac{100}{1}$$

Nitrogen Content Determination:

This was determined according to standard methods for examination of water and waste water [9]. Using Kjeldahl's method, 0.5g of slurries was placed in the bottom of the digestion flasks. Three millimeters of concentrated sulphuric acid and 3ml of catalytic mixture were introduced into the flask. The samples were heated initially at low temperature for 1hour and then at a high temperature. The mixture changed from black to greenish-yellow and then cleared during digestion. Digestion was completed at the end of 2 days. The cooled digests were diluted with 20ml of distilled water. This was transferred into a distillation apparatus and made alkaline will 8ml of 30% NaOH was distilled off into the receiving flask containing 5ml of 2% boric acid solution containing 3 drops of the lowered clear condenser. The distillation was continued for 5 minutes before stopping. The distillates were then titrated with 0.1m HCL from a burette. The nitrogen contents were determined.

B $$\text{Nitrogen} = \frac{\text{Titre x } 0.004}{\text{Weight of sample}} \times \frac{100}{1}$$

Identification of Bacterial Isolates

The methods and criteria contained in Medical Microbiological Techniques and in Bergey's Manual of Determinative Bacteriology were used for the identification of the bacteria isolates [10; 11]. The isolates were distinguished on the basis of their cultural, morphological and biochemical characteristics.

Statistical analysis: Unpaired t-test was used in the analysis of the data generated in this research [12].

RESULTS

The isolates were identified as *Staphylococcus aureus, E. coli, Bacillus sp, and Streptococcus Sp.* Table 1 shows the physico-chemical characteristics of cow dung alone, with elephant grass leaves and with elephant grass stalk. Table 2 shows physico-chemical characteristics of chicken droppings alone, with chicken feeds and with cow dung. The quantities of gas produced from the wastes over a period of 35 days at an average temperature of 31.5°C are shown in figures 1 and 2.

Table 1: The Physico-Chemical Characteristics of Cow Dung

Age of Sample (Days)	Temp (°C)	pH	Moisture Content (%)	Carbon Content (%)	Nitrogen Content (%)
1	29	6.50	66.45		
7	32	6.80	68.23		
14	30	6.95	87.98		
21	33	6.76	67.69		
28	35	7.01	65.05		
35	30	6.85	60.51	40.22	0.36

Table 2: Physico-Chemical Characteristics of Chicken Droppings

Age of Sample (Days)	Temp (°C)	pH	Moisture Content (%)	Carbon Content (%)	Nitrogen Content (%)
1	29	6.5	88.12		
7	32	7.0	86.12		
14	33	6.80	87.06		
21	35	6.96	87.41		
28	31	7.2	75.70		
35	30	7.0	73.44	39.09	1.56

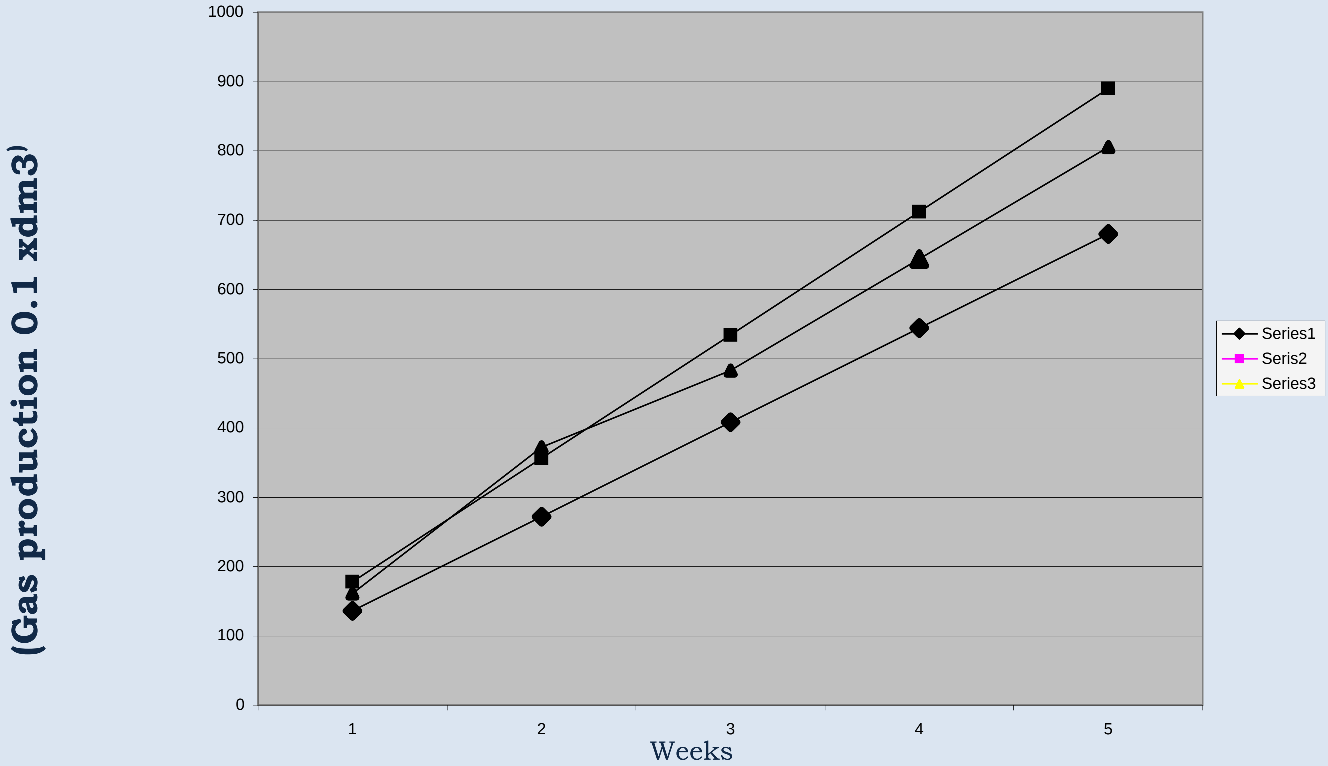


Figure 1: Average biogas production from cow dung

Key:

- Cow Dung

- Cow Dung + Elephant Grass

- Cow Dung + Elephant Grass Stalk

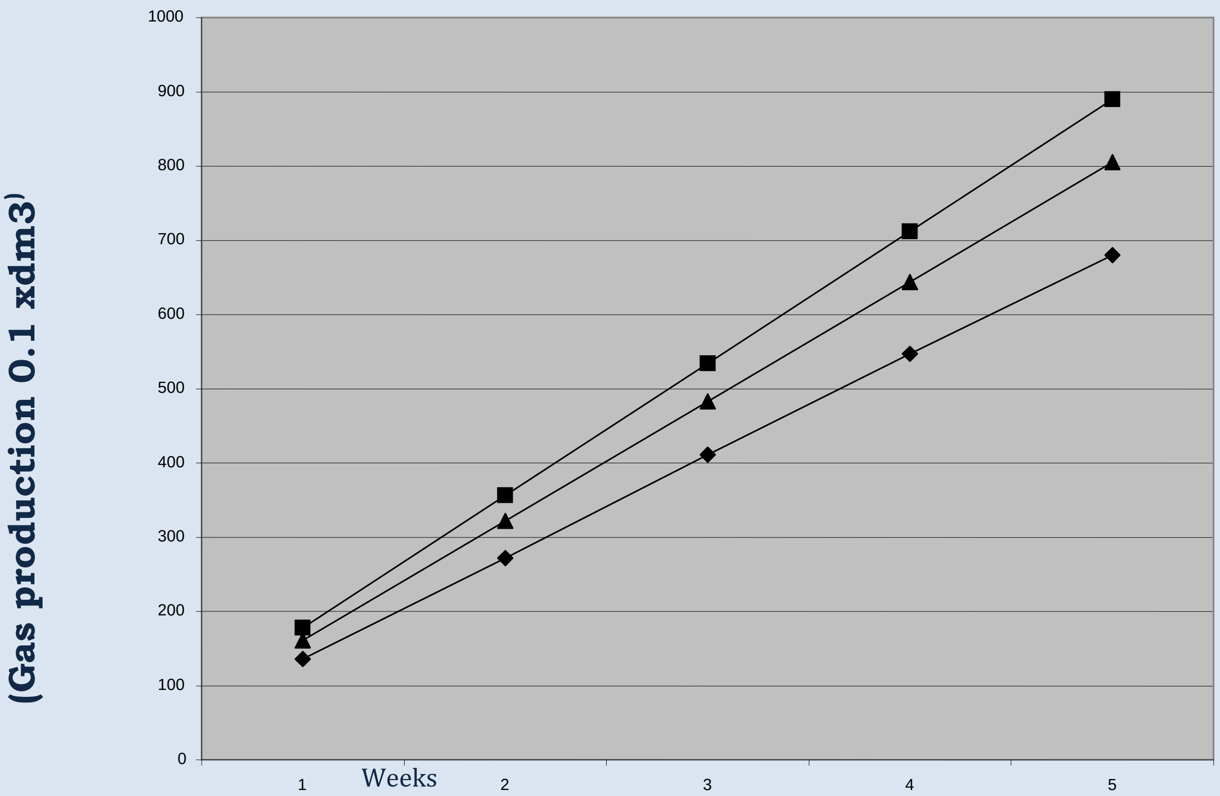
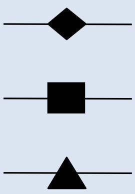


Figure 2: Average biogas production from chicken droppings

Key:



- Chicken Droppings

- Chicken Droppings + Feed

- Chicken Droppings + Cow Dung

DISCUSSION

Biogas production started in cow dung alone on the 9th day, on the 7th day in both cow dung with elephant grass leaves and cow dung with elephant grass stalk after loading. Biogas production in the poultry droppings alone started on the 4th day after loading while it started on the 3rd day and 7th day for poultry dropping with feeds, and poultry droppings with cow dung respectively (figure 1 and figure 2). The total biogas production in each of the bioreactors, revealed that for cow dung, the highest quantity of biogas (0.890dm^3) was produced by bioreactor A2 (cow dung with elephant grass leaves). Bioreactor A1 (cow dung alone) produced the least quantity of biogas (0.680 dm^3).

The increased biogas yield in bioreactor A2 could be traced to the presence of elephant grass leaves which as reported by Reddy *et al*. encouraged greater biogas yield [13]. In poultry droppings, reactor B2 (poultry droppings with feed) showed the highest biogas yield (0.960dm^3) while bioreactor B3 (poultry droppings with cow dung) showed the least biogas yield (0.789dm^3).

The pH of all the six wastes was generally 5.8 to 7.5 at the point of loading. The reason for the low pH is attributed to the fact that initially, the acid-forming bacteria will be breaking down the organic matters and producing volatile fatty acids [14; 15]. Generally, the pH of the six wastes, decreased at the point of charging, increased at the peak of biogas production and latter decreased at the end of digestion and gas production Table 1 and table 2 also show the changes in weekly temperature for the six wastes. The temperatures were increasing and decreasing. The temperature inside of the bioreactors was generally 28-36°c throughout the period of biogas production. This is in agreement with the optimum temperature for biogas production which was 29°c - 41°c according to Alerez *et al*. [16].

The results revealed that chicken droppings with or without supplement had greater biogas yield potentials than cow dung. This is partly because chicken droppings has more nutrients and nitrogen content compared with other animal wastes and is degradable since chicken do not feed on cellulosic materials like forage crops and leaves [17].

The differences in carbon-nitrogen ratios of the wastes were equal to the optimum C: N ratio for biogas production which is 25 or 30:1 as reported by Stalin & Prabhu [18] and Bhatia, [19].

CONCLUSION

The cumulative biogas yield from (1:3 waste to water ratio slurry of cow dung, with elephant grass leaves and with elephant grass stalks over a period of 35 days was found to be 680, 890 and 805 x 10^{3}dm^3 respectively. In poultry droppings (1:2 wastes to water ratio), the cumulative biogas yield was slurry from chicken dropping alone, with feed and with cow dung, it was found to be 960,985 and 789 x10^3 dm^3 respectively. At $P< 0.05$, there is a significant difference in the biogas yield potential mean values between cow dung and chicken droppings. Chicken droppings with or without supplement was found to produce more biogas than cow dung. Biogas produced from chicken dropping was found to be of good quality and can be conveniently applied for generation of electricity.

Cow dung, though it does not produce hydrogen sulphide like chicken droppings, it needed larger quantities of supplements such as forage crops and spent grains to produce a reasonable volume of biogas.

REFERENCES

1. Hill, D.T., (1994) "Methane productivity of the major animal type" *Journal of American Society of Agricultural Engineers*. **27**:50
2. Agarwal, A. (1998): Myths about forest depletion. *Down to Earth*. **7(1)**: pp29-42.
3. Nag K.N., Mathur, A.N. and Chhabra, K.K., (1986): Adoption of biogas plants in rural and tribal villages of Udaipur. *Journal of Rural Development*. **5(5)**:553-560.

4. Sodhiya, H.C.and Jain, K.K., (1988): Rural energy crisis and biogas technology. *Journal of Rural Development*. **7(4)**:427-432.
5. Ojolo, S.J., Oke, S.I., Aminasahun, K., and Adesuyi, B.K. (2005). Utilization of Poultry, Cow and Kitchen Wastes for Biogas Production. *Iran Journal of Environmental Sciences and Engineering*. **4(4)**:223-228.
6. Chukwura, E.I., Okotie, B., Ugwu, I.F., Alukwe, U.J., Anisi, C.C.G., and Olewe, O.V. (2007) Co-composting of Garden Refuse (Grass and Human Faeces, Cow Dung and Chicken Droppings with Human Male and Female Urine: A Comparative Analysis. In the Third World Organisation of Women in Science (Proceedings).
7. Klerbe, E. (1995) Animal Manure Digestion System in Central Europe. In Proceedings of the Second Biomass Conference Portland. Pp 34-36.
8. Ojolo, S.J. and Bamigboye, A.I. (2005) Biogas Production from Municipal Solid Wastes, In Proceedings of International Conference on Engineering, Lagos, Nigeria. Pg303-310.
9. American Public Health Association (1992) Standard Methods for the Examination of Water and Wastewater 15th edn. APHA, Washington DC.
10. Baker, D.I. and Breach, M.R. (1980) Medical Microbiological Techniques. Butterworth, London.
11. Buchan and Gibbons (1984) Manual of Determinative bacteriology.
12. Zar, R.H. (1984) Biostatistical Analysis. Prentice Hall, Englewood.
13. Reddy, K.R., D'Angelo, E.M., (1990): Biomass yield and nutrient removal by water hyacinth (*Eichhornia crassipes*) as influenced by harvesting frequency. *Biomass,* **21**:27-42.
14. Ranade, D.R., Yeole, T.Y., Godbole, S.H., (1987): Production of biogas from market waste. *Biomass*, **13**: 147-153.
15. Osman, A.G., ElTinan, A.H, Mohammed, E.F (2006) Biogas Production From Agricultural Wastes. *Journal of Food Technology*. **4(1)**: 37-39.
16. Alerez, R., Vilica, S., and Liden, G. (2006). Biogas Production From Illama and Cow Manure at High Altitude. *Biomass and Bioenergy*. **30**: 66-75.
17. Gallerrt, C., Henning, A., and Winter, J. (2003). Scale Up of the Anaerobic Digestion of Biowaste Fraction From Domestic Wastes. *Water Resources*. **37**:1433-1441.
18. Stalin, K. and Prabhu, H.J. (2007). Effect of Microbial Growth on Biogas Generation Using Carrier Material in the Self Circulating Biogas Plant. *APRN Journal of Engineering and Applied Sciences* **2**: 8-11.
19. Bhatia, R., (1990): Diffusion of renewable energy technologies in developing countries: A case study of biogas engines in India. *World Development*, **18 (4)**:575-590.

Climate Alert Mobile System

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ABSTRACT

The current climatic conditions have necessitated the need for an alert system that will give people information at the right time. Natural disaster such as flood, tsunami and tornado are inescapable unless people are forewarned. These disasters are mostly due to climate changes, and their damage could be reduced or averted if there is a functional alert system. A mobile system is more appropriate due to availability and portability of mobile devices. A Mobile System that gives alerts enables one to be prepared for necessary actions to be taken in any given situation anywhere anytime. A framework for climate alert mobile system is developed. The work identifies the features and services to be implemented for a mobile alert system. It involves the design of a system to be accessed by individuals, governments and climatologists at large. The system can implement various methods of mobile communication for climate notification. It also has a subscription system that allows users to subscribe to different services such as weather conditions alert, climate event alerts, climate news etc. The system is designed using open source technologies. The important features to be considered when designing a mobile alert are discussed and recommendations are made for supporting mobile user experiences.

Keywords: mobile, climate, alert.

INTRODUCTION

The effects of Climate Change on the environment and the follow up challenges on the survival of human race have become a global concern. According to the report in UN Business focal point issue 15, yearly climate disasters cause over 300, 000 deaths, seriously affecting over 325 million people, and lead to economic losses in the range of US$125 billion. Climate change has caused various forms of disasters such as floods, hurricanes, tsunamis, erosion, heat waves, drought, storm etc. in different parts of the world and Africa is not left out. Each of these disasters causes various forms of damage that negatively impact live and economy of the affected area or region. Nigeria, in 2012 experienced flood disaster that caused close to 400 deaths and more than 2,000,000 were displaced. Drought and flood are major cause of food and water insecurity which can lead to famine and these have affected the African region. The Nigerian experience was so disastrous due to lack of access to accurate and timely climate and weather information; this is the usual experience for most African countries. The need for using mobile devices in disseminating climate information which will assist in preventing and or reducing the effect of climate change disasters cannot be over emphasized. The use of Mobile devices such as cell phones, tablets, ipad etc. for communication are on the increase daily thus the potential of mobile technologies to alert people on climate change and weather forecast to assist with warnings and disaster prevention.

Alert systems have been implemented in different situations. An example is the Wireless Driveway alert systems that uses wireless receiver in homes that chimes when the infrared driveway alert sensor outside detects motion. This is a static system that its coverage is not more than a specific radius outside its location; the system is a private commercial system. Another one is the Amber alert or Child Abduction Alert system in the United States of America that inform the public about the abduction of a child via Commercial Radio Station, internet radio, e-mails, electronic traffic condition signs, radio, television SMS etc. As of January 1, 2013, Amber Alert is automatically sent to millions of cell phone users (Amber Alert WEI Information, Retrieved 5th July, 2013). Mobility has brought a new dimension into practicability of alert systems. Mobile Alert systems are now being employed in different situations such as the Integrated Public Alert System of the US which provides customers with timely and accurate emergency alerts and warnings via their cell phones and other mobile devices. There are other alert systems that are in place in advance countries such as the United States. Developing countries especially in this part of the world, Africa, are badly affected in the occurrence of natural disasters because such systems are hardly in place and if there are, they are probably not functioning as required.

CALMS FRAMEWORK

The significance of Climate ALert Mobile System (CALMS) is to enable the particular geographic location that is to be affected by natural disasters to have ample time and opportunity to prepare and put in place, if possible, preventive measures so as to minimize the odds of loss of life, damage to properties and so on. The alert system is needed at all times may be before, during and after an event has occurred. Because areas that was once safe for passage or habitation could later on become dangerous or impassable with time. For example, during the river Niger flooding in Nigeria in the year 2012, even after the supposed end of the disaster, people still lost their properties, roads that were passable in the morning became impassable by the afternoon. Some that were travelling from the west to the northern part of the country had to double back when they got to river Niger bridge in Kogi state, that happens to be the middle of the journey. Some had to abandon their vehicles, travelled down to the south to board a flight that took them to their destination. Apart from precious time wasted, loved once were put into agony of not being able to communicate with their loved during the journey due to communication network failure as part of the result of the disaster. The System is also able to specify the kind of alerts that people will get depending on their geographic location and the kind of warnings that will be needed for the particular location. Furthermore, the system is able to get a feel for different mobile devices that enable the recipients receive the alerts the way that best suit their devices.

CALMS Architecture

The framework of the system is subdivided into various components, A database of disasters that are likely to befall a particular geographic location which will be linked up with weather national grid of weather forecast stations, an interface that will be linked with the network communication service provider and the weather station that will know when the likely disasters are becoming a real threat or just to let the people be aware of the likely threats that may befall them, the database of necessary steps and precautions to be taken to avert such, if possible or the safety measures to take, a subscription interface for climate information is also included. The alert is unsolicited information while the subscription is strictly solicited. The design is based on four-layered components upon which the architecture of the system is built viz: the Climate Monitoring Device which is linked to a database of climate information, the alert content originator, the message originator and delivery components/phone gateways.

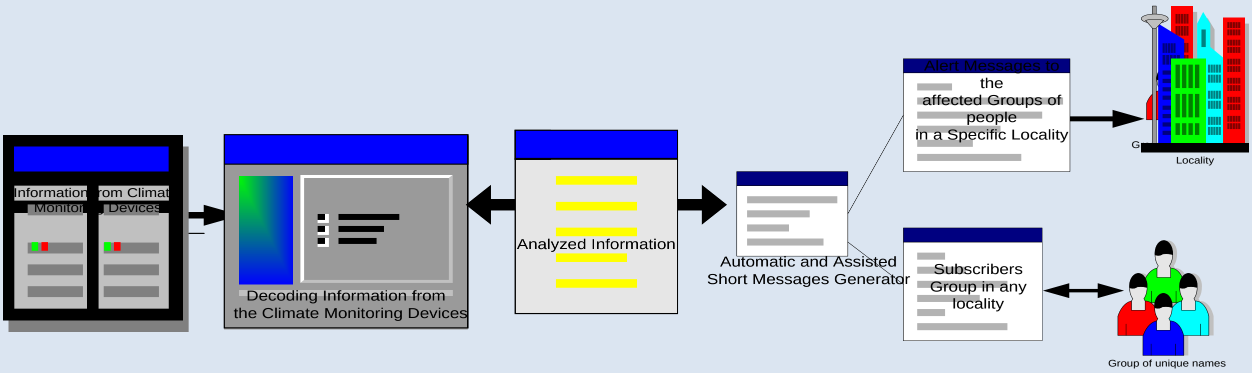


Fig. 1 Architecture of CALMS

Climate Monitoring Device

Climate Monitoring Devices are devices/sensors place in the satellite or any such equipment that acquire climate information from the earth or environment and transfer such to a computer and or device where the information is stored and analyzed for useful interpretation and dissemination. According to Wikipedia 2013, A satellite is an object that goes around, or orbits, a larger object, such as a planet. While there are natural satellites, like the moon, hundreds of man-made satellites also orbit the Earth. Telecommunications satellites require no optics, while environmental satellites do. Environmental satellites transmit images as numbers to a computer on Earth, which translates this digital data into images. Some of the data can be enhanced to look like photographs. The satellite gets the various images about the weather conditions at all times via sensors and transmit to computers on earth.

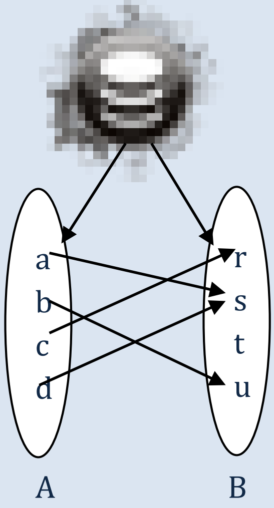
CALMS Content Originator

The second layer of the architecture which is the content generator is the facilitator of the message to be sent across the particular geographic location. This layer will know what the content of the message will be, the tone and the mode of dissemination. The mode of

operation of this layer will be that once the signal has been received by climatologists and the signals generated had been converted to understandable formats, then the tone of the message will be automatically generated. This level will also assist in choice of message contents and precisions. The contents will also depend on the enormity of the impending disaster and the recipients. The different measures that could be taken by the recipients will also be part of the information to be disseminated. The system attempts to restrict dissemination to the particular location, where the disaster is expected; this can be achieved with the help of the telecommunication network that will be transmitting the information. Content generation is based on rules, there are rules that determine the content of the alert/information so as to know the specific template to be generated for each event. By the application of these rules, the message template that best suit is automatically selected and will contain the necessary information about the impending disaster.
There rules are defined and are generated through the Rule-based language of the IF THEN ELSE Structure.

