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The Role of Ethanolic Leaf Extract of *Ageratum Conyzoides* in Amelioration of Haematological Parameters in Streptozotocin-Nicotinamide Induced Type-ii Diabetic Rats

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Abstract

Diabetes mellitus is a metabolic disorder characterized by disturbances in carbohydrate, protein, and lipid metabolism and by complications like retinopathy, microangiopathy, and nephropathy. Several haematological changes are shown to be directly associated with DM. This study was designed to investigate the haematological indices of ethanolic leaves extract of *Ageratum conyzoides* in streptozotocin induced diabetic wistar rats. Healthy adult male *Wistar* rats were used for the study and diabetes was induced by intraperitoneal injection of 60 mg/kg streptozotocin and divided into Group I: Negative Diabetic control rats received sterile water orally (as vehicle) daily. Group II: Positive Diabetic (DM) control rats received a standard drug, Glibenclamide (0.25 mg/kg) orally. Group III: Diabetic rats (treated group) received 500mg/kg body weight of crude extract of *Ageratum conyzoides* (DM + AC) orally. Daily water and feed intake were recorded. After day 28 treatments, blood was collected for haematological analysis. There was significant difference in the Packed Cell Volume, Red Blood Cell count, White Blood Cell count and Haemoglobin concentration comparing the different groups. Our data showed that, *Ageratum conyziodes* extract increase feed intake, body weight, red blood cells and packed cell volume of diabetic rats similar to what was observed in glibenclamide treated groups, but more effect was observed in the *Ageratum conyzoides* treated group. We conclude that *A. conyzoides* at the dosage of 500mg/kg like glibenclamide, can proffer better results in ameliorating the haematological indices in diabetic rats at cheaper cost.

Key words: Diabetes mellitus, haematological changes, *Ageratum conyzoides,* glibenclamide

INTRODUCTION

Diabetes Mellitus (DM) is a chronic disorder of the endocrine system and characterized by increased blood glucose level resulting from the defects in insulin secretion, action, or both (Irudayaraj *et al.,* 2002). Diabetes mellitus is a worldwide health problem and leads to microvascular and macrovascular complications (Umar *et al.,* 2010). Worldwide, it is expected that about 366 million people are likely to be diabetic by the year 2030 and Nigeria, more than 3.9 million (Lin *et al.,* 2004). Diabetes mellitus is a metabolic disorder characterized by disturbances in carbohydrate, protein, and lipid metabolism and by complications like retinopathy, microangiopathy, and nephropathy. Several haematological changes affecting the red blood cells (RBCs), white blood cells (WBCs), and the coagulation factors are shown to be directly associated with DM (Mbata *et al.,* 2015). Haematological abnormalities reported in the DM patients include RBCs, WBCs, and platelet dysfunction, anaemia, decrease oxygen carrying capacity of RBCs and hypercoagulation (Mirza *et al.,* 2012; Bharathi, 2016).. Interest is currently on amelioration of these effects. *Ageratum conyzoides (AC)* is an herb which grows abundantly throughout Nigeria, and known in folkloric medical practice for treatment of various disease conditions (Palmer *et al.,* 2019). It is a common annual herbaceous weed with long history of traditional medicinal use. *Ageratum conyzoides* preparation is a local herbal remedy can be readily available and cheap for human population. Its efficacy as an antibiotic, anti-inflammatory and analgesic agent have been verified (Palmer *et al.,* 2019). Research in Nigeria showed haematopoietic properties of ethanolic leaf extract of *Ageratum conyzoides* in albino rats. Specifically, a dose dependent increased effects was reported on pack cell volume (PCV), haemoglobin (Hb), RBC count, mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV). In Cameroon and Congo, it is used to treat fever, rheumatism, headache and colic (Bioka *et al.,* 1993); in Kenya it is also employed as an antispasmodic (Achola *et al.,* 1994). The use of this species in traditional medicine is extensive in Brazil as the aqueous extract of leaves or whole plant is utilized to treat colic, cold and fevers, rheumatism, and it is recommended by Brazilian Drugs Central as an antirheumatic (Galati *et al.,* 2001). However, the effect of *A. conyzoides* on haematological indices in streptozotocin-induced diabetic rats have not yet been elucidated. This study therefore aimed to evaluate the ameliorative effects of A. conyzoides on feed consumption rate, body weight gain and haematological parameters in streptozotocin-induced diabetic Wistar rats.