The Automatic and Assisted SMS generator
This layer of the architecture uses the general knowledge of the particular geographic location to know the exact area to locate with the information. This knowledge is kept in a database and the database will be populated with the aid of GIS that houses the locations of people in the area, the facilities available in these areas. Each alert is associated to a specific geographic location that describes alert recipients. To identify the actual targets, the rule is matched with locations in the GIS database.
The rules are identified as follows:
The function of each element of a set A is assigned a unique element of set B; the set A is called the domain of the function, and the set B is called the co-domain.

Let *f* denote a function from A into B $f: A \to B$



Let *f* assign to each short message as regards different climate conditions. The domain of *f* is the set of disasters resulting from the various climate conditions; the co-domain is the list of corresponding actions to take consequent to the climatic conditions. For instance the short message of flood occurrence is relocate, or in other words $f(flooding\ occurrence) => relocate$

The figure above defines a function f from $A = \{a, b, c, d\}$ $into$ $B = \{r, s, t, u\}$ in the obvious way. Here,

$$f(a) = s, f(b) = u, f(c) = r, f(d) = s$$

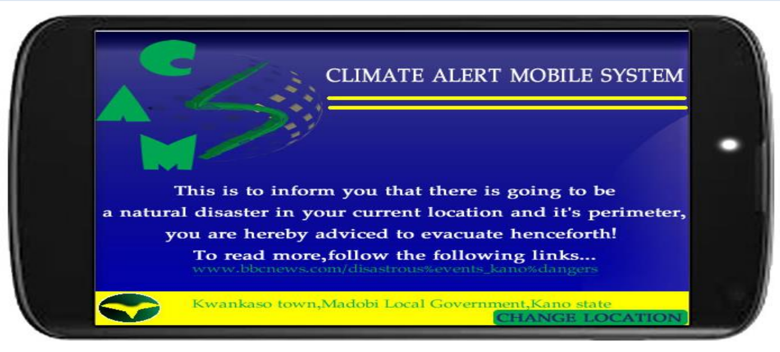
The image of f is the set of image values, $\{r, s, u\}$. Note that r does not belong to the domain of f because t is not the image of any element under f.

Delivery Components/Phone Gateways

This level of the system architecture modifies the messages received from the climatologists into formats that are readable for the appropriate recipients. Since the original message received from the Climate Monitoring Device may be in numbers or codes that may not be in readable format depending on the receiver, the system will convert it to texts and graphical images as appropriate. The information dissemination to the various mobile devices will be based on the existing protocols of the network communication providers available for that particular geographic location. This is done so as to minimize the cost of the alert messages since this is done on corporate social responsibilities from all existing network communication providers. To compensate the service provider, the subscription component is included, this can be charged as deemed fit by the service provider. Apart from the subscribed news, any alert or warnings being dispatched is given the utmost priority and the system is expected to work in such a way that whether there is network or not, the message must be delivered as in emergency. The system tries to give alert where it is possible before the actual date to avoid mass panicking and rush that may result in avoidable loss of both lives and properties.

DESIGN OF CALMS

In the system designed, alert is unsolicited information which is sent out to mobile networks subscribers, other forms of information as regards climate such as news, historical events and useful hints on what to do in a particular climate condition are to be solicited for through a subscription module. The subscription module requires the individual to register with his name, email address and location, this is done through a form that pops up when the subscription key or icon is tapped or selected. Verification is done before registering the individual by requesting him/her to type in some letters that will appear on the page, a message is issued to confirm registration. To facilitate the development of the application, mockup diagrams were used to have an understanding of the user interface. The experimental interface has been implemented on an Android mobile device, although, it is also portable on other mobiles devices. Below is a sample of the interfaces



4.0 Conclusion and future work

A framework for Climate Alert Mobile System has been presented; we intend to take the work from framework to actualization. Africa is lacking behind in effective and functioning alert and warning systems that could help in times of emergency. The government and the industries have not been of much help to move the region forward, to actualize this, it is expected that all stakeholders work together for a better tomorrow.

REFERENCES

1. Amber Alert – Wikipedia, accessed 5th July, 2013
2. UN Business focal point, issue 15, June, 2011
3. Wikipedia 2013 accessed 5th July, 2013
4. www.drivewayalarmstore.com, accessed 5th July 2013

Analysis of Rainfall Variability over Two Cities in Nigeria Using Harmonic Analysis Technique

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ABSTRACT
This paper presents the variability in rainfall using harmonic analysis technique as a tool in the estimation of annual rain amounts over Port Harcourt and Kano, Nigeria between the years 1977-2008. The estimated rainfall values of the years 2011 – 2014 were validated using a T- test analysis on the estimated and measured rainfall values of 2009 and 2010 data. The results show that rainfall variability in the two cities representing two different vegetative zones in Nigeria is strongly periodic and that the cyclic fluctuations in the rainfall are dominated by first harmonics, having large amplitudes of 90.40% and 75.41% in Port Harcourt and Kano respectively, thus indicating strong annual variations of rainfall in the stations. The mean monthly rainfall for both stations show different modal patterns of rainfall. The 2009-2010 prediction of monthly average rainfall for the city was validated at 95% confidence level.
Key words: Harmonic Analysis, Rainfall variability, Port Harcourt, Kano, T – test.

INTRODUCTION

The growing concern about climate change emphasizes the need for detailed information about the space and time distribution of rainfall. Although climate change is a global issue, its threat and vulnerability differ not only from one continent to another, but among sub regions, countries and even communities. Between the months of July and September, 2012, about thirty states in Nigeria had been affected by heavy flooding that displaced many people and destroyed properties worth millions of naira. The causes of the flooding which could be natural and or man-made had not been established. However, one of the possible causes could have been the changing world climate which triggered excessive rainfall, bursting dams and overflowing river banks. With the high tide in the Atlantic Ocean, river Niger and its tributary, the Benue which runs through the centre of the country experienced a back lash and surge of water into the hinterlands. Thus all the areas along the plains of the two rivers experienced flooding for some time. With a twist in the world climate, disasters of this nature are bound to occur. Hence there is need for proper study of the pattern in the variations of these climatic parameters, such as rainfall. This could be by testing whether their variations are periodic or not. This type of assessment will help in taking long term measures such as opening up of waterways, dredging of canals and building of dams in the flood prone areas.

Harmonic analysis of a time series uses a Fourier series to study periodic fluctuations. It is a particularly useful tool in studying annual precipitation patterns as it reveals the spatial variation of various precipitation characteristics. Harmonic Analysis, which is commonly applied to study periodic variations, decomposes a time series into its constituent parts if the time series represents a periodic phenomenon. It transforms a complex time series to a sum of many sinusoidal functions or harmonics [1]. The Harmonic analysis is based on a mathematical principle that a curve, viewed as a function, may be represented by a series of trigonometric functions. Hence, the series formula as used by [2, 3] is given as:

$$X_t = \bar{X} + \sum_{i=1}^{\frac{N}{2}} [A_i \sin(\frac{360}{P} it) + B_i \cos(\frac{360}{P} it)] \quad (1)$$

$$A_i = \frac{2}{N} \sum_{i=1}^{\frac{N}{2}} [\bar{X} \sin(\frac{360}{P} it) , B_i = \frac{2}{N} \sum_{i=1}^{\frac{N}{2}} [\bar{X} \cos(\frac{360}{P} it)] \quad (2)$$

X_t is the observed value at time, t, $\bar{X}$ is the arithmetic mean, A_i and B_i are coefficients or the amplitudes, N is the number of observations, i is the number of harmonics and P is the period of observation. In other words, the time series equals the mean plus the sum of all $\frac{N}{2}$ harmonics. The equation (1) above can be rewritten as;

$$X_t = \bar{X} + \sum_{i=1}^{\frac{N}{2}} C_i \cos[(\frac{360}{P} i)(t - t_i)] \quad (3)$$

The type of variation dominating the curve is revealed by a comparison of the sizes of the amplitudes C_i, where $C_i = \sqrt{A_i^2 + B_i^2}$ is the amplitude of the ith harmonic and $t_i = \frac{P}{360}$ arc sin (A_i/C_i) is the time at which the ith harmonic has a maximum. It can also be expressed in percentage. A harmonic with overwhelming contribution would definitely account for most of the periodic variation in the data, while the contributions of the other harmonics would be considered negligible. A large first harmonic amplitude suggests strong annual variation, while comparatively large second harmonic amplitude points to strong semiannual variation.

Several studies on the variations of some atmospheric parameters have been carried out using harmonic analysis technique. For example, [4] used it for areal and temporal analysis of rainfall. It has been used to study seasonal global precipitation by [5]. Similarly, [6] used it to study precipitation in Central America. Other studies of rainfall variation with harmonic analysis include: Studies of seasonal variation of rainfall [7 – 10]. In Nigeria, it has been used by [2] to study the hourly temperature variability in Makurdi, Nigeria. In addition, [3] investigated the validity of the harmonic analysis of the monthly rainfall variability in Makurdi, Nigeria.

In this work, we intend to investigate the pattern in the variations of rainfall in Port Harcourt and Kano Nigeria, using Harmonic analysis technique. Port Harcourt at (4° 47' 21" N, 6° 59' 55" E) is located in the rain forest zone, while Kano at (12°00′N 8°31′E) is located in the Sudan Savanna. The results obtained in this work will reveal the amplitude and patterns in rainfall variations at these two extreme vegetative zones in the country between the periods 1977 - 2010.

Source of data and method of Analysis

The daily rainfall data used in this study were obtained from the International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria. The period of this record is thirty-two (32) years from 1977-2008. The rainfall data were daily data yielding a sample size of about 30 for each month. Harmonic analysis on the averaged monthly rainfall observations was performed using the Turbo Pascal for windows programming language in order to implement the computation. This was carried out by fitting a periodic function of sinusoidal character to enhance the determination of the contribution of each harmonic (expressed as a percentage of total variation in the rainfall measurements it accounts for) and the amplitude of each harmonic.

Paired sample T-test (using the Statistical Package for Social Science, SPSS) was used to determine whether there is a significant relationship between the estimated rainfall values of the years 2009 and 2010 and their corresponding observed values. This serves as a test for the efficiency of the harmonic analysis model in estimating the rain fall amount in Port Harcourt and Kano representing two different vegetative zones in Nigeria. Table I links the months to the corresponding year.

Table I: Codes for the Month axis along with the year

Month	Year	Month	Year
0-12	1977	204-216	1994
12-24	1978	216-228	1995
24-36	1979	228-240	1996
36-48	1980	240-252	1997
48-60	1981	252-264	1998
60-72	1982	264-276	1999
72-84	1983	276-288	2000
84-96	1984	288-300	2001
96-108	1985	300-312	2002
108-120	1986	312-324	2003
120-132	1987	324-336	2004
132-144	1988	336-348	2005
144-156	1989	348-360	2006
156-168	1990	360-372	2007
168-180	1991	372-384	2008
180-192	1992	384-396	2009
192-204	1993	396-408	2010

RESULTS AND DISCUSSION

The time series and harmonics plots of average monthly rainfall for Port Harcourt are given in Figures 1 and 2 respectively while Figures 3 - 4 give respectively, the time series and harmonics plot of average monthly rainfall for Kano. On the other hand, Figures 5 –

6 present respectively, the combined time series and harmonic curves of the grand average monthly rain fall for Port Harcourt and Kano, Nigeria.

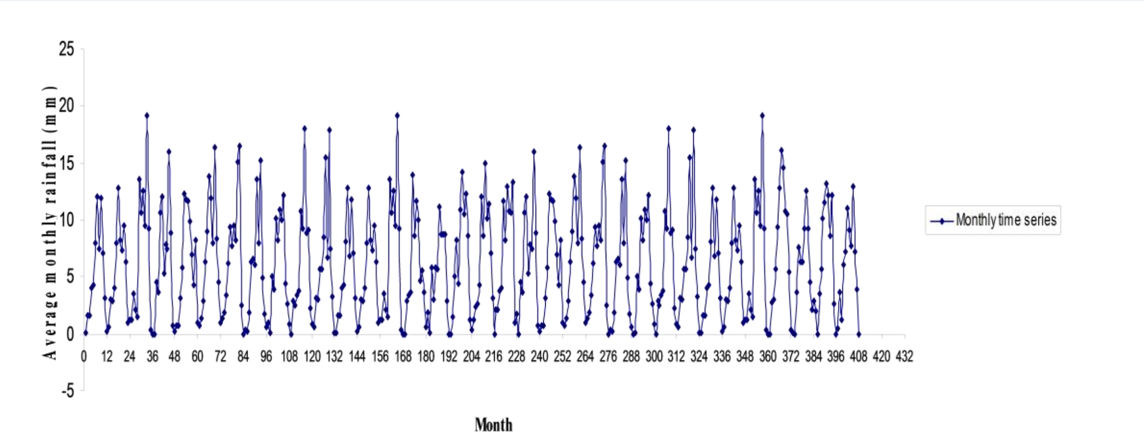

Figure 1: Time series plot of average monthly rainfall for Port Harcourt, Nigeria.

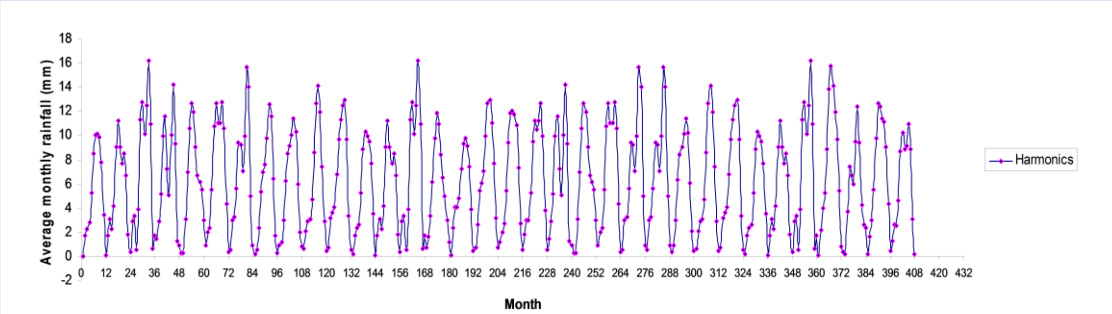

Figure 2: Harmonics plot of average monthly rainfall for Port Harcourt, Nigeria.

Average monthly rainfall

Month

Figure 3: Time series plot of average monthly rainfall for Kano, Nigeria.

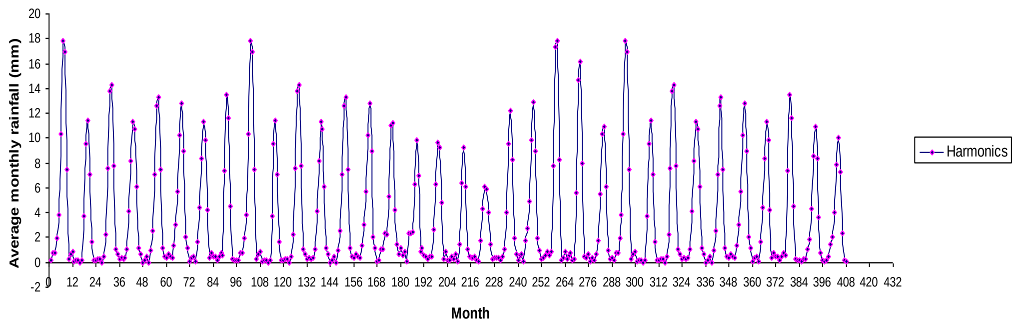

Figure 4: Harmonics plot of average monthly rainfall for Kano, Nigeria.

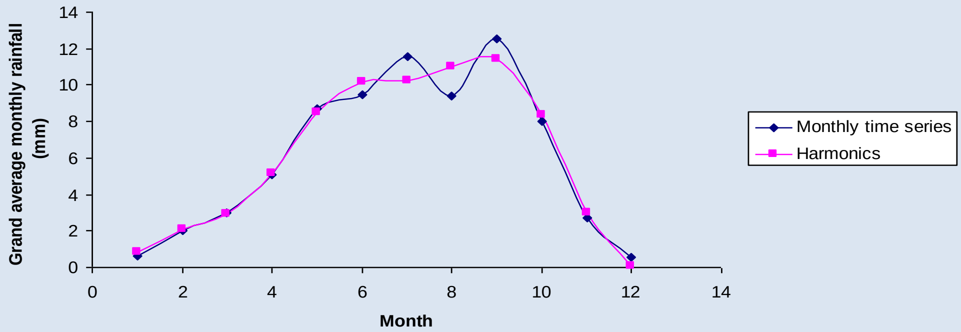

Fig. 5: Grand average of monthly rain fall and harmonics curves for Port Harcourt, Nigeria.

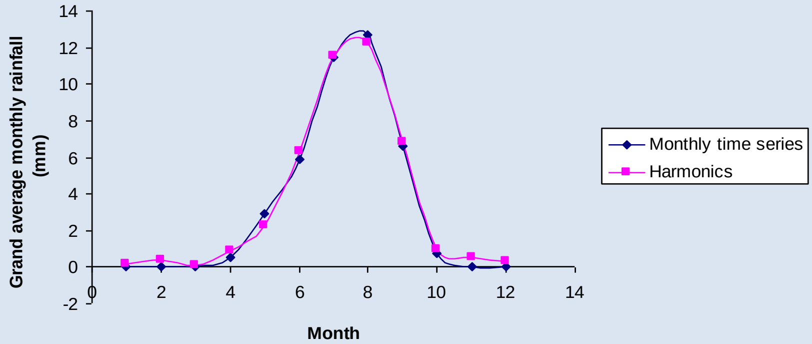

Fig. 6: Grand average of monthly rain fall and harmonics curves for Kano,

Considering the results for the Port Harcourt station, observations from Figures 1 – 2 show that there exists a similarity in the trend of variations of both the time series and harmonic series plots of the data; the plots exhibit more than one peak of rainfall in the area. That is, rainfall patterns are bimodal and multimodal in nature. This indicates that in a particular year, the rainfall peaks are observed in two or more months. For instance, in Figures 1 – 2, bimodal patterns are observed in 1977 – 78. Tri - modal pattern is observed in the 360th month and so on. These multimodal rainfall patterns could be attributed to the constant rain events in the area. However, in the harmonic plot, the observed multiple peaks in the time series plot are now reduced to mono- modal and bimodal patterns. Hence, the harmonic analysis could have filtered or smoothened out some noise or spikes in the data.

On the other hand, the vivid picture of the temporal variations in rainfall in Port Harcourt could be ascertained from Figure 3, which shows actually that the pattern of rainfall in the area is bimodal in nature. However, there is a strong phase shift between the harmonic and time series curves at the months between May and October. This coincides with the periods when the rain intensities are high in the area. But the periods of low rain intensities (November – April) indicate a strong phase relation between the two curves. Thus, in Port Harcourt, the months with highest rainfall are July and September. But in August, the rain subsides or 'breaks' momentarily. The regular and low rainfall variability in the area is probably due to the influence of water body such as the nearby Atlantic Ocean

However, for the Kano station, both the time series and harmonic analysis curves of Figures 3 - 4 respectively, show mainly mono modal patterns of rainfall. This is clear in the net mean monthly rainfall (Fig. 6), which shows a single peak of rainfall in August. Hence both the harmonic and the time series curves are in phase. It is interesting to notice from Figures 5 and 6 that the period of rain break (August) in Port Harcourt was the period of the largest peak of rainfall observed in Kano. This could be due to the movement of inter tropical discontinuity (ITD), which could have moved up to Kano at that time. Little or no rainfall was experienced between the period, October and April probably due to the movement of the ITD, which at this time is far down in the south. Rainfall was produced mainly due to local convection caused by the intensive heating of land surfaces [10]. Results extract from the run of harmonic analysis on average monthly rainfall for Port Harcourt and Kano, Nigeria are summarized in Tables II and III respectively.

Table II: Result extract from the run of harmonic analysis program on average monthly rainfall for Port Harcourt, Nigeria.

Harmonics	Sine Coefficient (A_i)			Cosine Coefficient (B_i)			Amplitude	Percentage Contribution (%)
	A1	A2	A3	B1	B2	B3		
1st	-3.4873	0	0	-4.2994	0	0	5.54	90.40
2nd	0	-0.1279	0	0	-1.0068	0	1.01	3.04
3rd	0	0	0.7792	0	0	-0.7407	1.08	3.41

Table III: Result extract from the run of harmonic analysis program on average monthly rainfall for Kano, Nigeria.

Harmonics	Sine Coefficient (A_i)			Cosine Coefficient (B_i)			Amplitude	Percentage Contribution (%)
	A1	A2	A3	B1	B2	B3		
1st	-3.6854	0	0	-4.0969	0	0	5.51	75.41
2nd	0	2.8833	0	0	-0.0908	0	2.88	20.66
3rd	0	0	-0.3107	0	0	1.0940	1.14	3.21

Table II shows that the first harmonic dominates the periodic components in the monthly average rainfall of Port Harcourt. It has the highest percentage contribution of 90.40%, indicating that the monthly rainfall in the station has strong annual fluctuations [7, 10]. This is also evident in Figure 3, where the months of July and September are prominent in the annual rainfall fluctuations.

Results from Table III also show that the first harmonics dominates the periodic components in the monthly average rainfall of Kano as it has the highest percentage contribution of 75.41, indicating strong annual fluctuation or periodicity of the monthly rainfall in the station. The periodic fluctuation is dominated by half a cycle as is evident in Figure 6.

Using the average monthly rainfall obtained as 6.15 and 3.41mm, the period of 12 months, and the sine and cosine coefficients in Tables II and III, the periodic function X_t for the monthly average rainfall of Port Harcourt and Kano were obtained using extracts from equation (1) as shown respectively in equations (4)and (5) as:

$$X_t = 6.15 + \sum_{i=1}^{3} \left[A_i \sin(30it) + B_i \cos(30it)\right] \quad (4)$$

$$X_t = 3.41 + \sum_{i=1}^{3} \left[A_i \sin(30it) + B_i \cos(30it)\right] \quad (5)$$

A_i and B_i are coefficients of sine and cosine respectively and i's are integers ranging from 1 to 3 as given in Tables II and II. Equations (4) and (5) were then implemented in the harmonic analysis program so as to make six year forecasts of monthly average rainfall measurements for Port Harcourt and Kano. Hence, Tables IV and V present the six year (2009 – 2013) forecasts of average monthly rainfall for Port Harcourt and Kano respectively.

Table IV: A display of six (6) years forecasts of average monthly rainfall for Port Harcourt, Nigeria

Month	Actual Value (mm)	Model Estimate (mm)	Prediction for Six (6) years						
			1	2	3	4	5	6	
January	0.64203	0.84941	0.85109	0.85110	0.85290	0.85381	0.85471	0.85561
February	2.03527	2.11492	2.11572	2.11618	2.11664	2.11710	2.11756	2.11802
March	3.01888	2.89198	2.89311	2.89382	2.89454	2.89525	2.89596	2.89668
April	5.10382	5.15605	5.15877	5.16066	5.16255	5.16443	5.16632	5.16821
May	8.70987	8.51952	8.52171	8.52339	8.52507	8.52675	8.52843	8.53011
June		10.1849	10.1852	10.1855	10.1858	10.1861	10.1863	10.1866
	9.48745	8	9	7	3	0	7	4
July		10.2250	10.2251	10.2252	10.2253	10.2254	10.2254	10.2255
	11.53226	7	6	4	2	0	9	7
August		10.9742	10.9748		10.9761	10.9768	10.9775	10.9782
	9.43720	2	2	10.9755	8	6	4	2
Septembe		11.4235	11.4230	11.4225	11.4219	11.4214	11.4208	11.4202
r	12.56186	0	8	2	6	0	4	7
October						8.35982		
	8.03093	8.37019	8.36845	8.36557	8.36270	1	8.35694	8.35407
November	2.68441	2.99283	2.99151	2.98869	2.98587	2.98305	2.98023	2.97742
December	0.57135	0.10323	0.10309	0.10267	0.10225	0.10183	0.10141	0.10099
Monthly	6.1500							
Average	0	6.15000						

Table V: A display of six (6) years forecasts of average monthly rainfall for Kano Stations

Month	Actual Value (mm)	Model Estimate (mm)	Prediction for Six (6) years					
			1	2	3	4	5	6
January	0.00000	0.15920	0.15841	0.15799	0.15756	0.15714	0.15672	0.15630
February	0.01156	0.38261	0.38265	0.38268	0.38271	0.38273	0.38276	0.38278
March	0.00161	0.12562	0.12640	0.12689	0.12739	0.12788	0.12837	0.12886
April	0.50108	0.90880	0.90943	0.90986	0.91029	0.91072	0.91116	0.91159
May	2.94512	2.26293	2.26479	2.26622	2.26765	2.26909	2.27052	2.27195
June	5.89662	6.32539	6.32908	6.33225	6.33541	6.33858	6.34175	6.34492
July	11.4421	11.56500	11.56802	11.57029	11.57256	11.57483	11.57709	11.57936
August	12.7258	12.28280	12.28130	12.27965	12.27801	12.27636	12.27471	12.2731
September	6.63031	6.86660	6.86360	6.85960	6.85559	6.85158	6.84757	6.84357
October	0.75484	1.00164	1.00026	0.99798	0.99570	0.99342	0.99115	0.98888
November	0.00069	0.52724	0.52713	0.52690	0.52666	0.52642	0.52618	0.52594
December	0.00000	0.31643	0.31655	0.31689	0.31724	0.31759	0.317936	0.31828
Monthly Average	3.41000	3.41000						

Observations show that equations (4) and (5) exhibit a good fit for the average monthly rainfall as they produce very close estimates of the actual monthly average rainfall. They yield the same means (average monthly rainfall) as that of the actual data; and very close standard deviations of the actual and that of the model estimates as shown in Tables IV and V, which also display the results of the forecasts with the corresponding actual and estimates of monthly average rainfall measurements. These estimates are known as model estimates.

Tables VI and VII display both the measured and the estimated rainfall values in Port Harcourt and Kano respectively, for the years 2009 and 2010. The level of deviation measured from the estimated rainfall values in both years were determined using paired sample T-test analysis. The results show that there are no significant differences at 95% confidence level between the measured and the estimated rainfall in both years as can be seen from the T and P values. Hence, the predictions for the four other years ahead are valid as far as rainfall variations in these stations are concerned.

Table VI: Validation results for Port Harcourt station

	2009		2010	
Month	Actual Value (mm)	Model Estimate (mm)	Actual Value (mm)	Model Estimate (mm)
January	1.97742	0.86085	0.47097	0.86175
February	0.00000	2.11603	3.64286	2.11649
March	3.48387	2.90179	1.22258	2.90251
April	5.63333	5.16332	6.07667	5.16519
May	10.09355	8.47609	7.25161	8.47773
June	11.54000	10.10871	11.01333	10.10899
July	13.23226	10.20078	9.13871	10.20091
August	12.13871	11.01727	7.72581	11.01797
September	8.55667	11.44969	12.87667	11.44901
October	12.18388	8.33435	7.15807	8.33145
November	2.58668	2.95022	3.86667	2.94741
December	0.000000	0.100223	0.00000	0.09982
T-value	1.17700		-0.63500	
P-value	0.26400		0.53900	
Remark	No significant Difference		No significant Difference	

Table VII: Validation results for Kano station

	2009		2010	
Month	Actual Value (mm)	Model Estimate (mm)	Actual Value (mm)	Model Estimate (mm)
January	0.00000	0.16960	0.00000	0.16916
February	0.00000	0.39104	0.00000	0.39108
March	0.00000	0.11046	0.00000	0.11094
April	0.88000	0.88755	2.19000	0.88798
May	2.03871	2.28310	1.40645	2.28458
June	5.24667	6.46097	4.03333	6.46421
July	5.87097	11.77335	8.58065	11.77562
August	14.92903	12.39636	8.96452	12.39463
September	4.45667	6.80640	8.29667	6.80230
October	6.03226	0.87899	1.85161	0.87672
November	0.00000	0.57876	0.00000	0.57847
December	0.00000	0.33115	0.00000	0.33152
Mean	3.28786	3.58898	2.94360	3.58893
T-value	-0.40100		-1.37300	
P-value	0.69600		0.19700	
Remarks	No significant	Difference	No significant	Difference

CONCLUSIONS

The following inferences are drawn from this work:

- Rainfall variability over Port Harcourt and Kano, significantly changes over time. This variability could have been caused by the movement of inter – tropical discontinuity which advances the rainfall patterns northwards between January and August, and retreats from the southern fringe of the Sahara desert after August [11].

- The variability across the stations presents cyclic fluctuations dominated by full cycles in Port Harcourt (probably due to its proximity near the coast) and half a cycle in Kano which is farther from the Atlantic Ocean. Thus, the presence of features such as large water bodies, or desert, reliefs, that characterize these stations might have influenced the variability in the monthly rainfall. Large first harmonics in both cases suggest strong annual variations in rainfall in both stations.
- Maximum average monthly rainfall records appear between July and September, while minimum average monthly rainfalls appear between November and March.

- The six years prediction of monthly average rainfall for each of the stations show strong indication and tendency of being repeated annually subject to the conditions of other atmospheric variables such as cloud, sunshine, wind and so on.

RECOMMENDATIONS

The following recommendations are made in this work:

- The harmonic model could be applied to the rainfall data of other stations so as to obtain a clear picture of the fluctuations and patterns of rainfall in those stations and Nigeria at large

- It can also be applied to other atmospheric variables (of the same period), such as air temperatures. The comparison of such results will enhance determination of the climatic variability in Nigeria.

- Further research could be advanced to determine the reason for the lag between the harmonics and time series plots

- The influence of other atmospheric phenomena such as the El- Nino Southern Oscillations could be investigated in order to determine whether they have any effect on the rainfall pattern.

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REFERENCES

[1] Park, S. (2008): Harmonic Analysis of Long Term Modis Time Series Data for Vegetation Dynamics in Hawaii. ASPRS 2008, Annual conference Portland, Oregon.

[2] Isikwue, B. C.; Agada,O. I.; Utah, E. U. and Okeke,F. N. (2011): Application of Harmonic Analysis in the Preliminary Prediction of Air Temperature over Lagos and Abuja, Nigeria. British Journal of Environment & Climate Change, 1(3): 53-65, 2011, SCIENCEDOMAIN international. www.sciencedomain.org

[3] Isikwue, B. C.; Ameh, M. E. and Utah, E. U. (2012): Validity of the Harmonic Analysis of the Monthly Rainfall Variability in Makurdi, Nigeria. World Journal of Applied Science and Technology, 2 (2) 189 – 195.

[4] Scott, C. M. and Schulman, M. D. (1979): An areal and Temporal analysis of precipitation in the North eastern United States, J. Appl. Meteor., 18, 627-633.

[5] Hsu, C. F. and Wallace, J. M. (1976): The global distribution of the annual and semiannual cycles in precipitation. Mon. Weather. Rev., 104, 1093-1101.

[6] Hastenrath, S.I. (1968): Fourier Analysis of Central American Rainfall. Arch. Meteor. Geophys., Bioklim, B16, 81-94.

[7] Kirkyla, K. I. and Hammed, S. (1989): Harmonic analysis of the Seasonal Cycle in Precipitation over the United States: A Comparison between Observations and General Circulation Model. Journal of Climate, (2) 12 1463-1475.

[8] Kadioglu, M., Ozturk, N., Erduu, H. and Sen, Z. (1999): On the precipitation Climatology of Turkey by harmonic analysis. Int. J. Climatol., 19, 1717-1728.

[9] Vines, R. G. (2007): Rainfall patterns in India. Int. J Climatol., 6, 135-148.

[10] Wong, C.L., Venneker, R., Uhlenbrook, S., Jamil., A.B.M. and Zhou, Y. (2009): Variability of rainfall in Peninsula, Malaysia, J. Hydrol. Earth System Sci. Discussion, 6, 5471-5503
[11] Okajima, H.; Xie, S. P. and Numaguti, A. (2008): Interhemispheric coherence of tropical climate variability: effects of climatological ITCZ. J. Meteorl.

THEME 12 : CLIMATE CHANGE AND WATER RESOURCES

Concentration of Heavy Metals and Petroleum Hydrocarbons in Arunton Creek and Environs in Escravos Niger Delta, Nigeria

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ABSTRACT
Contamination of the environment soil and sediment, water and air from operations of petroleum industry and spills is a frequent environmental challenge in the oil rich communities of the world including Niger, Delta of Nigeria. It is evident that petroleum exploration has contributed immensely to the welfare and economic of Nigeria particularly in the past two decades when it replaced agriculture as the cornerstone of the Nigeria economy. However, in the last few decades, the Niger Delta area of Nigeria has suffered human health risk and ecosystem degradation resulting from oil spillages, leakages of petroleum and other involuntary effluent discharge to the environment from oil exploration activities. This research seeks to address and assess the risk associated with heavy metals and petroleum hydrocarbons in the environment. The selected heavy metals (As, Cd, Cu, Cr, Fe, Hg, Ni, Pb, V and Zn) and Total Petroleum hydrocarbons (TPH) were considered. In this case, the contamination of sediment and water from Arunton creek and environ of the Niger Delta was investigated. Sediment and water samples were collected between April 2012 and September 2012. Samples were analyzed using the Atomic Absorption Spectrophotometer (AAS) for heavy metals and Gas chromatography GC for the petroleum hydrocarbons after adquate treatment. The variation of heavy metal concentration in the water and sediment samples respectively is:
Fe>Cu> Ni > Pb > Zn > Cd > Cr > V while As and Hg were not detected, and Fe >Zn > Ni >Pb >Cu >Cr >Cd >V > Hg >As TPH was detected in sediment samples, with values (594.04-1039.23) the values water ranges (1.00 – 31.00) mg/l. The nickel vanadium ratio for water and sediment are high with values 25.0 and 187.0 respectively. In general, the values Obtained compared with WHO standards are higher suggesting pollution related to the petroleum activities.

Keywords: Risk assessment, Heavy metal, Petroleum hydrocarbon, Arunton Creek, Niger Delta.

INTRODUCTION

In the past few decades there has been an increased public awareness of environmental issues particularly when contamination of soil, sediment, water and air are involved. Globally, scientists and environmentalists are faced with the challenge of overcoming the detrimental effects of the contamination of the environment. Spillages of crude oil on the environment; leakages from pipelines, underground and surface fuel storage tanks; in discriminate spill and careless disposal and mismanagement of waste constitute the major sources of petroleum contamination of the environment.

In recent years, environmental pollution due to the increasing release of hazardous and toxic substances into the soil, water, sediment and air in Niger Delta, Nigeria has been a widespread problem. Inyan (1997) and Stanley (1990) emphasized that oil exploration and exploitation has impacted disastrously on the Niger Delta oil bearing communities in the last four decades. Equally Nwankwo et al (1981) and Okoye et al (1987) noted that the oil industry is characterized by periodic spills which posse constant threat to quality of the environment. In fact, there are so many different chemicals in crude oil and in other petroleum products, such that it becomes practically difficult to measure each one separately. However, it is important to measure the amount of heavy metals and total petroleum hydrocarbon (TPH) at the study area. The analytical goal of each petroleum spill site is to asses the level of concentration and to efficiently and safely remove the spilled petroleum products from the environment in order to return the environment back to what it used to be or near it provided it is harmless to plants; fauna, human health and the entire ecosystem.

Environmental contamination by petroleum spills and petroleum products is of significant in the world and particularly the Niger Delta of Nigeria. The economy of Nigeria, the most populous, black African country is largely dependent on crude oil tapped in the Niger Delta region. Estimates of 2.4 million barrels of crude oil per day come from the Niger Delta. Niger Delta comprises of nine out of the thirty six sates of Nigeria and has a population of about 30 million people.

This region is not only richly blessed with oil but also solid minerals, fish from rivers and ocean, huge plants and variety of animals from the swampy forest. The protracted activities of oil drilling occasionally resulting in spillages and subsequent environmental contamination and gas flares pollute and rendered the once fertile-farm lands barren, with disappearance of vegetation, animals and fish. This situation led to poverty resulting from joblessness, emergency of irate militants and the jeopardy of human and ecological lives. Most human, aquatic and terrestrial lives in the Niger-Delta are endangered which often aroused conflicts and threat of abduction of oil workers. Poor supply of electricity, water, road net work and poor health care system plagued the oil rich region leaving them to drink from wells, streams,, rivers and most often from stagnant ponds that are contaminated.

This paper represents the initial study on environmental risk assessment of the presence of heavy metals and petroleum hydrocarbons in the Arunton creek and its environs of Escravos in Niger Delta due to the contamination of the environment by

petroleum and its products arising from petroleum exploration and exploitation in the area. The objectives of this study include the determination of the levels of selected crude oil pollution indicator heavy metals (Arsenic, Cadmium, Copper, Chromium, Iron, Mercury, Nickel, Lead, Vanadium and Zinc) and total petroleum hydrocarbons in the study area, comparison of the values obtained with regulatory limit standards and possibly give adequate recommendations.
An Arunton creek is in Arunton village of Escravous area in Warri Southwest local government area of Delta State, Nigeria. Arunton village is directly opposite the fenced Chevron tank farm and separated by the Arunton creek. Arunton creek is a source of water, fish and other aquatic resources.

MATERIALS AND METHOD

Consultation: Consultation with indigenes and residence with permission was done to obtain information about the environment, their living and past occurrences in relation to the Chevron Tank farm, and to familiarized one self with the environment and terrain.

Sample Collection and Handling

Sediment and water samples were collected monthly for six (6) months (April – September 2012) in triplicates from three locations within the study area.

Sediment Samples For Heavy Metals and TPH Analysis

The bottom sediments were collected with the aid of Ekaman-Birge (Sediment Grab) and wrapped aluminum foil to prevent contamination and preserved in an ice chest for onward transfer to the laboratory.

Samples collection for heavy metal

Water samples for the determination of heavy metals were collected in a 1 litre capacity polythene bottles which had earlier been cleaned by soaking in 5% nitric acid for 24 hours and rinsed with deionized water before use (APHA). Water samples were immediately acidified with 5ml analar grade concentrated nitric acid to prevent the adsorption of the heavy metals on the wall of the container (Bailey and Gardner, 1977).

Sample collection for TPH

Water samples for the determination of TPH were collected in a 1 litre capacity glass bottle washed with detergent, rinsed with deionizer water, soaked overnight with 5% sulphuric acid and finally rinsed with deionized water before use. The water samples were acidified with 2ml analar grade concentrated sulphuric acid immediately after sampling (APHA 1989).

Digestion for Heavy Metal Analysis

Each sediment sample was digested using double (mixed) acid (concentrated HCL and concentrated HNO_3, ratio 1:1).

The sediment sample was air dried in the open at room temperature after which it was ground and sieved to a mesh size of 650μm with a sieve.

10g of sieved sediment was weighed and transferred into polythene bottled. 100ml of the double acid was added and agitated on a mechanical shaker. The resulting mixture was filtered with Whatman No 42 filter paper, and the filtrate made up to 100ml with pure de-ionized water and labeled. A blank was prepared in the similar method but without the sieved sediment.

Extraction of TPH in Sediments

The sediment samples were extracted with hexane. 5g of wet sediment sample was weighed into a 50ml glass vial with a Teflon cap on mettle balance PE 360. 10ml of hexane was added and covered. The covered vial was shaken vigorously to aid the extraction process. This was followed by further addition of 10ml acetone and shaken again. The resulting mixture was filtered through a 0.45μm solvent resistant membrane filter to remove all the particulate matter. The extract column of 1g deactivated fossil in a vial. The filtrate was then concentrated to about

Extraction of TPH in Water

100ml of the water sample was measured into a 1 litre separating funnel, 20ml of analar grade. Hexane was added and shaken thoroughly. The mixture was allowed to settle at which time the TPH and water separates out with TPH on top and water at the bottom. The TPH was separated into a clean dry container containing anhydrous sodium sulphate to absorb moisture. It was then filtered into 1g of deactivated fossil in a beaker to remove polar materials by adsorption.

Analysis of Heavy Metals and TPH

Heavy Metal Analysis

The quantitative analysis of heavy metals in the sediment and water samples was carried out using Analyst 500 Pye Unicam Atomic Absorption Spectrophotometer (AAS).

The sediment digestion solution and the acidified water from the site were aspirated one after the other directly into AAS for the determinate of the different metals at their respective specific wavelengths against standard solutions of each of the metals.

Total Petroleum Hydrocarbon (TPH) Analysis

The TPH in the sediment and water samples were analyzed using the cleaned extracts. The extracts from sediment and water samples were injected directly into the gas chromatography system HP 6890 series for the analysis.

Statistical Analysis

Data Analysis

The experimental designs was completely Randomnized block design descriptive statistic Analysis of Variance (ANOVA) means comparison and were used to determined significant difference in the samples, heavy metal across the 3 stations and the months statistical analysis were carried out using the SPSS and excel package.

RESULT AND DISCUSSION

The mean values of heavy metals in sediment and water samples are presented in Tables 1 and 2 respectively.

The range of concentration of the heavy metals in the sediment and water samples is shown in Tables 3 and 4 respectively. The variation of mean heavy metal concentration in sediment samples are.

Fe > Zn > Ni > Pb > Cu > Cr > Cd > V > Hg > As.

The trend is slight different for water as indicated below.

Fe> Cu > Ni > Pb > Zn > Cd > Cr > = V

While As and Hg was not detected. The values of the heavy metals are quite high.

The mean nickel - Vanadium ratio for sediment and water samples values are 187.0 (18.56:0.10) and 25 (0.25:0.01) respectively are quite high and indicative of petroleum contamination.

TPH was detected in sediments and in water, the mean values ranged between 594.04mg/l and 1039.23mg/l for sediment while 1.00 mg/l and 31.00 mg/l. The values are quite significant.

CONCLUSION

The study reveals that the study locations are generally impacted and are unnatural. The mean concentration of heavy metals is higher in the sediment and lower in the water. The high values of the heavy metals, the nickel-vanadium ratio and the TPH in water and sediment shows that the environmental contamination is petroleum activity related.

Table 1: Mean concentration of heavy metals in sediments from the three (3) stations

	Stations		
	Aruntoncrk	**Arunton well**	**Estuary (Arunton)**
As	0.01 ± 0.00	0.01 ± 0.01	0.01 ± 0.00
Cd	0.77 ± 0.71	0.34 ± 0.42	0.12 ± 0.16
Cu	2.79 ± 0.75	1.70 ± 1.03	6.65± 0.59
Cr	0.48 ± 0.47	0.83 ±0.77	0.61± 0.51
Fe			
Hg	0.01± 0.00	0.01± 0.00	0.01± 0.00
Ni	11.95 ± 1.23	18.56 ± 7.64	8.59 ± 1.30
Pb	15.58 ± 3.23	5.15± 1.63	11.17± 0.69
V	0.10± 0.08	0.09 ± 0.13	0.04 ± 0.07
Zn	13.92 ± 8.24	17.67± 1.62	21.89± 3.66

Table 2: The summary mean values of Heavy Metals in the water

	Stations		
	Arunton crk	**Arunton well**	**Estuary (Arunton)**
As	0.01±0.00	0.00±0.00	0.00 ± 0.00
Cd	0.02±0.04	0.00±0.01	0.02±0.02
Cu	0.72±0.99	0.98±1.49	1.14±0.71
Cr	0.01±0.00	0.00±0.00	0.00±0.00
Fe	2.15±0.91	1.38±0.80	1.65±0.98
Hg	0.00± 0.00	0.00± 0.00	0.00± 0.00
Ni	0.15±0.14	0.13±0.11	0.25±0.08
Pb	0.03±0.02	0.07±0.12	0.03±0.03
V	0.00±0.00	0.00±0.00	0.01±0.00
Zn	0.04±0.03	0.03±0.02	0.04±0.02

Table 3: Range of mean concentration of heavy metals in sediment samples

S/No	Heavy metals	Range (mg/kg)
1	As	0.0 – 0.01
2.	Cd	0.12 – 0.77
3.	Cu	1.76 – 0.65
4.	Cr	0.48 – 0.83
5.	Fe	1058.28 – 3319.86
6.	Hg	0.01
7.	Ni	8.59 – 18.56
8.	Pb	5.15 – 15.58
9.	V	0.04 – 0.10
10.	Zn	13.92 – 21.89

Table 4: Range of mean concentration of heavy metals in water samples

S/No	Heavy metals	Range (mg/l)
1	As	ND
2.	Cd	ND-0.0.02
3.	Cu	0.72-1.14
4.	Cr	ND – 0.01
5.	Fe	1.38 – 2.15
6.	Hg	ND
7.	Ni	0.13 – 0.25
8.	Pb	0.03 – 0.07
9.	V	0.00 – 0.01
10.	Zn	0.03 – 0.04

Table 5: Range of Nickel-Vanadium (Ni: V) ratio for the water: and Sediment samples

S/No	Sample	Nickel – Vanadium ratio (Upper concentration)
1	Sediment	18.56 : 0.10 = 187.0
2.	Water	0.25 : 0.01 = 25.0

REFERENCES

Abohweyere, P.O. 1990. Study of limnological parameters and potential fish yield in Kigera Reservoir (Extensive System) in Kainji, New Bussa, Nigeria. Journal of Aquatic Sciences. 5: 53 — 58

Ackefors. H., Loforth, G., Rosen, C. G. 1970. Mercury pollution in Sweden with special reference to conditions in the water habitat proc. R. Soc London. B 177. D365 — 387.

Adams, T. G., Archison, G. and Vetter, R. J. 1980. Impact of industrially contaminated Lake on heavy metal levels in its effluent system. Hydrobiologia 69: 187 — 193

Adebisi, A. A. 1981. The physic-chemical hydrology of a tropical seasonal river — Upper Ogun River. Hydrobiogia. 79: 157—165

Ademoroti, C. M.A. 1987. "Contamination of shallow wells in Nigeria from river surface Contaminant migration". Environmental International, USA. 13: 491 -495.

Adermoroti, C.M.A. 1996. Environmental Chemistry and Toxicology. Foludex Press Ltd. Ibadan. 2l5pp.

Ademoroti C.M.A. 1996. Standard methods for water and effluents analysis. Foludex Press Ltd, Ibadan l82pp.

Adeyeye, E. I, 2000. Bio-Concentration of macro and trace minerals in four Prawns living in Lagos Lagoon. Park .1 Sd. md. Res. 43 (6) 367—373

Afolabi, O.A., Adeyemi, S.A., Imevbore, A. M.A., 1987. Studies on toxicity of some Nigerian crude oils to some aquatic organisms. In: Proceedings of International Seminar on Petroleum Industiy and the Nigerian Environment in Kaduna, 1985.

Agada, E. G. 0. 1 995. Heavy metals concentrations in selected fish fauna of Warn River and its tributaries. Ph. D. thesis, University of Benin, Benin City. pp 152.

Ajayi, S.O and Osibanjo, 0. 1981. Pollution studies on Nigerian Rivers. Water quality of some Nigerian Rivers. Environ. Pollul. (Ser. B,) 2: 87 — 95.

Akpan, A. W. 1995. Limnology and net plankton periodicity of a tropical freshwaters pond in Uyo (Nigeria). Tropical Freshwater Biology. Vol. 4: 65 — 81

Alabaster, J.S. and Lloyd, R. 1982. Water quality criteria for freshwater fish. 2 edition. London, Butterworth, 36 lpp.

Amdur, M.O. 1986. Air Pollutants. In Toxicology, the Basis Science of Poisons; Klassen, CD., Amdur, M.O Doull, J., Eds. Macmillan Publishing Co. New York. pp 801 — 824.

Amstrong, H., Fucik, W. K., Anderson, J. W and Neff, J. m. 1979. Effects of oil filed brine effluent on sediment and benthic organisms in Trinity Bay, Texas. Mar. Environ. Res. 2, 55.

Aderson, J. A 1974. A study of the digestion of sediments of the HNO3, H2N03, H2S04 and the HNO3. HCL procedures. AtAhsorpt. News. 13, 31

Aderson, J. W. 1977. Effects of petroleum hydrocarbons on the growth of marine organisms. Ibid. 171: 157— I65pp.

APHA, 1989. (American Public Health Association). Standard Methods for the Examination of Water and Waste, Clesceri, L.S; A. A. gathering and R.R Trussell, 17th Edition 3144pp

ASTM, 1986 (American Society for Testing and Materials). Annual Book of ASTM Standards Section 11: Water and Environmental Technology, Vol. 1102, Water (II).

Atuma, S. 0 and Egborge, A. B. m. 1986. Insecticides and metals in Nigerian surface water of Warn River. Inter. .1. Environmental Studies 27: 139 — 142

Bache, C. A., Gutemann, W. H., Lisk, D. J. 1971. Residues of total mercury and methyl mercuric salts in Lake trout as a function of age. Science. 172: 951 —952.