Materials and methods

Plant Collection and Extraction

The test plant, *Ageratum conyzoides* was collected from the University of Abuja environment and sent to the Botanical unit of the Faculty of Science of the University for proper identification. The plant was washed under running tap water, the leaves were then plucked, and allowed to dry at the temperature of 25^0C in a hood without exposure to direct sunlight. The dried leaves were then grounded into fine powder. Cold extraction method was carried following the protocol described by Ejeh *et al.,* (2019). Briefly, the leave powder was soaked with absolute ethanol for 72 h at room temperature with intermittent rigorous shaking using automated shaker. The extract was concentrated in a hot-air oven at 40^0C and stored at 4^oC until time of use.

Experimental Animals

Healthy adult male *Wistar* rats between 2 and 3 months of age and weighing 200-250g were obtained from the Faculty of Veterinary Medicine experimental animal unit and used for this study. The animals were kept according to experimental groups (six (6) members per group) in metal cages in a well-ventilated animal house of the Veterinary Medicine faculty, University of Abuja, Nigeria with a regular controlled light cycle (12 h light/12 h dark). Food (standard commercial pelletized rat feed) with clean tap water was provided *ad libitum.* Our animal experimental protocol received approval from the University of Abuja Ethics Committee on Animal experiments (UAECAU/2019/018) and was conducted according to ethical standard of ARRIVE guidelines, in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 and EU Directive 2010/63/EU for animal experiments.

Induction of non-insulin dependent diabetes mellitus (NIDDM)

Non-insulin dependent diabetes mellitus (NIDDM) was induced following the protocol described by Pellegrino *et al.,* (1998). Briefly, a single intraperitoneal (i.p) injection of 60 mg/kg streptozotocin was administered to each rat and fifteen (15) minutes later, a single i.p injection of nicotinamide at 120 mg/kg was also administered to same rats. Streptozotocin (STZ) was dissolved in citrate buffer (pH 4.5) and nicotinamide dissolved in normal saline. Hyperglycemia was monitored and confirmed by elevation of glucose levels in plasma at 48h, 72h and then 7days post induction. Only rats that are found to have permanent NIDDM were used for the study as diabetic rats.

Experimental design for anti-diabetic study

All diabetic and non-diabetic rats (rats not induced with streptozotocin and nicotinamide) were divided into the following groups of six (6) members per group: Group I: Negative diabetic control rats received sterile water orally (as vehicle) daily for 28 days. Group II: Positive diabetic control rats received a standard drug, Glibenclamide (0.25 mg/kg) orally for 28 days. Group III: diabetic rats (treated group) received 500mg/kg body weight of crude extract of AC orally for 28 days. This dose has been reported to be therapeutic with no toxicological effects (Palmer *et al.,* 2019). Group IV: Non diabetic control rats received sterile water orally (as vehicle) daily for 28 days.

Evaluation of fasting glucose level

Fasting blood glucose levels of each rat in each group was confirmed as described by Pellegrino *et al.,* (1998). Briefly, the tip of the tail of the rat was cut with a sharp scissors and a drop of blood was dropped on the glucose test strip already place in the AccuCheck® glucometer. The readings were taken after the beep sound from the glucometer.

Evaluation of daily body weight

During the experimental period, the rats were weighed daily using a bench-top digital scale (Kerro Ecostar USA, BL-PID/20001 with sensitivity of 0.1g) and the mean change in body weight calculated.

Blood sample collection

Twenty-four hours after the last treatment, blood was drawn from the retro-orbital venous plexus of each animal into EDTA tubes for haematology assay before they were sacrificed by quick cervical method as described by Usende *et al.* (2018a).

Haematology assays

Blood sample collected into EDTA sample tubes was used for the determination of haematological parameters, including red blood cell count, total white blood cell count, and other blood cells and specifically, red blood cell index using standard veterinary automated haemoanalyser (Labomed® ABX Micros ESV 60, USA).