Baker, D. E and Amacher, M. C. 1982. Nickel, copper, zinc, and cadmium. In: Methods of soil analysis part 2. Pp323 — 326. Agronomy 9. Soil Science Society America. Madison Wisconsin, U.S.A.

Barley, G. E Gardner, D. 1977. Sampling and Storage of Natural Waters for Trace metal Analysis. Inir. .Journ. Environ. 11: 745 -746pp.

Beauchamp, R. S.A. 1953. Sulphates in African Enland Waters. Nature. Lond. 171: 769 — 71.

Beca Carter-Caidwell Connell, 1980, Moa Point wastewater treatment plant and outfall study. Study of Wastewater Treatment and Disposal into Cook Strait for Wellington City Corporation.

Benka-Coker, 0. M. 1983. Studies of bacteriological and physic-chemical parametes of Warn, River. M. Sc. Thesis University of Benin City. 96pp.

Benka-Coker, 0. M. 1991. Studies on the Effects of Crude Oil and Heavy Metal concentrations of soil and water on the microbial populations at the Kokori Flare Site, of Bendel State. Ph.D. thesis University of Benin City, Nigeria 165pp.

Benoit, R. J. 1969. Geochemistry of entrophication In: Eutrophication. Causes, consequences, correctives. Washington, D.C., National Academy of Science, pp. 614— 630.

Berhe, J., Harrison, A. D and Hynes, H. B. N 1989. The degradation of a stream crossing the city of Addis Ababa, Ethiopia. Tropical Freshwater Bioio. 2: 112 — 120

Bertine, K. K., Goldberg, E. D. 1971. Fossil fuel combination and the major sedimentary cycle. Science. 178: 233 — 235.

Biney, C. A. 1991. The distribution of trace metals in the Kpong Headpond and Lower Volta Rover. Ghana. In: Perspectives in aquatic ecotoxicology, ed. Shastree, N. K Delhi, India, Narendra PubI. House 36lpp.

Biney, A. T., Amuzu. D., Calamari, N., Kaba, I. L., Mbome, h., Naeve, H., Ochumba, P. B 0., Osibanjo, o., Radegonde, V and Saad, M. A. H. 1991. Review of heavy rnetalsin the African aquatic environment FAO Fisheries Report No. 471, FIRI/R47 I (En).

Biney, C. A. and Beeko C. A. 1991. Trace metal concentrations in fish and sediment from the Wiwi, a small urban river in Kumasi, Ghana. Trop. Ecol., 32 (2).

Bioresearches, 1981a. Monitoring study of metal concentrations of Waiuku Riversediments and biota. Report prepared for New Zealand Steel Ltd pp 182.

Boecm, P D. 1981. Petroleum in the marine environment. Physical/Chemical methods. U.S National Research Council pp289.

Boesch, D. F. 974. Diversity, stability and response to human disturbance in estuarine ecosystems. Contribution No. 618, Virginia Institute of Marine Science.

Bond, G. B., Straub, C., P Prober, R. (Cd) 1973. Handbook of Environmental Control. Vol. Ill. Water Supply and Treatment CRC Press Ohio pp. 835.

Booth, R. S. 1976. A system analysis model for calculating radionuclide transport between water and bottom sediments. In: Environmental Toxicity of Aquatic Radionuclides, 133 — 163 pp.
Borneff, J. and Fischer, R. 1962a. Carcinogenic substance in water and soil, VII 1. Studies on activated charcoal after use for filtration in water works. Arch. Hyg. Bakteriol 146: 1-16.
Borneff, J and Fisher, R. I 962b. Carcinogenic substances in water and soil, IX. Polycyclic aromatic hydrocarbons in filter deposit from a water supply plant. Arch. Ryh. Backterioi.146: 183—197

Effect of Climate Change on Fishery in the Niger Delta Region of Nigeria

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ABSTRACT
In this paper information in the literature was used to examine and discuss the impact of climate change on fisheries in the Niger Delta in Nigeria and the adaptive strategies of the communities in the region to the changes induced by the climate. Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millennia. The Niger-delta region encompasses nine states in southern Nigeria. The ecosystem is highly diverse and supportive of numerous species of terrestrial and aquatic flora and fauna. A vast majority of people in the Niger-delta depend on fish for income and livelihood. However, the literature shows that climatic changes with respect to green house gases resulting from solar irradiation, urbanization, agriculture, deforestation, and industrialization affects spawning sites and phenology of fisheries; thus leading to reduction of fish population and caught fisheries which precipitate into socioeconomic issues. It has been established that subtle changes in key environment variables such as temperature, salinity, wind speed and direction and ocean currents sharply alter the abundance, distribution and availability of fish production in the Nigeria. Capacity building and resilience through awareness and enlightenment, and developing adaptation strategies becomes very important if fishery production in the region will experience any boost. Holistic approach to mitigate the impacts could include weather forecasting, disaster preparedness, emergency

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management and integration of water & fisheries development programmes. It is therefore recommended among others, that thinking globally and acting locally on environmental issues could enhance fisheries in the Niger delta region of Nigeria to adapt to climate change.

INTRODUCTION

Climate change is defined as statistically significant variation in climate that persists for an extended period, typically decades or longer (Intergovernmental Panel on Climate Change, IPPC, 2007). Climate change has been recognized as one of the greatest threat facing mankind (IFAD, 2007; World Bank, 2010). It is an uncertain natural phenomenon that makes adaptation difficult. It affects all parts of the world, but the degree depends on the capacity of different regions to cope with the changes and it varies from region to region. In this paper, we have used information in the literature namely: IPCC, FAO, Aphunu and Nwabeze, 2012, Ifeanyi, et al., 2012; Mustapha, 2013; World Fish Center, 2007b; Uyigue and Agho, 2007etc) to examine and discuss the impact of climate change on fisheries in the Niger Delta as well as the adaptive strategies of the communities in the region to the changes induced by the climate. It has been established that the Niger Delta of southern Nigeria is highly susceptible to adverse environmental changes induced by climate change because it is located in the coastal region of the world (Uyigue and Agho, 2007). In Nigeria, especially the Niger Delta region, it has been reported that gas flaring is a major cause of rising temperature and the associated global warming in its water bodies. Consequently, climate change has manifested in frequent rainfall, flooding, drought, temperature rise, run-off decrease and reduced river flow rate in the Niger Delta region of Nigeria (BNRCC, 2011, Mustapha, 2013).

Currently, fish is the greatest target of climate change being that increasing temperature tends to affect its general life cycle. The Niger Delta region of Nigeria is a major producer of fish, contributing about 50% of fish consumed in the country. Fish farming, therefore, is an important source of revenue and employment among the Niger Delta communities. It has been established that subtle changes in key environment variables such as temperature, salinity, wind, speed and direction, ocean currents due to climate change sharply alter the abundance, distribution and availability of fish production in the Nigeria, subsequently affecting the fisheries and the fisher folks (Ozor, 2009, Ifeanyi et al., 2012; Mustapha, 2013). This is evident from the work of Daw *et.al*. (2009), which affirmed that climate change affected fisheries in the context of scale, environment, species, technology, markets, fishers, management arrangement and political contexts.

Previous studies had also showed that fish is the most widely consumed foodstuff in the world (Williams and Rota, 2009), and 37% of fish produced (live weight equivalent) is traded internationally (FAO, 2009a). The livelihoods of 520 million people depend on fisheries and aquaculture (FAO, 2009a), 98% of who live in developing countries. Climate change has been observed to have serious implications on global fisheries and aquaculture and small scale or individual farmers are among the highest vulnerable to climate change (Tan, 1998). Global fish production have been estimated to be about 144 million metric tons (mmt) comprising 92mmt from capture and over 51mmt from aquaculture. The 92mmt was calculated to represent a decrease of 2.2mmt compared to figures for 2005 (FAO. 2009b).

The Federal Department of Fisheries in Nigeria estimated fish production of over 1.7mmt comprising 201, 300mt (off shore fisheries) 288.200mt (inland fisheries) and 1,180,215mt (aquaculture)(George, 2010). A Climate change effect, among other factors is considered as one of the constraints to increased fish production in Nigeria (Aphunu and Nwabeze, 2012).The developing tropical countries which are more vulnerable to climate change because of their lower adaptive capacities, have adopted some strategies to cope with the impact. However, fishermen in the Niger Delta communities have difficulties in coping and adapting to climate variation because of poverty. The impacts and mechanism of climate change on fisheries have been described as still poorly understood and highly complex because of the unpredictability of climate change and the links that entwine fishery and aquaculture livelihood with other livelihood strategies and economic sectors (World fish center, 2007b; Stern 2007, FAO, 2008a; Williams and Rota,2009).

GEOGRAPHICAL LOCATION OF NIGER DELTA

The Niger Delta lies in the Atlantic coast of Southern Nigeria and "within the Ibo Plateau and the Cross River Valley". It is between latitude 3^{o}N and 6^{o}N, and longitude 5^{o}E and 8^{o}E (Ndubuisi and Asia, 2007). A watery maze of intricate marshland, creeks, tributaries and lagoons flung across approximately 70,000 square kilometers, the delta has an extremely delicate and sensitive ecosystem. It is Africa's largest wetland and the second largest in the world after the Mississippi (Nseabasi, 2005). About 2,370 square kilometers of the Niger Delta area consist of rivers, creeks and estuaries while stagnant swamp covers about 8,600 square kilometers. The region's ecosystem is highly diverse and supportive of numerous species of terrestrial and aquatics flora and fauna. As a result of its delicate nature, it is susceptible to adverse environmental change.

Politically, the Niger Delta is panoply of geographically contiguous area currently cutting across nine states in Southern Nigeria; namely Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers states (Fig.1). It has 185 Local Government Areas (LGAs) consisting of more than 2,000 communities. Also, the Niger Delta has several minority ethnic groups with a population of over 40 million people. The area accounts for more than 23% of Nigeria's total population and has one of the highest population densities in the world, with 265 people per square kilometer (Balouga, 2009). The Niger Delta is Nigeria's richest region because of the products from crude oil which makes Nigeria the largest petroleum producer in Africa and the sixth in the world.

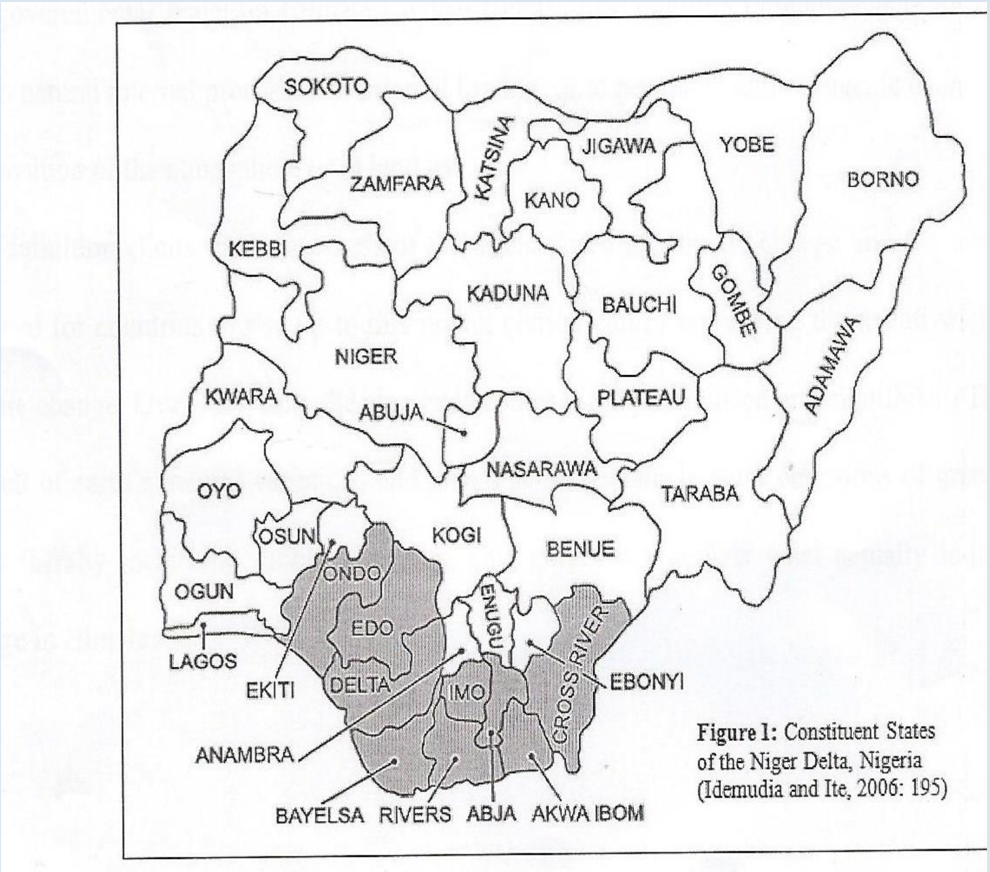

Figure 1: Constituent States of the Niger Delta, Nigeria (Idemudia and Ite, 2006: 195)

Causes of Climate Change in Niger Delta Region

In the Niger Delta region of Nigeria, the major cause of climate change in the aquatic ecosystem is Global Warming. This occurs with respect to green house gases (GHGs) resulting from Industrialization, Solar irradiation, Deforestation, Agriculture and Urbanization. According to IPCC (1990) a strong correlation exists between green house gases emission and climate change and between global temperature and sea level rise. Sea level rise and flooding are already affecting millions of people worldwide (IFRC, 1999). One of the most important causes of global warming is gas flaring (industrialization) in the Niger Delta region. Nigeria has a coast line of about 860 km in a West-east stretch from Lagos to Cross River. Global estimate indicates that gas flaring in this coastal area of Nigeria alone accounts for 28% of total gas flared in the world. The flaring of gas has been practiced in the Niger Delta region for over four decades.

Currently, there are about 123 flaring sites in the region (Energetic Solution Conference, 2004), making Nigeria one of the highest emitter of green house gases in Africa. Carbon dioxide emissions in the area are among the highest in the world (Iyayi, 2004). Some 45.8 billion kilowatts of heat are discharged into the atmosphere of the Niger Delta from flaring 1.8 billion cubic feet of gas every day (Agbola and Olurin, 2003). Gas flaring has raised temperatures and rendered large areas uninhabitable (Uyigue and Agho, 2007). Like every coastal country, Nigeria has a coastal based economy through the onshore and offshore oil exploration, and so majority of the industries and commerce are located along the area in proximity with ports and borders for effective transmission of goods and services. These factors put so much pressure on the coastal biodiversity and reduce their suitability. Other causes of climate Change in this region include: Episodic events in the frequency and intensity of rainfall, Flooding, and Rise in temperature (Mustapha, 2013)

Effects of climate change on Fish population

It has been observed that increasing temperature tends to affect every stage of the life cycle of the physiological, morphological, reproductive, migratory and behavioral responses of fish (Mustapha 2013). In addition, alterations in their food web processes and interactions, species invasion and spread of vector borne diseases could result from the effects of climate change. Fishes being cold blooded are sensitive to temperature changes. Any increase in temperature above the tolerant limit in their habitat will have serious negative effects on their physiology especially in the supply of O_2 to their tissues.

Variation in climate affects the physico-chemical variables in the aquatic ecosystem which is linked with plankton production, subsequently affecting the food and the feeding pattern of the fish. When this occurs, high predation rate on larvae is observed and this will in turn affect recruitment of fish species and their population in such environment. According to Mustapha (2013) climate change has negative impact on the spawning success of fishes spatially and temporally in their habitats. This is because time and locations of spawning of several species of fish are linked to physical conditions such as temperature, currents etc, as well as biological factors like food.

Reports also showed that fish species have been driven away from their home range with likelihood of extirpating the population as a result of global warming (Mustapha 2013). This agrees with an earlier study which states that measurable changes in the phenologies and distribution of freshwater fish species will occur due to climate change(Parmesan and Yohe, 2003). Harvell *et. al.* (2002) reported that another possible effect of global warming is species invasions and disease outbreak. They observed positive correlations between increase temperature and pathogen manifestation, survival, development, transmission and host vulnerability.

Effects of climate change on Fisheries

Fisheries is the interaction of the fish, habitat and the fisher folks. Any effect of climate change on fish and its habitat also affects the fisheries and the fishermen. The examples in the literature are:

Sea level rise and floods: The Niger Delta region may be the source of oil wealth but its low-lying terrain criss-crossed with water ways makes it vulnerable to flooding. Okoh and Egbon (1999) reported the occurrence of coastal erosion in the Niger Delta, while the report of Udofa and Fajemirokun (1978) showed a rise in sea level along Nigerian coastal water. Okali and Eleri in the Nigerian Environmental Study Action Team (NEST,2004) further reported that sea level rise and repeated ocean surges will not only worsen the problems of coastal erosion that are a menace in the Niger Delta, but that the associated inundation will increase problems of floods, intrusion of sea-water into fresh water sources and ecosystems, thereby, destroying such stabilizing system as mangrove, and affecting agriculture, fisheries and general livelihoods. Flooding of low lying areas in the region has been observed and settlements displaced. Coastal erosion poses serious problem for the economic activities in the Niger Delta especially natural sectors such as farming and fisheries (about 50% of the fishes consumed in Nigeria is from the Niger Delta (Awosika, 1995).

Increased salinity of both surface and underground water due to the intrusion of sea water is another effect of sea level rise in the Niger Delta (Uyigue and Agho, 2007). It leads to the death of aquatic plants and animals that cannot tolerate high salinity. The brackish water which is home for several species of fishes and breeding sites for several others will be greatly affected and this may lead to loss of fish species. Inhabitants of the region who depend on underground water as their main source of water for drinking and for other domestic use domestic use will be affected and the region will experience the emergence of health related hazards (Uyigue and Agho, 2007).

Temperature rise and Change in phenology of aquatic organisms: According to literature (Uyigue and Agho, 2007), the best time to go fishing is dawn and dusk, in the early morning, or at night if you have the right equipment. As a result of increase in temperature, fishes move toward the bed of the water body making it difficult for the net to get to the fishes, resulting in low yield of fishes caught. Aquatic species move to higher latitudes and this shift in distribution results in reduced species diversity in tropical waters. Change in phenology is one of the key indicators of the impact of climate change on biological populations. For many species, the climate where they live or spend part of the year influences key stages of their annual life cycle, such as migration, blooming, and mating. As the climate has warmed in recent decades, the timing of these events changes and will affect their phenology. Hence, global warming results in fish migration to temperate regions thus affecting the livelihood of fisher folks in the tropical region. Change in aquatic organisms phenology leads to early spawning, shift in migration time and decrease in growth and survival of migrants.

Shortage of Fish Seed and Socio-Economic Impact: As a result of decline in fish production, predation on fingerlings by the adult or even diseases outbreak, the supply of wild fish seed for stocking in natural or artificial ponds could be threatened. The people of the Niger Delta are highly dependent on their environment for their source of livelihood. They make their living from the exploitation of the resources of their land, water and forests as farmers, fishermen and hunters. However, environmental degradation caused by climate change and exploration and exploitation activities of multinational companies has resulted to distortion of the economic activities of the people (Uyigue and Agho, 2007). Their source of livelihood is lost and there is subsequent high cost of living in these communities. This condition predisposes them to hunger, sicknesses, resource over-exploitation and other social vices such as conflicts, kidnapping and militancy.

Mustapha (2013) stated that the synergistic effects produced by climate change on food webs, run off, flow, flooding and anoxia etc affect fish assemblages in the river ecosystems bringing changes in the distribution of pelagic fisheries. Thus, there is low productivity of the water body, low fish production, less number of adult fishes in the system, abundance of juvenile fish, reduced productivity of commercially important species and a low catch per unit efforts by the fishermen. Consequently, adaptive strategies such as alterations and modifications of the fishing gears and other associated fisheries processes of preservation, marketing and even fishing periods are adopted to suit the new climatic factors. The attendant costs, technology, reduced profitability, less viability of fishing etc, to the fishermen (Mustapha, 2013), often results in the total abandonment of the fisheries occupation and increased poverty.

Information Dissemination and Fish Farmers' Awareness of Climate Change: Investigations had shown that the main source of information on climate change was through personal experience, radio/television and friends/neighbours (Aphunu and Nwabeze, 2012; George, 2010 and Tologbonse *et. al.*, 2012). Extension agents, who are regarded as the custodian of dependable information to fish farmers, however provided the least source of information on climate change. Aphunu and Nwabeze's (2012) survey showed that 75% of respondents were aware of climate change impacts on their fish farming activities and on their lives. However, the extent of awareness (knowledge) of local communities on climate change impacts was still described as low in the Niger Delta region of Nigeria (Aphunu and Nwabeze, 2012; Nzeadike *et.al.*, 2011). The results by Aphunu and Nwabeze (2013) showed that the general opinion of fish farmers about climate change impact is that it causes drastic change in weather condition, destruction of property, increased incidence of flooding, high temperatures and heat waves, excessive sunshine, poor harvest of fish (especially during spawning for fingerlings production) and increase in food insecurity and hunger. The study also revealed that fish farmers do not believe that climate change could cause increased harvest of fish, increased incidence of drought, increased cost of fish production or reduced cost of fish production. The findings showed that only the negative impacts of climate change are being experienced by fish farmers in the Niger Delta region. It has been predicted that significant negative impacts will be felt across 25% of Africa's inland aquatic ecosystems by 2100 (Dewit and Stankiewicz, 2006).

***Adaptation and Mitigation of Impacts**:* Adaptation has been understood to include efforts to adjust to ongoing and potential effects of climate change; the actions people take in response to, or in anticipation of changing climate conditions in order to reduce adverse impacts or take advantage of any opportunities that may arise (Mani, *et al*, 2008, Aphunu & Nwabeze 2012). It was noted that developing tropical countries are highly vulnerable because of their lower adaptive capacities. Many of the communities adopt a combination of the following strategies:

1. Seeking/listening to information about climate change (Aphunu & Nwabeze ,2012)
2. Capacity building and resilience through awareness, enlightenment and initiatives to mitigate the impact of climate change on fisheries (Mustapha, 2013).
3. Weather forecasting, disaster preparedness, emergency management, reduction of conflicts associated with climate change between fisheries stakeholders and integration of water and fisheries development programme into national and regional adaptation programmes.
4. Development of sophisticated monitoring programmes and models (Mustapha, 2013).

In addition to the above, Uyigue & Agho (2007) highlighted the following two major coping strategies that the fishermen in the Niger Delta adapt.

- ***Change of Occupation***: Hitherto, an estimated 50% of the fish consumed in Nigeria come from the Niger Delta. However, because of the degradation of their environment, many people in the Niger Delta who can no longer engage in fishing and farming change their occupations to trading, civil service jobs and unskilled employments in the multinational oil companies operating in the area. The change of means of livelihood from natural sectors to non-natural sectors, results in decrease in fishery and agricultural products (Uyigue and Agho, 2007).
- ***Coping with Floods***: Flooding often disrupts settlements and communities cohesion. In extreme cases of flooding, many people abandon their houses, settlements and relocate to other areas that are not affected by flood. The consequences of the settlement and family fragmentations results in attendant community crises and social disharmony.

CONCLUSIONS AND RECOMMENDATIONS

This review has shown that the threat and risk posed by climate change has great impact on fisheries, occupations of fishing communities, settlement cohesion and fragmentation in the Niger Delta region of Nigeria. Although the people are adopting various coping strategies, increased awareness and enlightenment on the climate variation and the identification of more indigenous adaptation strategies will boost fish production in the Niger Delta region of Nigeria. It is recommended that:

- Government should enforce the implementation of the policy on gas flaring which is the major cause of global warming in the Niger Delta region.
- Green house gas emissions should be slowed down, stored or absorbed through various ways of carbon sinks.
- Improved energy efficiency performance of all utilities such as means of transportation etc, and behavioural changes to reduce GHGs through the adoption of renewable energy should be encouraged and advocated.
- Establishment of National Adaptation and Mitigation Programme of Action on Climate Change (NAMPACC) in Nigeria which should be fully funded to coordinate

researches and maintain climate change knowledge, database, management and learning platform will help minimize the impacts of climate change on fisheries.

- Efforts should be geared towards identifying and compiling indigenous adaptive strategies to climate change that fish farmers may have used over the years.
- There is need for a multimedia enlightenment campaign of the effects and possible adaptation strategies of climate change, to reach all fish farmers, using the available extension structures on ground by all stakeholders.

REFERENCES

1. Agbola, T. and Olurin, T. A. (2003) Landuse and Landcover Change in the Niger Delta. Excerpts from a Research Report presented to the Centre for Democracy and Development, July, 2003 .

2. Aphunu A. and Nwabeze G.O. (2012). Fish farmers' perception of climate change impact on fish production in Delta State, Nigeria. *Journal of Agricultural extension.* 16(2), 1-13.
3. Awosika, L. F. (1995). Impacts of global climate change and sea level rise on coastal resources and energy development in Nigeria. In: Umolu, J. C. (ed). Global Climate Change: Impact on Energy Development. DAMTECH Nigeria Limited, Nigeria.
4. Balouga, J. (2009). The Niger Delta: Defusing the Time Bomb. *First Quarter* (International Association for Energy Economics), 8-11. Beck, U. (1992). *Risk society: Towards a new modernity*. London: Sage.

5. Building Nigeria's Response to Climate Change (BNRCC) (2011) Climate Change Adaptation Strategy Technical Reports-Nigeria. (CCASTR) Ibadan, Nigeria: Nigerian Environmental Study/Action Team (NEST).
6. Daw T, Adger WN, Brown K, Badjeck MC (2009) Climate change and capture fisheries: potential impacts, adaptation and mitigation. In: Cochrane K, De Young C, Soto D, Bahri T (eds). Climate change implications for fisheries and aquaculture: overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper. No. 530. Rome, FAO: 107-150
7. De Wit, M. and Stankiewics, J. (2006). Changes in surface water supply across Africa with predicted change. *Science,* 311: 1917-1921.
8. FAO (2008a) Climate change implications for fisheries and aquaculture. In: *The State of Fisheries and Aquaculture 2008*. FAO, Rome, Italy, pp. 87–91.
9. FAO (2009a) *The State of World Fisheries and Aquaculture 2008*. FAO, Rome, Italy, 176 pp.
10. FAO (2009b) Climate change implications for fisheries and aquaculture: overview of current scientific knowledge (K. Cochrane, C. De Young, D. Soto and T. Bahri, eds.). *FAO Fisheries and Aquaculture Technical Paper* No. 530. FAO, Rome, Italy, 212 pp.
11. George, F. O. A (2010). Indigenous and Emerging Technologies for climate change Adaptation in Aquaculture and Fisheries. *Journal of Sustainable Development,* 7, (2) 34-42.
12. Harvell C.D, Mitchell C.E, Ward J.R, Altizer S., Dobson A.P. (2002). Climate warming and disease risks for terrestrial and marine biota. *Science* ,296: 2158-2162.
13. IFAD (2007) *IFAD Strategic Framework 2007–2010*. IFAD, Rome, Italy, 35 pp. Available at: http://www.ifad.org/sf/strategic_e.pdf. Date accessed: 6 December 2010. Center, Penang, Malaysia, 8 pp. Available at: http://www.worldfishcenter.org/resource_centre/ClimateChange2.pdf. Date accessed: 6 December 2010.
14. Ifeanyi-obi C. C., EtukU.R. and Jike-wai O.(2012). Climate Change Effects and Adaptation Strategies; Implication for Agricultural Extension System in Nigeria. *Greener Journal of Agricultural Sciences*, 2(2), 53-60.
15. Intergovernmental Panel on Climate Change-IPCC (1990). Working Group III, 1990. Strategies for Adaptation to Sea Level Rise. Report of the Coastal Zone Management Subgroup,

Intergovernmental Panel on Climate Change Working Group, Rikkswaterstatt, The Netherlands. 122p.

16. Intergovernmental Panel on Climate Change-IPCC (2007a). Climate change 2007.Sythesis Report – Contribution of working Groups I, II and III to the fourth intergovernmental panel on climate change. Core Writing Team: R. K. Panchauri and A. Reisinger, eds. IPPC, Geneva, Switzerland.
17. International Federation of Red Cross and Red Crescent Societies (1999). World Disaster Report 1999. pp 11.
18. Iyayi, F. (2004). An Integrated Approach to Development in the Niger Delta. A paper prepared for the Centre for Democracy and Development (CDD).
19. Mani, M., Markandya, A and Ipe V. (2008). Climate Change: Adaptation and Mitigation in development PROGRAMMES: A practical guide. Washington , D.C : Word Bank.
20. Mustapha M.K. (2013) Potential Impacts of Climate Change on Artisanal Fisheries of Nigeria*. J Earth Sci Climate Change* ,4: 130.
21. Nseabasi, A. (2005). Conflicts in Nigeria's Niger-Delta: Issues on Response and Management. *International Journal of Social Sciences* 4 (1), 161-175.
22. Nzeadibe, T.C., Egbule, C.L., Chukwuone, N.A. and Agu, V.C. (2011). Climate Change Awareness and Adaptation in the Niger Delta Region of Nigeria.African Technology Policy Studies Network. Working Paper Series/No. 57.
23. Okali, D and Eleri, E. O. (2004). Climate Change and Nigeria: A guide for Policy Makers. The publication of the Nigerian Environmental Study Action Team (NEST).
24. Okoh, R. N. and Egbon, P. C. (1999). Fiscal Federalism and Revenue Allocation. ThePoverty of the Niger Delta. in Aigbokhan, B. E. (ed): *Fiscal Federalism and Nigeria's Economic Development* Selected Papers of the 1999 Annual Conferenceof the Nigerian Economic Society. NES Ibadan.
25. Ozor, N. (2009). Understanding climate change. Implications for Nigerian Agriculture, policy and Extension. Paper presented at the National conference on climate change and the Nigeria Environment. Organized by the Department of geography, university of Nigeria, Nsukka, 29 June-2nd July.
26. Permesan C, Yohe G (2003) A globally coherent fingerprint of climate change impacts across natural systems. Nature 421: 37-42
27. Stern, N. (2007). *The Economics of Climate Change. The Stern Review*. Cambridge University Press, Cambridge, UK, 712 pp.
28. Tan, C.K. (1998). Overview of Aquaculture in Malaysia. Occasional Publication No. 9. Kaula Lumpur: Malaysian Fisheries Society.
29. Tologbonse, E.B., Auta, S.J., Bidoli, T.D., Jaliya, M.M., Onu, R.O. and Issa, F.O. (2010). Farmer's Percption of the Effects of Climate Change and Coping Strategies in Three Agro-Ecological Zonnes of Nigeria. *Journal of Agricultural Extension,* 14 (1),144-156.
30. Uyigue E. and Agho M. (2007). Coping with Climate Change and Environmental Degradation in the Niger Delta of Southern Nigeria .Community Research and Development Center (CREDC) Nigeria.31p . Available at http://www.global-greenhouse-warming.com/.
31. Williams and Rota (2009) impact of climate change on fisheries and aquaculture in the developing world and opportunities for adaption. Fisheries Thematic Paper: Tool for project design available at *www.ifad.org/irkm/pub/fisheries.pdf*.
32. World Bank (2010) *World Development Report 2010: Development and Climate Change*. The World Bank, Washington, DC, USA, 424 pp.
33. WorldFish Center (2007b) The threat to fisheries and aquaculture from climate change. *Policy Brief*. WorldFish Center, Penang, Malaysia, 8 pp. Available at: http://www.worldfishcenter.org/resource_centre/ClimateChange2.pdf. Date accessed: 6 December 2010.

Effects of Dietary Protein Levels on African Catfish (*Clarias gariepinus,* Burchell, 1822) Growth And Survival In Floating Net-Hapa Trial

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ABSTRACT

Study was conducted to evaluate effects of varying dietary protein levels on growth, survival and yield of *Clarias gariepinus* using net-hapas for 24 weeks. Juvenile catfish with mean weights of 4.50± 0.01g were randomly stocked at 20 fish per net-hapa (1m^3). To provide an effective economic diet for this species 5 experimental diets containing crude protein levels varying between 40.0-50.0% were fed to triplicate groups. 20% of stock was sampled for growth fortnightly. Profit index was evaluated, relevant physico-chemical parameters were monitored and experimental feed and fish carcass were analysed for their proximate composition. Growth responses of fish under tested diets were assessed, there were no significant differences ($p>0.05$) in Metabolic growth rate, Protein productive value, Energy retentive value, Protein intake, Survival, Total feed fed, Cost of feeding, Total cost of production, Net fish production, Value of fish, for all the treatments, however there were significant differences ($p<0.05$) in Gross profit, profit index and Economic conversion ratio. The preferential diet (42.5% CP) exhibited the best growth and feed utilization performances having final fish weight of 946.89±2.33g; FCR, 0.265±0.01 and fish production of 17.850±607.82kg/hapa. This diet was also considered best on the basis of the profit index of 8.50±0.02 compared with the range of 7.33±0.08 to 8.11±0.08 for the other four diets.

Keywords: fish culture; nutrient; production; profit index.

INTRODUCTION

The African catfish, *Clarias gariepinus* (Burchell, 1822) is an omnivorous species indigenous to Africa and one of the most cultured species in sub Saharan Africa. It has been shown to have remarkable growth rate as well as high quality meat and excellent taste, and hence is in great demand and commands good commercial value in Nigeria market [1]. In formulating diet for fish, it is important to meet all the requirements of nutrients for optimum growth as lack of good quality feed for economic production adversely affects growth rates, disease manifestation and total harvest of fish [2].

Proteins are complex organic compounds, which are made up of various repeated units of amino acids linked together by peptide bonds. Dietary protein has been appraised as the body block building nutrients and given the most prominent consideration in the formulation of fish feeds. Dietary protein requirements of African catfish have been severally reported such as 40% [3], 42.5% [4], 45.0% [5] and between 38 and 50% [6]. However, little nutritional research with respect to economic index and profitability has been established for intensive culture of this species, thus hindering the viability of commercial catfish production using diets having organic inputs. The present study has been designed to determine a proper dose response relationship regarding catfish production using an environmentally friendly and sustainable diet for maximum profitability.

MATERIALS AND METHODS

An outdoor concrete tank (L x B x H: 8m x 5m x 1.65m) situated at the Vika Farms Limited, Mbak Etoi, Uyo, Akwa Ibom State, located at geographical coordinates of Latitude: 5^{o} 3′ 0″ North and Longitude: 7^{o} 56′ 0″ East was used for the production stage of the study. This tank was equipped with both inlet and outlet facilities and a 5,000 lit capacity overhead tank served as water reservoir. The experimental design was made up of a module consisting of 8.5 x 6.5m bamboo raft with sixteen 1.5 x 1.5m apartments fittable with sixteen 1x1x1 net-hapas constructed and placed to fit on the concrete tank. The net-hapas had top covers which prevent the caged fish from jumping out and also protect the fish from being preyed upon by aerial predators. Before the experiment commenced, the tank was properly washed and filled with water to a depth of about 1.2m. Fifteen net-hapas were fitted to the compartments representing five treatments with three replicates each. Each hapa was rigged and suspended at a depth of 0.75m in water. The float lines were tied to the four corners of each compartment using kuralon rope (No 15) as described [7].

Experimental Diets Preparation: Diet compositions for the feeding trial are presented in Table 1. All ingredients were procured at the same time to avoid variations associated with batch differences. They were carefully weighed out, mixed, made into pellets using 2mm meat mincer, air-dried and labelled separately according to diets.

Fingerling Rearing: Each net-hapa was randomly stocked with *Clarias gariepinus* (mean initial weight of 4.5±0.10g) at 20 fish per rearing net-hapa and raised to a point of inflection (24 weeks) with compounded diets (D1 – D5) having crude protein contents varying from 40 to 50% (Table 1). The stocked fish were fed at 5% of their body weight three times daily. This amount was divided into three equal portions and fed at 8.00hr, 13.0hr and 18.0hr. 20% of the fish were sampled fortnightly from each hapa and feed rations were recomputed based on new biomass. Weights and lengths were measured using a Furi Digital Balance (Model: FEJ-6000) to the nearest 0.01g and metre rule to the nearest 0.1cm respectively. Data obtained were used to determine growth responses and feed utilization of fish.

Proximate Analysis of Experimental Fish and Diets

Proximate analysis of feed ingredients, experimental diets, and fish carcass was done according to [8]. Crude protein by micro – kjeldahl method; Crude fat by soxhlet extraction; Total ash by muffle furnace combustion; Crude fiber by trichloroacetic acid method; Moisture by oven – drying to a constant weight; Carbohydrate by 100 – (% protein + % fat + % fiber + % ash + moisture) and Gross Energy using physiological fuel value of 16.7, 16.7 and 37.7KJ g-1 for protein, carbohydrates and lipid, respectively [9].

Determination of Nutrient Utilization Parameters

Mean Weight Gain (MWG) (g) = Final weight (g) –Initial weight (g)

Average Daily Growth (ADG) = MWG (g)/length of feeding trial (days)

Daily Growth Coefficient (DGC) = t (days)/MWG (g)

Relative Growth Rate (RGR) = 100[MWG (g)/Mean final weight (g)]

Metabolic Growth Rate (MGR) = $(W_1-W_0)/[\{(W_0/1000)^{0.8}+(W_1/1000)^{0.8}\}/2]t$

Where: W_0 = initial weight (g); W_1 = final weight (g); t= length of feeding trial (days)

Specific Growth Rate (SGR, %/day) = $100(\ln W_2 - \ln W_1)/T_2-T_1$

Where: W_2 = Weight at time T_2; W_1 = Weight at time T_1

Feed Conversion Ratio (FCR) = Total dry feed fed (g)/MWG (g)

Feed Efficiency Ratio (FER) = MWG (g)/total dry feed fed (g)

Protein Efficiency Ratio (PER) =MWG (g)/ protein intake in feed (g)

Lipid Efficiency Ratio (LER) =MWG (g)/ lipid intake in feed (g)

Protein Productive Value (PPV) = 100 (Protein gain / protein intake in feed)

Lipid Productive Value (LPV) = 100 (Lipid gain / lipid intake in feed)

Energy Retentive Value (ERV) = 100 (Energy gain / energy intake in feed)

Protein Index (PI) = Survival (W_1-W_0) x t [10]

Nitrogen Metabolism (NM) = $[0.54(W_1-W_0) \times t]/2$ [3]

Where: 0.54 is experimental constant; W_1= Fish final weight (g); W_0 = Fish initial weight (g); t = length of feeding trial (days)

Condition Factor (CF) = $100(W_1/L^3)$

Where: W= mean final weight; L= mean final standard length.

Percentage Survival Rate (%SR) = 100(Number at end of feeding trial/Number at start of feeding trial).

Physico-chemical Parameters Analysis

Physico-chemical parameters in terms of water temperature, dissolved oxygen, pH, ammonia, nitrite, nitrate and conductivity was monitored weekly during the experiment using: Potable DO meter (Well-Knit DO-510) for dissolved oxygen; Combined meter (Combo Hanna) for water temperature, pH and conductivity; NTLABS test kit for ammonia, nitrate and nitrite.

Data Analysis

Descriptive statistics (mean and standard error), One-way Analysis of Variance (to compare data) and Duncan Multiple Range (to test for significance at $p<0.05$) [11] were used. All the analyses were carried out using Statistical Package for Social Sciences (SPSS 19.0, 2010 version.

Table 1: Composition (%/100g) of the experimental diets containing varying dietary protein levels

	Different Crude Protein (CP) Diets (%)				
Ingredients (%)	**D1(50.0)**	**D2(47.50)**	**D3(45.00)**	**D4(42.50)**	**D5(40.00)**
Fishmeal (Danish)	23.06	21.53	20.00	18.60	17.21
Soybean meal	23.06	21.53	20.00	18.60	17.20
Corn flour	01.12	06.75	12.43	18.20	23.97
Groundnut cake	45.66	43.10	40.46	37.50	34.51
Fish oil	07.00	07.00	07.00	07.00	07.00
Lysine	0.030	0.030	0.030	0.030	0.030
Methionine	0.030	0.030	0.030	0.030	0.030
Fish Premix*	0.050	0.050	0.050	0.050	0.050
Proximate Composition of Experimental Diets (%)					
Estimated CP	50.00	47.50	45.00	42.50	40.00
Analysed CP	48.25	45.01	43.43	40.05	38.83
Ash	8.61	8.49	7.82	7.11	6.48
Lipid	8.87	8.75	8.64	8.40	8.38
Fibre	4.78	4.76	4.75	4.74	4.72
Moisture	14.10	14.00	13.82	13.72	13.75
NFE	15.39	18.99	21.54	27.98	27.84
Gross energy (KJ/g)	1397.19	1398.68	1410.72	1419.38	1429.32

*1kg fish premix contains: Vitamin A=10,000,000I.U.D;D3=2,000,000I.U.D; E=23,000mg; K3=2,000mg; B1=3000mg; B2=6,000mg; niacin=50,000mg; calcium pathonate=10,000mg; B6=5000mg; B12=25.0mg;folic acid=1,000mg; biotin=50.0mg; choline chloride=400,000mg; manganese=120,000mg; iron=100,000mg;copper=8,500mg;iodine=1,500mg;cobalt=300mg;selenium=120mg;antioxidant=120,000mg.

RESULTS AND DISCUSSION

The results of growth performances, nutrient utilization and survival of African Catfish *Clarias gariepinus* fingerlings fed diets containing different dietary protein levels to point of inflection are shown in Table 2. The results showed that all the growth indices were highest in D4 (42.5%) followed by D3 (45%), D2 (47.5%), D5 (40%) and D1 (50%). There was an inverse relationship between crude protein levels and average daily growth, mean weight gain, relative growth rate, feed efficiency ratio, lipid productive value, protein intake and nitrogen metabolism. Although, the highest amount of protein required to produce a 1kg fish was highest in group fed Diet 3, there was not a direct relationship between protein productive value and change in dietary protein. However, and in contrast, the amount of lipids needed to produce the same amount of fish decreased significantly with increasing dietary protein from 40 to 50%. Feed conversion ratio of 0.28 obtained in this study was better than 1.28 observed in *Clarias gariepinus* fed with 40% protein [12]. Average daily growth obtained for Diet 4 (5.88±0.01g) was also higher than the highest (0.59±0.24g) obtained by [13]. Profit index for all the treatments were significantly different ($p<0.05$). Inverse relationship was observed between dietary protein intake and net fish production, gross profit, and value of fish (Table 3).

The culture of *Clarias gariepinus* in net-hapas seems to be feasible if these results are compared with those obtained in conventional culture systems. At the end of the 168 days of feeding, the percentage survival rate ranged from 88.33 to 90.00% and was not affected by dietary protein levels. These values were comparable with survival for *H. longifilis* (90%) cultured in earthen pond by [14]. The growth performances of *Clarias gariepinus* in this study was influenced by dietary protein levels. Similar results were observed in production of hybrid catfish [13], *Chrysichthys nigrodigitatus* [15], *Heterobranchus longifilis* [16; 14]. However, [13] reported that growth rate and weight gain in hybrid catfish increased progressively with dietary protein level to a maximum at 50%, while [17] observed high growth in terms of live weight gain and specific growth rate in milkfish (*Chanos chanos*) fed at 40% protein level. In addition, [18] reported that catfish fingerlings fed with 40% protein gave the best growth (SGR: 1.06%/day and FCR: 0.62). In this study, best growth was observed in fish fed 42.5% protein levels. Interspecific differences observed could however be explained by the varieties of methodology (feed formulation and feeding rate tests) and culture system (net hapas) used.

However production was generally high in this experiment. This high production could be attributed to the favourable physico-chemical conditions of the production system and the experimental design. The in-tank water quality parameters measured included DO (5.15-6.90mg/l), pH (6.50-8.10), ammonia (0.00-0.15mg/l), nitrate (4.10-11.06mg/l), phosphate (15.80-17.10mg/l) sulphate (1.85-2.90mg/l) and conductivity (6.35-8.60µs/cm) (Table 4).

Table 2: Growth performances, nutrient utilization and survival of African Catfish *Clarias gariepinus* fingerlings fed diets containing different dietary protein levels for 24 weeks.

Growth Indices	Different Crude Protein Diets (%)				
	D1	D2	D3	D4	D5
MIW[1]	4.50±0.01	4.51±0.02	4.51±0.01	4.51±0.01	4.51±0.01
MFW[2]	773.63±2.29^{a}	790.23±8.04^{a}	843.27±6.61^{b}	946.89±2.33^{c}	884.17±0.82^{a}
MFSL[3]	43.10±0.40^{a}	44.07±0.90^{a}	46.63±0.22^{b}	47.60±0.20b^{c}	43.60±0.10^{a}
MWG[4]	769.13±2.29^{a}	785.72±8.05^{a}	838.70±6.61^{b}	942.38±2.33^{c}	879.66±0.82^{a}
ADG[5]	5.32±0.01^{a}	5.38±0.05^{a}	5.77±0.04^{b}	5.88±0.01^{c}	5.32±0.01^{a}
DGC[6]	0.19±0.00^{b}	0.19±0.00^{b}	0.17±0.00^{a}	0.17±0.00^{a}	0.19±0.00^{b}
RGR[7]	198.33±0.93^{a}	200.54±2.38^{a}	214.79±1.50^{b}	218.85±0.58^{bc}	198.74±0.31^{a}
MGR[8]	2.95±0.01	2.94±0.02	2.96±0.00	2.96±0.00	2.96±0.00
SGR[9]	3.15±0.00^{a}	3.16±0.01^{a}	3.20±0.00^{b}	3.21±0.00^{c}	3.15±0.00^{a}
FCR[10]	0.29±0.00^{b}	0.28±0.01^{b}	0.27±0.01^{ab}	0.27±0.00^{a}	0.28±0.00^{b}
FER[11]	3.50±0.04^{a}	3.57±0.07^{a}	3.67±0.10^{ab}	3.77±0.01^{b}	3.51±0.04^{a}
PER[12]	7.25±0.08^{a}	7.93±0.16^{b}	8.45±0.23^{c}	9.41±0.02^{d}	9.08±0.07^{d}
LER[13]	39.46±0.43^{b}	40.79±0.81^{bc}	42.46±1.14^{c}	44.86±0.10^{d}	41.97±0.46^{c}
PPV[14]	31.83±1.10	36.95±2.12	41.78±0.55	59.55±0.56	49.08±1.75
LPV[15]	32.59±0.05	37.46±2.53	50.86±1.02	60.06±0.73	53.58±1.38
EPV[16]	28.04±1.15	31.24±0.53	39.92±0.88	52.96±1.85	46.78±0.88
PI[17]	4.61±0.19	4.76±0.21	5.00±0.34	5.29±0.18	4.80±0.00
NM[18]	40.52±0.15^{a}	41.13±0.40^{a}	44.00±0.26^{b}	44.76±0.15^{c}	40.67±0.00^{a}
CF[19]	1.12±0.03^{b}	1.07±0.06^{b}	0.96±0.01^{a}	0.92±9.01^{a}	1.08±0.01^{b}
%SR[20]	86±3.33	88.33±3.33	86.67±6.01	90.00±0.00	90.00±0.00

*Means with different superscript letters within a row are significantly different ($P < 0.05$).

Where: [1]Mean initial weight (g); [2]mean final weight (g); [3]mean final standard length (cm); [4]mean weight gain (g); [5]average daily growth (g/day); [6]daily growth coefficient; [7]relative growth rate; [8]metabolic growth rate (g/kg$^{0.8}$/day); [9]specific growth rate (%/day); [10]food conversion ratio; [11]feed efficiency ratio; [12] protein efficiency ratio; [13]lipid efficiency ratio; [14]protein productive value (%); [15]lipid productive value (%);[16]energy retentive value (%); [17]protein index (g/day); [18]nitrogen metabolism; [19]condition factor; [20]percentage survival rate.

Table 3: Cost Benefit Evaluation of *Clarias gariepinus* fed diets containing varying levels of Dietary Crude Protein in Net-hapas for 24 weeks.

Economic Variables	Different Crude Protein Diets (%)				
	50.00	47.50	45.00	42.50	40.00
PP[1]	168.00	168.00	168.00	168.00	168.00
SD[2]	20.00	20.00	20.00	20.00	20.00
SR[3]	86.67±3.33	88.33±3.33	86.67±6.01	90.00±0.00	90.00±0.00
TFI[4]	255.2±2.42	253.53±4.51	264.37±6.26	261.93±1.19	254.97±2.75
COD[5]	239.6±0.00^{a}	233.80±0.00^{b}	227.80±0.00^{c}	222.70±0.00^{d}	217.50±0.00^{e}
COF[6]	1061.09±40.77	1048.24±54.96	1047.30±95.82	1050.23±38.17^{ab}	1000.00±10.62
CF[7]	600.00	600.00	600.00	600.00	600.00
CH[8]	2500.00	2500.00	2500.00	2500.00	2500.00
TCP[9]	4161.09±40.77	4148.24±54.96	4147.30±95.82	4150.23±38.17	4100.62±10.62
NP[10]	15561±63.66	16064±71.04	16865±15.7	17850±60.82	16215±14.84
VOF[11]	7781±31.85	8032±35.01	8432±57.37	8925±30.87	8107±7.50

GP[12]	3619.91±27[a]	3884.09±48[ab]	4285.2±26[ab]	4774.77±26[c]	4006.88±12[ab]
PI[13]	7.33±0.08[a]	7.67±0.15[a]	8.09±0.22[b]	8.50±0.02[c]	8.11±0.08[b]
ECR[14]	68.61±0.73[b]	65.62±1.27[b]	62.17±1.60[a]	58.98±0.13[a]	61.84±0.64[a]

*Means with different superscript letters within a row are significantly different (P < 0.05).
[1]Production period (days); [2]Stocking density (per hapa); [3]Survival rate (%); [4]Total feed intake (g); [5]Cost of diet (N/kg); [6]Cost of feeding (N/hapa); [7]Cost of fingerlings (N/hapa); [8]Cost of hapa (N); [9]Total cost of production; [10]Net production (kg/hapa); [11]Value of fish @ N500/kg; [12]Gross profit; [13]Profit index; [14]Economic conversion ratio.

Table 4. Mean Monthly Physico-chemical Parameters of the In-tank Water during the Experiment.

Parameters	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
DO (mg/l)	5.15±0.15	6.30±0.20	6.20±0.20	6.60±0.10	6.70±0.20	6.90±0.05
pH	8.10±0.10	7.05±0.25	7.03±0.23	6.50±0.40	6.85±0.15	7.22±0.02
T (^{o}C)	28.25±0.25	27.35±0.55	26.75±0.25	27.05±0.25	27.10±0.10	27.35±0.05
NH_3 (mg/l)	0.10±0.00	0.10±0.00	0.00	0.10±0.00	0.00	0.15±0.05
NO_3 (mg/l)	11.06±0.00	8.00±3.00	5.25±0.25	4.10±1.50	4.35±0.67	8.00±3.00
PO_3 (mg/l)	17.00±0.00	16.65±0.45	16.25±0.25	15.80±0.80	16.45±0.55	17.10±0.10
SO_3(mg/l)	1.85±0.15	2.80±0.70	2.50±0.50	2.40±0.40	2.15±0.15	2.90±0.10
Con. (µs/cm)	6.35±0.15	8.50±0.30	8.60±0.20	8.15±0.65	8.10±0.10	7.70±0.50

CONCLUSIONS

Increasing the protein content significantly reduced fish growth in this study. *Clarias gariepinus* fed with diet containing 42.5 % protein had high growth with low food intake. This indicated the capacity of this species to accept and utilize compounded diet efficiently in net-hapa system. The highest profit index and economic conversion ratio obtained probably pointed to the fact that 42.5% protein inclusion level may be better in economic terms than all other protein diets in this study. This is also reflected in lack of significant differences (p>0.05) in metabolic growth rate, protein productive value, energy retentive value and protein intake for all the treatments. It is therefore apparent that biological and economic benefits could be achieved in intensive culture of African catfish under conditions similar to those adopted in this study.

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REFERENCES

[1] Aluko, P.O., Woru, D. (1996). Production of sterile triploid *Clarias* and *Heterobranchus* by first producing tetraploids through determination of the onset of first mitosis. National Institute for Fresh Water Fisheries Research, New Bussa, *Annual Report,* pp: 57-63.

[2] Alatise, S.P., Ogundele, O., Eyo, A.A., Oludunjoye, F. (2006). Evaluation of different soybean-based diets on growth and nutrient utilization of *Heterobranchus longifilis* in aquaria tanks. FISON conference Proceeding. Calabar 13th -17th Nov. 2006, pp: 255-262.

[3] Jamabo, N.A., Alfred-Ockiya, J.F. (2008). Effects of dietary protein levels on the growth performance of *Heterobranchus bidorsalis* (Geoffrey- Saint-Hillarie) fingerlings from Niger Delta. *Afr. J. Biotechnol.*, 7(14): 2483-2485.

[4] Olufeagba, S.O., Aluko, P.O. (1997). Growth and survival of triploid *Heterobranchus longifilis*. National Institute for Freshwater Fisheries Research, New Bussa, *Annual Report,* pp: 102-109.

[5] Fagbenro, O.A., Balagon, A.M., Anyanwu, C.N. (1992). Optimum dietary protein level of *Heterobranchus bidorsalis* fed compounded diet. *Nig. J. Appl. Fish. Hydrobiol*, 1: 41-45.

[6] N. R. C. (National Research Council) (1993). *Nutrient Requirements of Warmwater Fishes and Shellfishes*. National Academy Press, Washington D.C. 140pp.

[7] Otubusin, S.O. (2000). The effect of feedstuffs on Tilapia, O*reochromis niloticus* fry in floating net-hapas. *Nig. J. of Science,* 34(4): 377-379.

[8] AOAC (Association of Official Analytical Chemists), 2004.Official Methods of Analysis, Washington DC, USA, 844pp.

[9] Meyer, G., Fracalossi, D.M. (2004). Protein requirement of jundia fingerlings, *Rhamdia quelen*, at two dietary energy concentrations. *Aquaculture,* 240: 331–343.

[10] Pangni, K., Atse, B.C., Kouassi, N.J. (2008). Effect of stocking density on growth and survival of the African catfish *Chrysichthys nigrodigitatus*, Claroteidae (Lacepede 1803) larvae in circular tanks. *Livestock Res. Rural Dev.*, 20(7): 9.

[11] Duncan, D.B. 1955. "Multiple F-test". *Biometrics,* 11: pp: 1-42.

[12] Sotolu, O.A. (2010). Feed Utilization and Biochemical Characteristics of *Clarias gariepinus* (Burchell, 1822) Fingerlings Fed Diets Containing Fish Oil and Vegetable Oils as Total Replacements. *World J. Fish Marine Sci*., 2(2): 93-98.

[13] Diyaware, M.Y., Modu, B.M., Yakub, U.P. (2009). Effect of different dietary protein levels on growth performance and feed utilization of hybrid catfish (*Heterobranchus bidorsalis* x *Clarias anguillaris*) fry in north-east Nigeria. *Afr. J. Biotechnol.,* 8(16): 3954-3957.

[14] Babalola, T.O.O., Apata, D.F.(2006). Effects of dietary protein and lipid levels on growth performance and body composition of African catfish *Heterobranchus longifilis* (Valenciennes, 1840) fingerlings, *J. Anim. Vet. Adv.*, 5: 1073-1079.

[15] Adewolu, M.A., Benfey, T.J. (2009). Growth, Nutrient Utilization and Body Composition of Juvenile Bagrid Catfish, *Chrysichthys Nigrodigitatus* (Actinopterygii: Siluriformes: Claroteidae), Fed Different Dietary Crude Protein Levels. *Acta Ichthyologica Et Piscatoria*, 39 (2): 95–101.

[16] Kerdchuen, N. (1992). L'alimentation artificielle d'un silure africain *Heterobranchus longifilis* (Teleostei: Clariidae): incidence du mode d'alimentation et première estimation des besoins nutritionnels. Thèse de Doctorat, Université Paris 6, France, 182 pp.

[17] Jana, S.N., Garg, S.K., Barman, U.K. (2006). Effect of varying dietary protein levels on growth and production of *Chanos chanos* (Fosskal) in inland saline ground water: laboratory and field studies. *Aquact. Int.*, 14: 479-498.

[18] Alatise, S.P., Ogundele, O., Olaosebikan, B.D. (2005). Growth response of *Heterobranchus longifilis* fingerlings fed with varying levels of dietary freshwater *mussel (Aspatharia sinuata).* In: 19th Annual Conference of the Fisheries Society of Nigeria (FISON), 29 Nov to 03 Dec 2004, Ilorin, Nigeria, pp: 637-643.

Impacts of Climate Change on Fisheries and Aquaculture in Nigeria

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ABSTRACT

Fisheries and aquaculture play an important role in economy of Nigeria. The development and management of this sector is a major challenge for food security. This sector is threatened by the impacts of climate changes. Many people who depend on fisheries and aquaculture as sources of income are being affected directly or indirectly by impacts of climatic changes, whether through changes in physical environments, ecosystems, fishing or farming operations and livelihood. If Climate change or global warming is not managed appropriately, it will have adverse effects on livelihoods in Nigeria especially on fisheries and aquaculture products or activities, because the rainfall patterns will be altered, floods which devastate aquatic bodies would occur, and this will increase the poverty level of fishermen and women folk. This paper reviews the importance of fisheries and aquaculture as sources of food security in Nigeria, and the likely impact of climate change on these activities and some practical measures to be taken in order to adapt to the effects of climate change and global warming on fishing activities.

Key words: Fisheries, aquaculture, poverty alleviation, climate change, food security,

INTRODUCTION

There has been increase in global average air temperature and average sea surface temperatures have also risen since 1950 as the ocean has absorbed 80% heat (IPCC, 2007). Increasing water temperature and associated thermal expansion accounts for 57% of the global average sea level rise of 1.8 mm per year between 1961 and 2003(IPCC, 2007).The Oceans have also absorbed approximately 25% of anthropogenic CO_2 causing ocean acidification (Eakin *et al.*, 2008).

The sudden increase in temperature of the oceanic water, rivers, dams and seas have been affected by climate change and this has seriously affected the eco-system. Fishermen are sensitive to this because fishing is their main sources of living and changes in productivity, costs and market prices affect profitability and sustainability of fisheries activities in the country. Aquatic products play an important role in economy of Nigeria because they are widely traded foods in the world and about 4 % of these products enters international trade (FAO,2008). Fishing activities are found mainly along the coastal areas of the country and also in lakes and rivers where most communities livelihood is mainly on fishing. These coastal areas are found in : Lagos state (230 km), Ondo State (88km), Ogun State (18km), Delta State (126km). Rivers State (390km), and Cross rivers State (108km) where, most fishing activities occur.

Percentage fisheries production in Nigeria are: aquaculture (4%), artisanal inland fishing (6%), artisanal coastal fishing (80%) and Industrial coastal (trawl) fishing (10%) . According to Idowu *et.al*, (2011) ,the artisanal fishing activities in Nigeria has an output of 680,000 metric tons per annum, industrial coastal fishing is about 85,000 metric tons ,artisanal inland fishing produces 56,000 metric tons per annum while aquaculture accounts for 34,000 metric tons per annum but he reported decline in catch per unit effort as a result of impact of climate change ,flooding of fish ponds, erosion of coastline, deposition of beach sands and mud deposition coastal features .

According to Uyigue 2007, the mean sea level in Nigeria rose by 0.462 m between 1960 and 1970 while DFID 2009 projected that there will be increase by 0.3 m by 2020 ,1.0 m by 2050 and 2.0 m by 2100.Thus, the marked increased in climate change has seriously affected fisheries and aquaculture activities and productivities in Nigeria and this must be addressed in order to develop strategies for it.

Importance of Fisheries and Aquaculture

In 2006, fisheries and aquaculture produced a total of 143.6 million tonnes of fish (FAO,2009), 81.9 million tonnes from marine capture fisheries, 10.1 million tonnes from inland capture fisheries, 31.6 million tonnes from inland aquaculture and 20.1 million tonnes from marine aquaculture. China is by far the largest producer of fish, producing 51.5 million tonnes of fish in 2006, 17.1 million tonnes from capture fisheries and 34.4 million tonnes from aquaculture (FAO, 2009).

One third of the world's population rely on fish and other aquatic products for at least 20% of their protein intake (Dulvy and Allison, 2009) , fish provides more than 50% of all the protein and minerals consumed by 400 million of the world's poorest people (MAB, 2009).
Fish accounts for 30% of animal protein consumed in Asia, 20% in Africa and 10% in Latin America and the Caribbean (Prein and Ahmed, 2000), it contributes to the food security of the coastal areas where their poverty level is very high.
FAO, 2008 reported that millions of people around the world depend on fisheries and aquaculture for their livelihoods and this sector contributes to Gross Domestic Product (GDP) ranging from 0.5 to 2.5 % .
Many people depend on fisheries/aquaculture for food and livelihood .Fish products provide more than2.8 billion people with about 20 % of annual protein and fish contributes to about 50 % of the total animal protein intake in most developing countries including Nigeria. Fisheries sector has provided income, food supply and security to artisanal fishermen and women in the developing countries of the world.

Impact of Climate Change on Fisheries and Aquaculture
The major causes of climate change is due to industrialization and the burning of fossil fuels (coal, oil and gas) to meet increasing energy demands in the world today, and increased agricultural activities to meet increasing food demand, which leads to deforestation.

Climate change affects fish and their habitats, increase temperatures influence the abundance, migratory patterns and mortality rates of wild fish stocks and determine what species can be farmed in certain regions of the country. The heating of oceans and inland water bodies affect adaptation of fish to narrow temperature range while intense thermal stratification has limited mixing of the water bodies thereby weakening recycling of nutrients to the water surface. Thus there is decrease in biological productivities of water bodies.
Increase in temperature has resulted in decreased O_2 concentration of the water bodies and this has affected the aquatic organisms by finding it very difficult to breathe while increase in dissolved CO_2 as a result of acidification of the ocean has increased the H^+ and HCO^3, decrease in CO_3^{2-} reduces the aquatic organisms to produce calcarcous exo-skeletal structure
Fisheries and aquaculture are vulnerable to the direct or indirect impacts of climate change through changes in physical environment, ecosystem and aquatic activities such as fishing. Changes in ocean salinity as a result of rising in sea level have contributed to the reduced yield observed in fisheries sector.
Generally, climate variations have affected fish distributions. Fish species , diversity of aquatic bodies are sensitive to climatic disturbances thus there is reduce in the number of fish that sp awn due to lower dry season water levels, these have contributed to

decrease in egg hatching ,reduction in metabolism activities , decreased fertilization rates ,reduced thermal tolerance and mortality.

Fisheries and aquaculture sector is facing a serious problem as a result of increase in climate change, there is increase risks in fishing activities and many fishermen have lost their lives and infrastructure. Fishing communities are experiencing unstable livelihoods, decrease in availability of fish for food and problem of safety during fishing , harsher weather conditions and problem of safe landing.

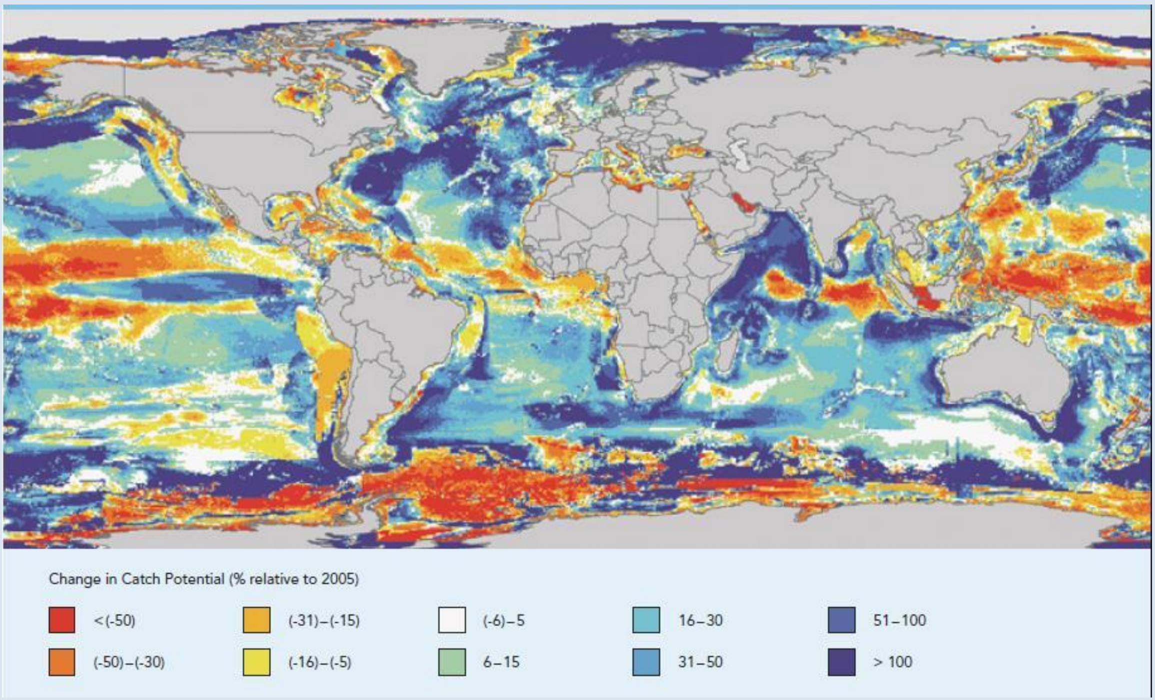
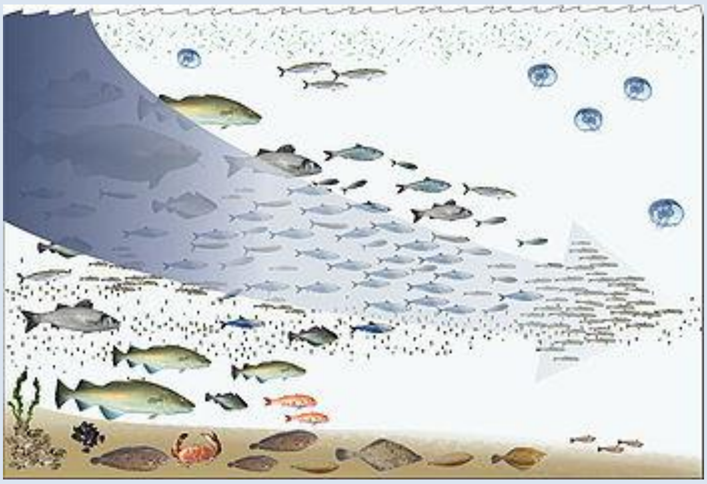


Fig.1: Changes in catch potential as a result of climate change (PEW 2009)

Fishing communities and households where women play a significant role in fishing, harvesting, smoking and sales of fish are under serious conditions of stress and increased competition for resources and employment as a result of climate change. This has really increased the poverty level of the fishing communities.

Fisheries have significant importance on aquaculture and as a result of impact of climate change on fisheries, this has also affected the productivity and profitability of aquaculture systems in the Nigeria. Vulnerability of aquaculture system to harsh weather/climate could cause physiological stress on fish stock thereby increasing their vulnerability to diseases and causing death.

Fisheries and aquaculture subsectors have being affected by impacts of harsh weather, and this has contributed to reduction in genetic diversity of the fish in the wild thereby affecting fish species biodiversity.The aquatic ecosystems, especially the freshwater ecosystem has been affected by great reduction in volumes of lakes and rivers in drought- prone areas of the country, carrying capacity of fish production is reduced. For instance, water volume of lake Chad has reduced to 10% of its former size between 1963 and 2005, while fish production has declined from 200,000 tons in 1974 to 50,000 in 2001 (Adamu 2005).. Intensification of water volume stratification as a result of increase in temperature has affected lake productivities by reducing internal nutrient recycling and loading (O' Reilly et.al.,2000)



Fishing down the food web. :

Impacts of fisheries and aquaculture in Food Security

Fish provide the main source of animal protein to about one billion people worldwide. Fishery is an important part of food security, particularly for many poor people in developing countries. Fish and fisheries contribute to food security in a variety of ways:

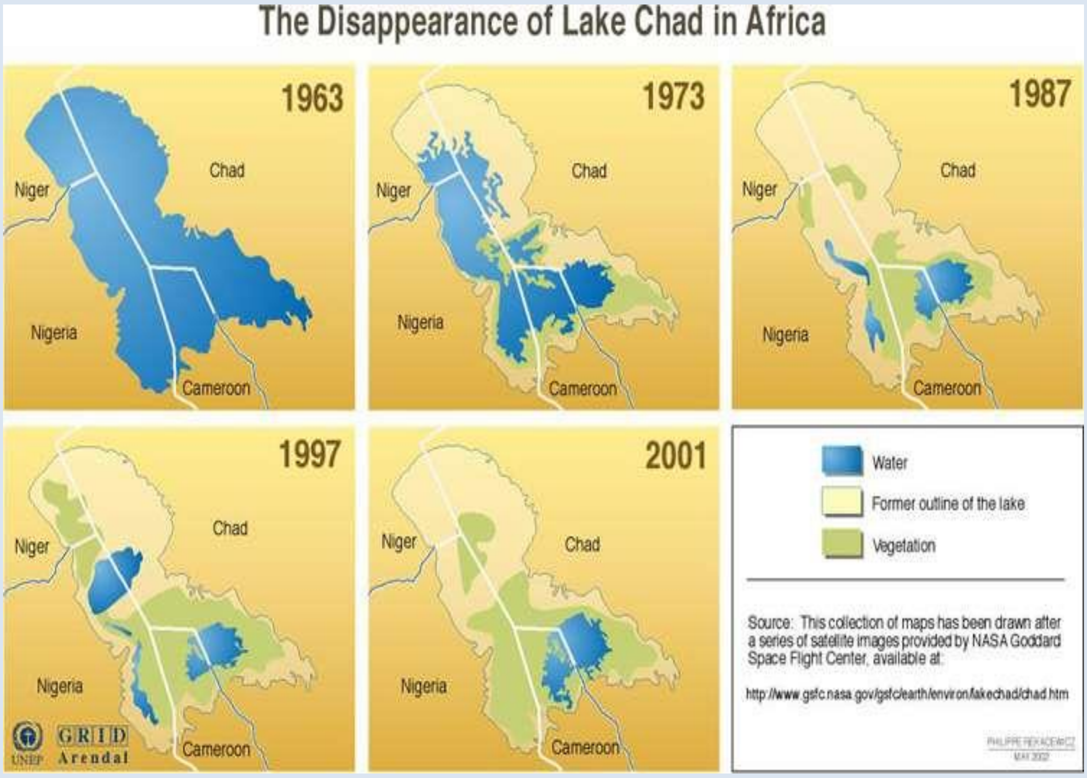
a. Fisheries provide food for consumption, employment and financial income for fishermen in riverine areas;

b. Inland fisheries provide direct fish supply for the poor as they are one of the cheapest protein sources available in developing countries;

c. Over 38 million people in the world are employed in fisheries, 95% are found in developing countries and the money from fish sales provides cash which can be used for the purchase of other foodstuffs.

There have been a lot of efforts towards the empowerment of women in the agricultural sector because food fish from fisheries or aquaculture plays an important role in human nutrition and global food supply, particularly within the diet and food security of the people in the rural communities. Women are responsible for half of the world's food production in most developing countries including Nigeria. As a result of this, efforts are made in encouraging women to get involved in fish culture activities because of the nation food security/benefits. Fish is the cheapest source of animal protein and it is available in different forms: Frozen, dried, smoked or fresh. The nutritional benefits from aquaculture and fisheries really have impact on the food security.

Fisheries /Aquaculture plays an important role in food security by producing sources of protein for people to eat and by providing the primary source of livelihood and employment for people in order to alleviate poverty in the riverine areas of the country. Therefore, if fisheries and aquacultural productions of the low-income people of Nigeria is adversely affected by climate change, the livelihoods of many rural people in the country will be at risk and their vulnerability to food insecurity will increase.



The shrinkage of Lake Chad, 1963 to 2001 (Sources: www.google.com.ng; http://strangemaps.files.wordpress.com/2007/03/14-lakechad.jpg).

Some Practical Measures to Be Taken

There should be a general awareness campaign among the fishermen on the potential impact of climate change on fisheries systems in the country and the practical measures to be taken (Table 1).

- Fishermen should be encouraged to be involved in alternative occupations for livelihood such as farming and they also need to be empowered to take actions by increasing their access to appropriate financial services and opportunities for training.

- Our mangrove forests must be protected in such a way to reduce the impact of storms and floods in order to support the life history of many fin- and shell-fishes. Mangroves provide vital coastal defence and support local fish stocks by providing food, shelter and habitat (UNEP-WCMC, 2006).
- They are also very effective at absorbing excess nutrients from wastewater, sequestering carbon and provide fuelwood, building material and fodder for animals. However, due to overexploitation, extreme weather and unsustainable aquaculture development 35% of the world's mangroves have been lost over the last 20 years, rising to 80% in some areas (TEEB, 2008).
- The conservation, rehabilitation and afforestation of mangroves are important means of both adapting to and mitigating the effects of climate change. This can

involve raising community awareness of their importance, reducing stress from other environmental threats, preventing overexploitation of mangroves for animal fodder or firewood and planting new mangroves artificially using collected seeds and fertilizer.

- Researchers should intensify their research on how to domesticate more freshwater fish species that are have economical important such as Estuarine catfish (*Chrysichthys nigrodigitatus*) and Snakehead (*Parachanna obscura*); and marine species such as Bobo croaker (*Pseudotolithus elongatus*) among others. More researches are needed on impacts of climate change at the levels of individual species and local fisheries and fishing communities, and investment is needed in the development of policies that will help reduce vulnerabilities and encourage people to take the actions needed to adapt to changed circumstances.

- There should be effective management of fishery stocks, fishing activities ,pollution and habitat alteration – healthy fish stocks show a higher resilience and lower sensitivity to climate change impacts.
- Management of fisheries and aquaculture need to focus on maintaining the integrity of ecosystems, taking into account complex linkages and relationships between species and their wider ecosystems. Marine Protected Areas and permanent closures could play a very important role, on fish stocks within and around them (World Bank, 2005)..

- Mechanisms to protect fishing communities from immediate impacts of climate change should be put in place, that is, ability to monitor the environment and provide early warning of threats needs to be enhanced. For example, fishermen need to receive weather forecasts and warnings via their mobile phone, reducing the number of vessels caught at sea by typhoons (FAO, 2007).

- Access to emergency funds and appropriate insurance products would also reduce vulnerability of the livelihoods of small-scale fishermen and fish farmers to loss of income and assets resulting from extreme weather events.
- There is a need to move towards mari-culture in aquaculture to mitigate the impact of climate change on freshwater hydrology. Brackish water aquaculture should be broadened in scope, research on new strains of aquaculture species that are tolerant of lower water quality and higher levels of salinity to cope with changes driven by climate change should be developed.

It was reported that the World Fish Center received the World Food Prize in 2005 for a project that converted a million seasonally flooded ditches and pools to fish production in Bangladesh (World Fish Center, 2007), the same could be practise in Nigeria.

Efforts will need to be directed at preserving the wetland 'hinterland' of African inland fisheries and deep sections of shallow lakes as refuges for fish when water levels fall. With the exception of large, deep lakes, changes in climate, rainfall in particular, are the main cause of stock changes in these fisheries, not fishing effort. In such cases reductions in fishing effort have little effect on stocks and serve only to reduce the incomes of fishermen (Allison *et al.*, 2007).

REFERENCES

Allison, E.H., Andrew, N.L. and Oliver, J. (2007) Enhancing the resilience of inland fisheries and aquaculture systems to climate change. *Journal of Semi-Arid Tropical Agricultural Research* 4(1). Available at: http://www.icrisat.org/Journal/SpecialProject/sp15.pdf. Date accessed: 6 December 2010.

Dulvy, N. and Allison, E. (2009) A place at the table? *Nature Reports Climate Change* 3, 68–70.

Eakin, M.C., Kleypas, J. and Hoegh-Guldberg, O. (2008) Global climate change and coral reefs: risingtemperatures, acidification and the need for resilient reefs. In: *Status of Coral Reefs of the World: 2008* (C. Wilkinson, ed.). Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, Australia, pp. 29–40. Available at:ttp://www.reefbase.org/download/download.aspx?type=1&docid=13311. Date accessed: 6 December 2010.

FAO (2007) Building adaptive capacity to climate change: policies to sustain livelihoods and fisheries. *New Directions in Fisheries – A Series of Policy Briefs on Development Issues* No. 8. FAO Rome, Italy, 16 pp. Available at: ftp://ftp.fao.org/docrep/fao/010/a1115e/a1115e00.pdf. Date accessed: 6 December 2010.

FAO (2008) Climate change implications for fisheries and aquaculture. In: *The State of Fisheries and Aquaculture 2008*. FAO, Rome, Italy, pp. 87–91.

FAO (2009a) *The State of World Fisheries and Aquaculture 2008*. FAO, Rome, Italy, 176 pp.

IPCC (2007) *Climate Change 2007: Synthesis Report – Contribution of Working Groups I, II, and III to the Fourth Intergovernmental Panel on Climate Change*. Core Writing Team: R.K. Pauchauri and A. Reisinger, eds. IPCC, Geneva, Switzerland, 8 pp.

MAB (Multi-Agency Brief) (2009). *Fisheries and Aquaculture in a Changing Climate*. FAO, Rome, Italy, 6 pp.Available at: ftp://ftp.fao.org/FI/brochure/climate_change/policy_brief.pdf. Date accessed: 6 December 2010.

PEW. (2009) Redistribution of Fish Catch by Climate Change: A Summary of a New Scientific Analysis: Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J. L., Kearney, K., Watson, R., Zeller, D. and Pauly, D. 2009.

Prein, M. and Ahmed, M. (2000) Integration of aquaculture into smallholder farming systems for improved food security and household nutrition. *Food and Nutrition Bulletin* 21(4), 466–471.

TEEB (2008). *The Economics of Ecosystems and Biodiversity: An interim report*. UNEP, Bonn, Germany, 66 pp. Available at: http://www.teebweb.org/InformationMaterial/TEEBInterimReport/tabid/1278/language/en-

UNEP-WCMC (2006) *In the Front Line: Shoreline protection and other ecosystem services from mangroves and coral reefs*. UNEP-WCMC, Cambridge, UK, 33 pp. Available at: http://data.iucn.org/dbtw-wpd/edocs/2006-025.pdf. Date accessed: 6 December 2010.

Uyigue E and Agho, M.(2007).Coping with climate change and environmental Degradation in Niger Delta of Southern Nigeria .A publication of the Community Research and development in Center Nigeria

World Bank (2005) *Turning the Tide. Saving fish and fishers: Building sustainable and equitable fisheries governance*. The World Bank, Washington, DC, USA, 20 pp. Available at www.seaweb.org/resources/documents/reports_turningtide.pdf. Date accessed: 6 December 2010.

WorldFish Center (2007a) Fisheries and aquaculture can provide solutions to cope with climate change. *Issues Brief* No.1701. WorldFish Center, Penang, Malaysia, 4 pp. Available at:http://www.worldfishcenter.org/v2/files/CC-ThreatToFisheries1701.pdf. Date accessed: 6 December 2010.

Perceived Effect of Deforestation for Charcoal Production on Water Availability for Fish Farming in Ibarapa Area, Oyo State, Nigeria

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ABSTRACT

Climate change is a growing environmental concern. Due to the poikilothermic nature of fish, its impacts on freshwater fishes and livelihood of fish farmers are immense. This paper highlights the implications of deforestation for charcoal production on fish farming in Ibarapa area of Oyo State, Nigeria. It provides information on the interrelationship between climate change due to deforestation, fish farming and food security. Majority of the inhabitants of the study area are into charcoal production which involves felling of mature trees thereby causing deforestation, reducing soil cover and resulting in environmental degradation. The practice has adverse effects on water availability for fish farming activities and the economic status of the fish farmers. The people are thus vulnerable to food insecurity. Adaptation measures to mitigate the climate change challenges caused by charcoal production activities in the area are also discussed.

Keywords: Charcoal production; adaptation; climate change; fish farmers; Ibarapa

INTRODUCTION

Self sufficiency in agriculture means food security and self reliance. Food security entails ensuring sustainable access availability and affordability of adequate quantity and quality food to all citizens to meet up their physiological requirements. Food security exists when all people have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active healthy life (FAO, 1996). The capacity to maintain food supplies for an increasing and expectant population will depend on maximizing the efficiency and sustainability of the production methods in the wake of global changes that are expected to adversely impact the former. Three major challenges have arisen that threaten to drastically complicate efforts to overcome food insecurity and malnutrition: climate change, the growing use of food crops as a source of biofuel and soaring food prices. As a result of climate and global environmental changes such as land degradation and changes in hydrological resources, essential ecosystems' services, agricultural production systems and access to food are likely to decline drastically particularly in Sub-Saharan Africa and South Asia (Easterling et al., 2007). Climate can simply act as an average whether over a long period of time. Climate of a region is dictated by both natural and human activities. The human factors entail land and resource uses; while natural elements are those of the atmosphere, hydrosphere, geosphere and biosphere. Therefore, any alterations in both the elements and factors can lead to local, regional and global change in the climate. Climate change will affect in profoundly adverse ways; some of the most fundamental determinant of life (health) food water and air (Chan, 2008; Eke & Onafalujo, 2011). Climate change or global warming is caused by emission of heat trapping gases produced by vehicles, power plants, industrial processes and deforestation.

Forests are vital for life, home to millions of species, they protect soil from erosion, produce oxygen, store carbon dioxide and help control climate. Deforestation by human is causing all these necessary functions to be lessened, and hence damaging the atmosphere even further. In Nigeria, deforestation has been most severe; where more than 410,000 hectares of forest are lost to desertification annually. This lend credence to the information on type of fuel for cooking in Nigeria which is made of that almost 80% used wood, kerosene (18.5%), electricity (0.2%), gas (0.6%), coal (1.1%) and solar (0%). It indicates that high dependency on fuel wood than other energy source by household in the country. Fuel wood and charcoal are the most important sources of energy in developing countries (Aweto, 1995; Arms, 2008).Even in urban areas where the use of modern fuel such as electricity and liquefied natural gas is becoming increasingly important, the use of tradition fuels especially fuel wood and charcoal remain popular among the low income earners, on account of the non affordability of modern fuels, electric and gas cookers. The use of fuel wood is predominant in rural areas, charcoal utilization assumes considerable importance among low income earners in urban centers. Including those developing countries that enjoy relatively high income levels such as Botswana in southern Africa, the use of biomas energy is popular among the poor in rural areas and in towns. The biochar, application of charcoal, to the soil has general beneficial effects. It has been reported to improve soil fertility and soil biota, and hence soil biological dynamics. Also it remediates contaminated soil, especially those containing excessively high levels of heavy metals. However, the production of charcoal has several adverse environmental effects. It has been linked with deforestation in Brazil and in other parts of the tropics and with soil deterioration and organic matter decline (Foley, 1985). Deforestation is a major cause of environmental degradation worldwide. It accelerates soil erosion, induces increased sedimentation and flooding, affects water supply situation and quality; and it is a major factor in desertification (Adelua, 1992). Soil is an important natural resource for agriculture and forestry. Soil is a major element of the physical environment, and its properties are of considerable importance in agriculture, forestry, rural and urban planning, land development and management projects, and in many construction and engineering works (Adeniji, 1993). Human socio-economic activities since the dawn of civilization exerted pressures beyond the limits of the environment which posed our environment into perpetual economic and environmental disaster (flooding) due to changes in the landscape (deforestation).

In the savannah area, reduced infiltration rates associated with deforestation adversely affect ground water recharge and storage as a result of its direct impact on the major element of the physical environment especially soil (Ebisemiju, 1990). The effects often turn some formerly perennial rivers into seasonal or ephemeral streams. The process of charcoal production also influences soil properties especially in kiln sites, where dried fell tree are accumulated and burned (Aweto, 1995). In Ghana, Ogunkunle and Oladele (2004), Oguntunde et al; (2008) and Ayodele et al; (2009) examined the effects of charcoal production in soil physical and chemical properties in the derived savannah zone of Ghana. Water is the medium for the culture of fish. The quantity and quality of water is at the mercy of the environment and state of the environment is greatly affected by its cybernetics. The main objective of the study was to highlights the implications of charcoal production on fish farming in Ibarapa area of Oyo state, Nigeria. Specifically, the objectives were to: ascertain respondents' perceived causes of climate change in Ibarapa; identify respondents' perceived effect of climate change on fish production due to charcoal production and identify respondents' adaptation strategies of climate change.

METHODOLOGY

Study Area

This study covers the whole of Ibarapa region which include: Ibarapa central local government (Igboora, Idere), Ibarapa North local government (Tapa, Aiyete, Igangan) and Ibarapa East local (Eruwa, Lanlate Maya). Ibarapa falls between the region of latitude 7^{o} 15' and 7^{o} 55' N; between longitude 3^{o} 00' and 3^{o} 30' E. The region is bounded in the north by Oke-Ogun area of Oyo state, to the east is Ido and to the west is Ogun state of Nigeria. Ibarapa region is a transition zone between the rainforest in the southern Oyo state and the savannah belt of northern part. Therefore, the southern fringe of the region posses the characteristics features of the grassland. Agriculture remains the 45% of the total population of the town while charcoal production was 30%. Other occupation include carpentry/woodwork, textile clothe weaving, blacksmith, bricklaying, trading among others. The annual rainfall is between 1500mm and 2000mm. relative humidity is over 80% in the morning and falls between 50% and 70% in the afternoon. The mean annual temperature range is 27^{o}C and annual temperature range is 80^{o}C. The region experiences about 7 months of rain between late March / early April to late October or early November. The dry season occurs between November and March/April. There is been short break of rain around August on the past few years and these have not been constant which fluctuates between July and August.

Study population, sampling procedure and data collection

The target populations of this study are fish farmers who are within Ibarapa region, Oyo State. Purposive sampling techniques was used in the study due to the few number of fish farmers in the study area. Data was collected through the primary and secondary sources. The primary source was through administration of a well structured questionnaire while secondary data was obtained from relevant literature. Information was collected on selected personal characteristics such as age, sex, family size, educational level, farming experience, level of awareness, perception of climate change on food security as well as adaptation strategies to climate change.

Data analysis

Descriptive statistics such as frequency count mean percentages and mean statistic were used to summarize the data. The respondents were asked to indicate on a 4- point likert type scale the extent of their perceptions towards the shortlisted causes of climate change. Their response categories and the corresponding weighted values were: To great extent =4, to some extent=3, to little extent =2, and to no extent=1. These values were added to obtain a value of 10 which when divided by 4 gives a mean score of 2.5. The respondents mean were obtained on each of the items. Any mean score greater than or equal to 2.5 was regarded as "to great extent", while any mean score less than 2.5 was regarded as "to no extent". The respondents' perception about climate change was also measured by using 8 perceptual statements. In ascertaining perceived impact of climate change on fish production, a four-point likert-type .
Their response categories and the corresponding weighted values were: To strongly agree =4, agree =3, disagree =2, and strongly disagree =1. These values were added to obtain a value of 10 which when divided by 4 gives a mean score of 2.5. The respondents mean were obtained on each of the items. Any mean score greater than or equal to 2.5 was regarded as "agreement", while any mean score less than 2.5 was regarded as "disagreement". Also, to determine strategies adopted by fish farmers to reduce the

effects of climate change, fish farmers were agreed to tick options from a list of various adaptation options obtained from literature, expert opinions and observations.

RESULTS AND DISCUSSION

Charcoal production constitutes a major vocation and means of livelihood for a lot of people in Ibarapa region of Oyo state. An appreciable number of people that are involved in the production and marketing chain ,namely producers, transporters (Plate 1), retailers and final users do not see the deforestation associated with the practice as a problem since in their opinion the trade is their main source of income and survival. Plate 2 also shows fully loaded charcoal vehicles with retailers' standing by to bargain. Social and demographic information as shown in table 1 revealed the dominance of men (100%) in fish farming in the region under study. This may not be unconnected to the associated risks that influence the gender disparity. 22.5% of the respondents were between the age of 21-40yrs and were regarded as youths, while majority (70%) of the respondents that can be referred to as productive/labour force were engaged in fish farming. This depicts the employment potential of fish farming for the teaming population of youths in the region. However, education provides and equips individuals with knowledge and application of the acquired information. Majority (65%) of the respondents were literate as shown in table 1. The study revealed that, 75% of the studied population had the minimum of 10 years on the job experience. This indicates that the region and studied population were earlier equipped with the information that reveals the need to intensify food fish production through pond culture method in order to abridge the long existing gap between fish supply and demand by the extension agents to meet the protein requirement of mankind. All respondents engaged in one secondary occupation or the other with over 50% engaged in other non-agricultural vocations in order to boost their monthly incomes for an improved socio-economic status of the family in providing basic life needs (shelter, food, clothing etc) for their households. The fish yields and harvest in the surveyed fish farm are mostly less than 10 tons/ha with over 61% falling within this category (Table 2). This is considered below optimal production compared to the abundance of young virile population involves in fish farming in the region as over 70% of respondents farmers are within the age brackets greater than 20years and less than sixty.

Plate 1.Vehicles fully loaded for transportation of charcoal in Igbo-ora,Oyo State

Plate 2. Fully loaded charcoal vehicles with retailers' standing by to bargain

Table 1: Demographic and operational information of respondents

Variable	Frequency(%)
Age	
<20years	7(17.5)
20-40years	9(22.5)
41-60years	19(47.5)
>60years	6(12.5)
Gender	
Male	40(100)
Female	—
Fish farming experience (years)	
5-10	10(25)
11-15	8(20)
>15	22(55)
Highest Education Qualification	
No formal education	14(35)
Secondary school	18(45)
Higher education OND and above	8(20)
Secondary occupation	
Crop farming	18(45.0)
Trading	10(25.0)
Artisans	12(30.0)
Family size	
<3	10(25.0)
4	23(57.5)
>4	7(17.5)

Source: Field survey, 2013

Table 2: Monthly income and average fish yields of respondents

Variable	Frequency(%)
Average monthly income, ₦	
<15000	14(35.0)
15,000-25,000	17(42.5)
>25,000	9(22.5)
Average yields (tons/ha)	
<5	15(37.5)
5-10	9(22.5)
11-15	11(27.5)
>15tons	5(12.5)

Source: Field survey, 2013

Interview with the famers especially the older ones revealed declining productivity on last 10 yrs as compared with what use to obtain when deforestation for charcoal production activities are relatively low. Less than 15% of respondents reported above 15tons/ha. Average monthly income in most of the respondents fall below ₦25, 000 about over 70% of respondents are within this category. This is below expected sustainable income for a family size of six. Going by Nigerian economic indices, a family of six should at the minimum survive on not less than ₦36,000 per month (a minimum wage of ₦18,000 per month for the parents). Thus, the food security of the average family in the region under study is threatened pushing most of the fish farmers to engage in secondary occupation as evident in table 1. This has concomitant negative effects in fish farming yields with the attention of farmers divided away from the primary occupation of producing fish.

Causes of Climate Change

Table 3 shows that the respondents perceived deforestation (M=3.80), bush burning (M= 3.00), burning of firewood (M=3.13) , natural occurrence (M=3.33), overgrazing (M=2.78) excessive use of chemicals (M=2.58), overgrazing (M=2.78) caused adverse climate change to great extent. Practicing of intensive agriculture (M=2.33) was regarded as cause of climate change to some extent while other causes such as emission from green house, CO_2 emission from transportation, gas released from industries and depletion of ozone layer, with low mean (M) scores of 1.30, 1.25, 1.15 and 1.15 respectively, did not cause climate change (perceived as to no extent).

Table 3: Distribution of respondents according to perceived causes of climate change

Causes of climate change	Mean(M)	Standard Deviation
Burning of fossil fuels	1.58	0.747
Deforestation	3.80*	0.405
Bush burning	3.00*	0.716
Emission for green house	1.30	0.608
CO_2 emissions from transportation	1.25	0.438
Burning of firewood	3.13*	0.607
Excessive use of chemicals	2.58*	0.675
Overgrazing	2.78*	0.768
Gases released from industries	1.15	0.362
Practicing of intensive agriculture	2.33	1.306
Depletion of ozone layer	1.15	0.362
Natural occurrence	3.33*	0.526

**= To great extent (M ≥ 2.50)*
Source: Field survey, 2013

Perception about climate change on food security due to deforestation

Table 4 shows that the respondents were of the general opinion that the main effect of deforestation on fish farming are flooding (M=4.68), water pollution (M=4.43), suspended silt (M=3.70), fish kill (M=4.58), rise in P^H (M=3.28), decline in fish quality (M=4.33), and drying of water source (M=4.50). However, the respondents “disagree” to the question on water temperature (M=1.30). The implication of the results in Table 3 tends to indicate that respondents have unfavorable disposition towards effects of charcoal production on fish production with resultant influence on food security.

Table 4: Perception about effect of deforestation for charcoal production on water availability for fish farming

Perceptional statements	Mean(M)	Standard deviation
Flooding of pond	4.675	0.474
Water pollution	4.425	0.500
Suspended silt	3.700	0.791
Fish kill	4.575	0.506
Rise in P^H	3.275	0.501
Decline in fish quality	4.325	1.141
Drying of water source	4.500	1.132
Water temperature	1.300	0.464

Source: Field survey, 2013

Adaptation measures

The Intergovernmental Panel on Climate Change, IPCC, in 2007 defined adaptation to climate change as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities .The major goals of climate change adaptation measures are to reduce vulnerability and build resilience to the impacts brought by climate change (Brooks and Adger 2005). Vulnerability to climate change is the degree of susceptibility to harm, damage or loss as a result of climate change impacts or events (IPCC 2001). Fish farmers in Ibarapa area of Oyo state have developed different measures to and cope with the adverse impacts of climate change adaptation. These measures and the frequency of adoption of the strategies among the respondents are as shown in Table 5.

Table 5: Distribution of Measures adopted by fish farmers in Ibarapa region, Oyo State to handle the impacts of Climate Change due to deforestation

SN	Adaptation measures	Yes Freq (%)	No Freq(%)
1.	Digging of wells and drilling of boreholes	40 (100)	0
2.	Regular water quality monitoring	33(82.5)	7(17.5)
3.	Stocking of healthy fast growing fingerlings	35(87.5)	5(12.5)
4.	Avoidance of pond leakages (use of pond liners)	33(82.5)	7(17.5)
5.	Planting of shrubs as windbreak	30 (75)	10(25)
6.	Diversification of livelihood systems	15(37.5)	25(62.5)
7.	Adjusting time of stocking	40 (100)	0
8.	Introduction of organic manure	12(30)	28(70)
9.	Getting information about climate change	22(55)	18(45)
10.	Farming Fish indoors (use of tanks)	8(20)	32(80)

Source: Field survey, 2013

All the respondents have resorted to digging of deep wells and drilling of boreholes to ensure uninterrupted water supply for fish farming operation, over 82% consider regular monitoring of pond water quality as very important to offsetting the negative impacts of climate change. About 55% of respondents chose to seeking/listening to information about climate change; 83% do adopt methods to reduce and avoids leakages of water from ponds. All respondents adapt to negative effect of climate change by adjusting time of stocking, most times to fall within the rainy seasons while 87% reported that they source for and stock healthy fish seeds (fingerlings, juveniles) that are fast growing. Only eight, 20% of the respondent farmers farm fish indoors.

Constraints faced in Fish Farming due to Deforestation for Charcoal production

Responses in Table 6 presents the fish farmers' perception of the impacts of deforestation for charcoal production is the extent of their agreement to which variables such as low production, delay or stunted growth, shortage of water, high fish price, fish farmers are few, high mortality rate, disease infestation . The result shows that respondents were of the general opinion that deforestation for charcoal production in Ibarapa area of Oyo state has led to low fish production, high mortality rate and the low interest in fish farming ventures explaining the reason for very few farmers in the area.

Table 6: Constraints faced in Fish Production due to Charcoal production

Constraints	Frequency*
Low production	72
Delay or stunted growth	34
Shortage of water	36
High fish price `	32
Fish farmers are few	56
High mortality rate	36
Disease infestation	20

*Multiple responses recorded

Source: Field survey, 2013

CONCLUSION AND RECOMMENDATION

Findings in this study confirmed that negative impacts of deforestation for climate change charcoal production are being experienced by fish farmers in the Ibarapa region of Oyo state, Nigeria. Farming systems and practices that ensure conjunctive utilization of the little available water resources would go a long way in alleviating the challenges created. Integrated agriculture with fish farming, feeding water for irrigating crops through fish culture ponds first before applying to crops would enhance productivity, increase food production and enhance incomes of farming households.

REFERENCES

I. FAO (1996) “Policy Statement on Gender and Wood Energy” Regional Wood Energy Development Programme in Asia. Retrieved from www.fao.org/sd/egdirectdateaccessed04/06/2010 on 04 June,2010.

II. Easterling, W. E., Aggarwal, P. K., Batima, P., Brander, K. M., Erda, L., Howden, S. M., et al. (2007). Food, fibre and forest products. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), Climate change 2007: Impacts, adaptation, and vulnerability, contribution of working group II to the Fourth assessment report of the intergovernmental panel on climate change (pp. 273–314). Cambridge and New York: Cambridge University Press.

III. Chan, M., (2008). Climate Change and Health. WHO publication. Retrieved from http://www.who.int/mediacentre/news/statements/2008/S05/en/index.html .on 28 August 2012.

IV. Eke, P.O, and Onafalujo, A.K, (2011): Effects of Climate Change on Health Risks in Nigeria. *African Journal of Business and Management Sciences 1(1): 2004-2015.*

V. Aweto, A. O. (1995) A spatio-temporal analysis of fuelwood production in West Africa. *OPEC Review* 19, 333- 347.

VI. Arms, K. (2008) *Environmental Science*. Holt, Rinehart and Winston, Orlando.

VII. Foley, G. (1985): Charcoal Making in Development countries. Earthscan Techenical Report. No 5. London, International Institute for Environment and development.

VIII. Adelua, F.O (1992); Social waste management and environmental pollution: Case studies of Ado-Ekiti and Iworoko. Unpublished B.Sc essay, Dept. of geology, Ondo state University, Ado-Ekiti.

IX. Adeniyi, A.O (1993) Ado-Ekiti Region. A Geographical Analysis and Master Plan. Printed and published by Alpha print; A Division of Zed and Biz Ltd. 31-33.

X. Ebisemiju, F.S (1990): Sediment delivery ratio prediction equation for short catchment slopes in a humid tropical environment. *Journal of Hydrology 114, 191-208.*

XI. Ayodele, A.P, Oguntunde, A. Joseph and M.D Dias (2009): Numerical Analysis of the Impact of Charcoal Production on Soil Hydrological Behavior, Run off, Response and Erosion Susceptibility. Revista Brasileira De Ciencia Do Solo, 33, 137-145.

XII. Brooks N, Adger W.N (2005). Assessing and enhancing adapti ve capacity, In *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures*, Lim B, Spanger-Siegfried E, Burton I, Malone E, and Hug S (eds), Cambridge University Press, Cambridge.

XIII. IPCC. (2001). *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, McCarthy J.J, Canziani O.F, Leary NA, Dokken, D.J and White K.S (eds), Cambridge University Press, Cambridge, United Kingdom.

XIV. IPCC. (2007). Glossary of Terms. In *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry ML, Canziani OF, Palutikof JP, van de Linden PJ, and Hanson CE (eds), Cambridge University Press, Cambridge, United Kingdom.

XV. Ogunkunle, A.T.J and F.A Oladele (2004): Ethnobonical study of fuelwood and timber wood Consumption and replenishment in Ogbomosho, Ogbomoso, Oyo state, Nigeria. Environment Monitoring and Assessment, 91,223-236

XVI. Oguntunde, P.G, B.J, Abiodun, A.E Ajayi and N. Van de Giesen (2008); Effects of Charcoal on Soil Physical properties in Ghana. *Journal of plant Nutrition and soil Science. Zeltschriff Fier Pflanzenernahrung Und Bodenkunde, 171,591-596*

Characterisation of a Textile Industry Wastewater and its Impact on the Water Bodies in Lagos, Nigeria

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ABSTRACT

Textile industry is one major contributor to the industrial pollution problem facing Nigeria and efforts are being made to control it. The textile industry produces large volumes of wastewater during processing. Wastewater from the textile factory were randomly sampled and characterized. Water samples from two wells within 300 m radius to the artificial lake of wastewater discharge, the river downstream and the factory water supplied to the community were collected and characterized. Triplicate analyses were carried out on all the samples. The mean for parameters determined for wastewater, Well water, Stream and the factory supplied water using standard methods show that the limits set by regulatory guidelines for most of the parameters were exceeded except temperature and the metals which are within the limits. There is therefore the need for the textile industries to engage in an improved environmental management and adopt an environment friendly technology for their production.

Keywords: Wastewater, Textile, Environment, Regulation

INTRODUCTION

Consumers in developed countries are demanding biodegradable and ecologically friendly textiles (Chavan, 2001). Cotton provides an ecologically friendly textile, but more than 50 % of its production process involves the use of reactive dyes. Unfortunately, dyes are unfavourable from an ecological point of view, because the effluents generated are heavily coloured, contain high concentrations of salts and exhibit high value of biological oxygen demand (BOD). Air quality, water quality and solid waste generation are affected greatly by the textile industry and employees of textile mills are also subjected to indoor air quality issues (Hazardous Substance Research Centers/South & Southwest Outreach Program, 2006).

Contaminated air, soil and water by effluents from the industries are associated with heavy disease burden and this could be part of the reasons for the current shorter life expectancy in the less developed countries when compared to the developed nations. Some heavy metals contained in these effluents (either in the free form or adsorbed in suspended solids) from the industries have been found to be carcinogenic (Tamburlini *et al*., 2002), while other chemicals equally present are poisonous depending on the dose and exposure duration (Kupchella and Hyland, 1989). These chemicals are not only poisonous to humans but also found toxic to aquatic life and they may result in food

contamination (Novick, 1999). Ammonia is harmful to fish or other aquatic organisms at free (un – ionized) concentration of 10 – 50 µg/L or higher pH and the sulphide in the effluent are of environmental concern because they can lead to poor air quality of an area if not properly taken care of. It then becomes a threat to human, vegetation and materials. The same is applicable to pH that has been identified to raise health issue if water available for human use is not of the required pH level (WHO, 2009).
Textile industries are major sources of these effluents (Ghoreishi and Haghighi, 2003) due to the nature of their operations which requires high volume of water that eventually results in high wastewater generation. They are one of the largest water users and polluters (Nemerow, 1978). The textile mill in Ikorodu discharges its effluent directly through a hollow tube that perforated the wall of the factory into an artificial lake constructed behind the factory.
However, there is little or no information on the efficiency of the treatment adopted, if any, by the company. This study therefore assessed the physicochemical characteristics of the discharged effluent.

MATERIALS AND METHODS

Description of the study area

This study was carried out in the community (Owode- Ibese) that neighboured an artificial lake of discharged waste water from United Textile Company in Igbogbo Bayeku local council development area in Ikorodu local government in Lagos state, Nigeria. Owode –Ibese is characterized with a permanent foul odour.The factory is located on latitude N6.34.331 E329.244 with an altitude of 2m. The factory covers an area of about 4,583m^2 and started its operations in 1975. It’s major products are cotton fabrics in various form like Ankara and Adire. All wastewater resulting from various processes are been discharged into the artificial lake behind the factory.

Sampling Stations and Sample collection

The sampling points in the map of the study area are presented in Fig.1.Samples were collected from a total of six stations comprising composite samples (from four points A, B, C, D) on the artificial lake, two wells within 300m radius to the lake (W_1 and W_3), two locations at the factory water supply outlet (W_2 and W_4), and lastly from the river downstream of the artificial lake. Temperature and pH of the samples were determined in situ. Samples were preserved according to standard methods relevant for the intended analysis.
Laboratory Analyses
The parameters listed in Table 2 were determined in the samples collected using standard methods.

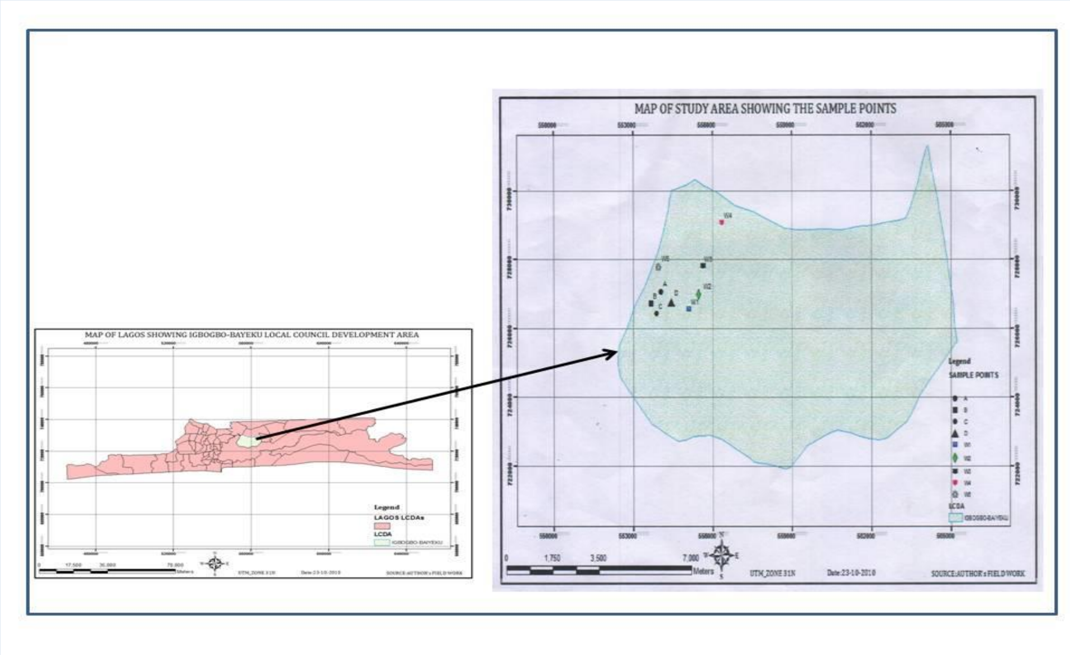

FIGURE 1: MAP OF LAGOS SHOWING IGBOGBO-BAYEKU COUNCIL DEVELOPMENT ARF

Fig. 1. Map of the study area showing the sampling points.

Table 1: The Selected Parameters Determined and Analytical Instruments Used.

Parameter	**Instrument used**	**Method**	**Reference**
Temperature	Mercury in glass Thermometer	Immersion in Sample immediately After sampling	
pH	pH meter	Electrometric	
Turbidity	Turbidity meter	Nephelometric turbidity unit	APHA *et al.*, 2005
Alkalinity/Acidity	pH meter	Titrimetric	
Chloride	Volumetric indicator	Titriimetric	Golterman *et al.*,1978
COD(chemical oxygen demand)	Reflux apparatus	Open reflux	Golterman *et al.*,1978
BOD (biological oxygen demand)	BOD incubator	Winkler, Titrimetric 3days, 27^{o}C	Golterman *et al.*,1978
Heavy metals (Cd, Zn, Mn, Fe, Pb)	Spectrophotometer	Atomic Absorption Flame Spectrometerphotometer (AAS)	Golterman *et al.*,1978

TABLE 2: MEAN VALUE ± SD OF SOME SELECTED PHYSICAL PROPERTIES OF THE SAMPLES

SAMPLES	Mean±SD/ Range	Temp ºC	pH	Turbidity NTU
Wastewater n=4	Mean ±SD	30±0.8165	8.48±0.82	379.5±417.7
	Range	29-31	8.0 ±0.12-9.7±0.34	153-1005
Well water n=2	Mean±SD	29.50±0.71	5.6±0.28	0.52±0.04
	Range	29-30	5.4 ±0.37-5.8±0.52	0.49-0.55
Stream	Mean±SD	31.00±0.365	8.00 ±0.32	9.75±1.65
Factory water n=2	Mean±SD	30.00 ±0.01	7.30±0.14	4.16±1.81
	Range	30.00	7.2±0.25-7.4±0.35	2.88-5.44

TABLE 3: MEAN LEVEL ± SD OF SOME SELECTED CHEMICAL PROPERTIES OF THE SAMPLES

SAMPLES	Mean±SD/ Range	T/acidity (ppm)	T/alkalinity (ppm)	Chloride (ppm)	BOD mg/l	COD ppm
Wastewater n=4	Mean±SD	48.75±1.03	4123.8 ±678.29	50.59±4.47	952.0±469.54	1827.5±574.41
	Range	35-60	3345-4850	46.15-56.80	349.39-1362.07	1190-2465
Well water n=2	Mean±SD	12.5±3.53	85±2.12	21.33±1.00	251.40±56.21	1377.0±216.37
	Range	10-15	70-100	14.26-28.40	211.65-291.15	1224-1530
Stream	Mean±SD	15	41	2.73	49.48	816
Factory water n=2	Mean±SD	17.50±1.06	337.50±3.54	3.12±1.61	47.40±1.30	146.20±81.74
	Range	10-25	335-340	1.98-4.26	38.59-56.56	88.4-204

TABLE 4: MEAN (± SD) METAL CONCENTRATION (mg/l) OF THE WASTEWATER AND WATER SAMPLES.

S/N	SAMPLES	MEAN /RANGE	Cd	Pb	Fe	Mn	Zn
1	Wastewater n=4	Mean±SD	ND	ND	4.41±3.75	0.07±0.05	0.29±0.31
		Range	-	-	2.04-10.00	0.02-0.14	0.04-0.70
2	Well water n=2	Mean±SD	ND	ND	0.25±0.9	0.02±0.02	0.10±0.07
		Range			0.18-0.31	0.00-0.03	0.05-0.15
3	Stream	Mean±SD	ND	ND	0.60	0.02±0.03	ND
						0.00-0.03	
4	Factory water n=2	Mean±SD	ND	ND	0.20±0.28	ND	0.21±0.30
		Range			0.00-0.39		0.00-0.42

DISCUSSION

The results of temperature, pH and turbidity of the various water samples are presented in Table 2. The temperature of the waste water sample ranged from 29-31^{o} and it falls within the Federal Ministry of Environment / National Environmental Standards and Regulations Enforcement Agency (FMENV/ NESREA) limit for effluent discharge. The temperatures for the well, stream and factory water were also within the 29.50 - 31^{o}C. However, elevated temperatures could have significant ecological impact since temperature increase by 3 ^{o}C could increase evaporation rate of wastewaters thereby polluting the air of an area.

The pH of the wastewater ranged from 8.0 – 9.7 with a mean value of 8.48 ± 0.82. This shows that the wastewater is Alkaline. This is slightly above the limits set by NESREA (6-9) for discharged effluents from textile industry. This could change the soil permeability and hence pollute underground resources of water (Rump and Krist, 1992).

The pH of the well water samples is 5.6 ± 0.28 which is indicative of being weakly acidic while the pH value for the stream is 8.00 which is also alkaline but not as alkaline as that of the wastewater. The pH value of the factory supplied water has a mean value of 7.3 ± 0.14 which is very close to being neutral. The values for the alkalinity of the waste water (4123.8 ± 678.29 ppm) and the well water (85 ± 2.12) ppm in Table 3 justified their pH values. The high alkalinity value of the wastewater is in agreement with the results of Juinkins (1982) who reported that the textile wastewaters are highly alkaline. The alkalinity value of the stream is 41ppm and that of the treated water supplied by the factory is unexpectedly high with mean value of (337.50±3.54) ppm. High alkalinity is indicative of the capacity of wastewaters to neutralize acids, and is undesirable.

Solids concentration is another important characteristic of wastewater and could be a major problem as the accumulation of dissolved solids in the effluents pollutes the receiving water streams. Various research groups have tried to develop economically feasible technologies for effective treatment of dye effluents (Karim et al., 2006; Cairne et al., 2004).

The turbidity of the effluent ranged from 153 -1005 NTU (Table 2). The concentration of chloride (50.59±4.47 ppm) of the wastewater in this study is below literature values. The chloride content in the samples well water, stream and factory supplied water are 21.33±1.00, 2.75 and 3.12±1.16 ppm respectively as presented in Table 3. Chloride concentration is higher in wastewater than in other raw water could be due to high concentration of chloride that may be present along the sea coast, because of the possible salt water leakages into the sewage system.

Textile effluents are reported to be high in biological oxygen demand (BOD) due to fibre residues and suspended solids (AEPA, 1998). This explains why the BOD is highest (952±469.54 mg/l) in the wastewater sample followed by 251.40±56.21mg/l for the well water. The stream and the factory water supply have relatively close BOD values of; (49.48) mg/l and (47.40±1.30)mg/l respectively (Table 3).The chemical oxygen demand (COD) of the wastewater and well water are 1827.5±574.41 ppm. and 1377.0±216.37 ppm respectively while the stream has COD value of 816 ppm and the mean COD value for the factory water is 146.20±81.74 ppm (Table 3). The BOD and COD values for the wastewater are above the benchmark for NESREA, BOD; (80) mg/l, and COD; (20) mg/l. Although, the factory claimed to have treated the factory water supplied to the community, the chemical load in terms of COD (146.20±81.74) was higher than NESREA benchmark.

The high levels of BOD are indications of the pollution level of the wastewater. This implies that there could be low oxygen available for living organisms in the wastewater to degrade the organic matter present. High COD level indicates a toxic condition and the presence of biologically resistant organic substances that is susceptible to oxidation by a strong chemical oxidant (Sawyer and McCarty, 1978). The results show that the waste water sample is highly polluted. High BOD and COD produce unaesthetic color, endanger water supplies and decrease recreational value of water ways (Tyagi and Mehra, 1990). These results agree with the report of Kertell and Hill (1982) who reported a high BOD and COD values in the textile effluents. Kumar, (1989) also noted that high BOD and COD values show that the effluents have high oxygen demanding waste which causes the depletion of dissolved oxygen (DO) which is a fundamental requirement for aquatic life.

Heavy metals in the wastewaters could be of negative impact to the environment. The concentrations of (mg/l):Fe (4.41±3.75), Mn(0.07±0.05) and Zn(0.29±0.31), in the waste water sampled were all below the values set by regulatory standards (NESREA, FEPA and WHO) while lead and Cadmium were not detected (Table 4). Sekhar *et al.*(2003) traced heavy metal contamination of an area to industrial effluent. Also the products of reactions between some of the chemicals present in the effluents (Soldan,

2003) may be toxic to the environment and this support the fact that waste minimization is of great importance in decreasing pollution load(Ramesh *et al.*, 2007)
Source reduction of pollutants and effective treatment methods should be embraced by the textile industries to ensure a healthy environment for all concerned.

CONCLUSION

The physicochemical properties and heavy metal content of the textile industry wastewater and the existing water bodies in the area have been determined. The levels of the physicochemical parameters determined in the matrixes show that the effluent from the textile industry is not adequately treated to meet standards set by the regulatory guidelines. However, the heavy metal concentrations are all within the standards. The textile industry should be encouraged to improve on the treatment technology for the waste water been released to the environment.

REFERENCES

(AEPA,(Australian Environmental Protection Authority) 1998. Environmental guidelines for the textile dyeing and finishing industry, State government of Victoria, Melbourne, Victoria, Australia.

APHA (2005). Standard methods for the examination of water and waste water. 21st ed. Amer. Pub. Health Assoc. Inc.Washington D.C.

APHA 1995.Standard methods for the examination of water wastewater. American Water Works Association, Water Environment Federation Edited by Greenberg, A. E. Clesceri L.S., Eaton A. D. (eds)18th edition 1100p.

Carine A., P. Moulin, M. Maisseu, and F. Charbit. 2004. Savings and re-use of salts and water present in dye house effluents. Desalination 162:13-22.

Chavan, R.B. 2001. Environment-friendly dyeing processesfor cotton. Ind. J. Fibre Textile Res. 4:239-242.

Environmental Hazards of the Textile Industry. 2006. Hazardous Substance Research Centers/South & Southwest Outreach Program. *Environmental Update* #24.

Ghoreishi, M. and Haghighi, R. 2003. Chemical catalytic reaction and biological oxidation for treatment of non – biodegradable textile effluent. Chemical Engineering Journal, 95, 163-169

Golterman, H. L., Clymo, R. S. and Ohestad M. A. M.1978. Methods for physical and chemical analysis of freshwaters. IBP Handbook No. 8 , Blackwell Scientific, Oxford.

Jiunkins, R. 1982.Pretreatment of textile waste water. Proc. 37th Industrial waste conference Purdue Uni., Lafayette, Ind., 37: 139

Kertell, C. R. and Hill, G. F. (1982). Textile dye house waste water treatment. Proc. 27th industrial waste conference purdue Univ. Lafayette, Lad, 37:147

Karim, M.M., A.K. Dasa, and S.H. Lee. 2006. Treatment of colored effluent of the textile industry in Bangladesh using zinc chloride treated indigenous activated carbons. Anal. Chim. Acta 576:37-42.

Kumar, A. (1989). Environmental chemistry Wiley Eastern Limited New Delhi India.

Kupchella, C. E.and Hyland, M. C. 1989. Environmental Science : Living within the system of nature, ISBN - 10: 0132827409 637p.

Nemerow, N. L. 1978. Industrial water pollution: Origins, characteristics and treatment, Addison-wesley, ISBN : 0201052466. 738p

Nigerian Industrial Standard (2007) Nigerian standard for drinking water quality, Standard Organization of Nigeria (SON), NIS 554; p 30

Novick, R. 1999. Overview and the health in Europe in the 1990s, World Health Organization, Europe Regional Office, Copenhagen EUR/ICP/EH/CO 02 02 05/6, p20.

Ramesh, B. B., Parande, A. K., Raghu, S. and Prem Kumar, T. 2007. Cotton Textile Processing: Waste Generation and Effluent Treatment. http://journal.cotton.org, © The Cotton Foundation 2007. The Journal of Cotton Science 11:141–153 (2007) 141.

Rump, H. H and Krist K., 1992. Laboratory manual for examination of water, waste water and soil.2nd ed., VCH publishers, New York

Sawyer, C, C. and McCarty, P.L.1978.Chemistry for environmental engineers, McGraw Hill, New York. pp 331-554.

Sekhar, S., Lu, C. T. and Zhang, P., 2003. A unified approach to detection spatial outliers, GeoInformatica 7, 139-166.

Soldan, K. Babara, J. Robinson, A. and Slopecki A. 2003. Bacteria contamination of blood components. Vox Sanguinis, 78: 66-67.

Tamburlini G., Ehrenstein, O. V. and Bertollini R. 2002. Children's health and environment: A Review of evidence, In: Environmental issue report No. 129,WHO/ European Environment Agency, WHO Geneva, p223.

Tyagi, O.D. and Mehra, M. 1990. A textbook of environmental chemistry. Anmol Publications,404p.World Health Organization (WHO 2009), Guidelines for Drinking-water Quality, pp. 454", http://www.who.int/water_sanitation_health/dwq/GDWQ2004web.pdf.

OWSD

2nd AFRICA REGIONAL CONFERENCE 2013

Hosted By the University of Energy and Natural Resources (UENR), Sunyani-Ghana

The era of great inventions and far reaching scientific ideas has its own accompanying devastating effects which has left the world still researching and thinking for commensurate solutions to tackle the problems head on. Researchers all over the world are now saddled with an enormous responsibility of finding practically workable solutions to climate change issues in a manner that will ensure sustainability of the environment. Climate patterns play a fundamental role in shaping natural ecosystem which, invariably influence the human economies and cultures. Nations vary in their ability to cope and adapt to climate change and it is disheartening that Africa has been identified as the most vulnerable to projected climate change impacts based on her widespread poverty which in turn limits her adaptation capabilities, unfortunately women are mostly affected.

It was in the light of this that the Organization of Women in Science for the Developing World (OWSD) organized the 2nd Africa Regional Conference in October, 2013 under the theme " **Climate Change and Its Impact on Africa: The Role of Sciences and Engineering''**. The conference was hosted by the University of Energy and Natural Resources (UENR), Sunyani in the Brong Ahafo Region of Ghana and attended by over 400 scientists, researchers, academicians and practitioners across the sub-Saharan Africa. The conference covered twelve (12) thematic issues in the area of Climate Change and its linkages with i) Biodiversity; ii) Education; iii) Energy; iv) Food Security; v) Gender Mainstreaming; vi) Health Delivery; vii) Legislation and Policy for sustainable Development; viii) Millennium Development Goals; ix) Natural Resource Management; x) Political Instability in Africa; xi) Technology and Climate Change and xii) Water Resources.

The proceedings comprises the scientific papers within the scope of research of the participants. It is full of relevant information on climate change with respect to the above mentioned topical issues which lend special credence to the African terrain. With the rich research experience of the participants coupled with their in-depth analyses of the data, the proceedings have the potential of fostering mitigation and adaptation of the adverse effect of climate change.

KNOWLEDGE INTEGRITY IMPACT

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