Techniques of Data Analysis

All data obtain from this study was expressed as mean and SEM (Standard Error of the Mean). The significant difference in means between treatment and control groups was determined using one-way analysis of Variance (ANOVA) at P value of 0.05 (Duncan multiple range test as posthoc) using Graph pad prism version 9.

Results

Feed consumption

Feed intake of diabetic and non- diabetic rats was not significantly different ($p>0.05$); Although not significant, there was slight decrease feed intake in DM + NT group compare to diabetic treated group with either Glibencamide or *Ageratum conyzoides* group. However, a constant increase in the feed intake was observed across groups from week 0 to week 4 (Fig. 1).

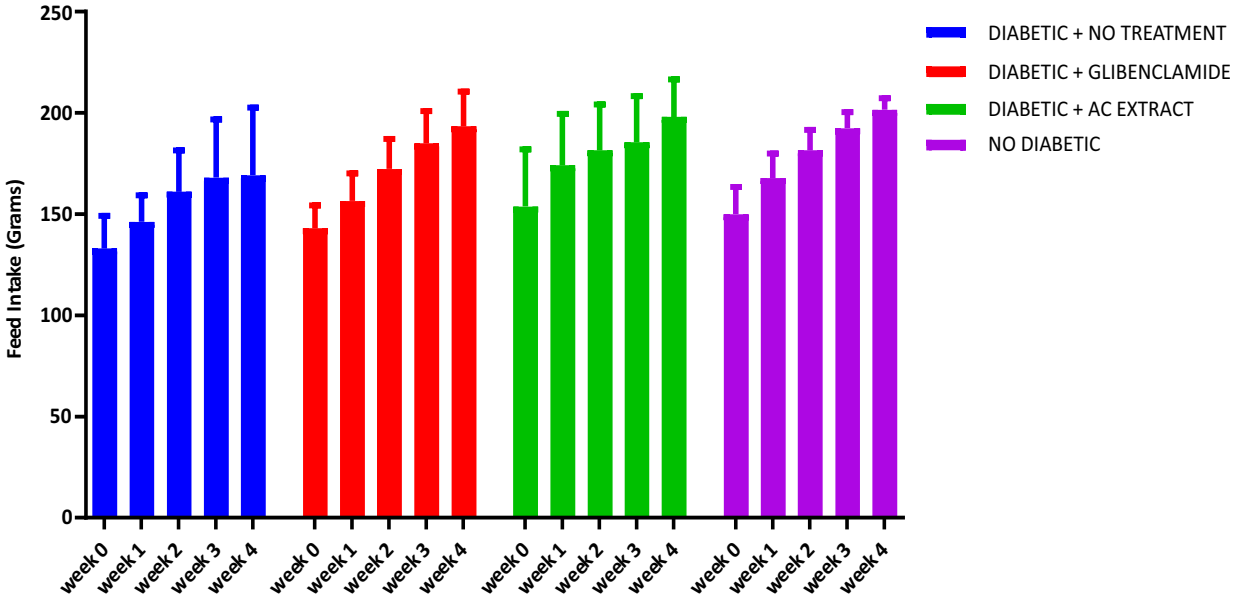

Fig 1: Bar chart showing the weekly feed intake of diabetic groups and non-diabetic group with constant increase in feed intake from induction of DM to week 4 of treatment. No statistically significant difference was noticed.

Body Weight

The body weight of wistar rats in each group were measured weekly and subjected to statistical analysis. There was no significant difference in the weekly body weight of diabetic groups and normoglycaemic rats (Fig. 2). However, there was gradual gap between the DM + NT comparing to other groups (NO DM, DM + GLI and DM + AC) from week 1 all through to week 4 of the study with the DM +NT group having the least weight gain. At week 3 and week 4, there was no difference in body weight of the DM + NT which indicates no weight gain for the week. For the DM + AC treated rats, there was a constant weight gain from week 2 to week 3 with no mean weight loss. Interestingly, The DM +AC group has higher weight compared to the DM +GLI and the NO DM groups (Fig. 2).

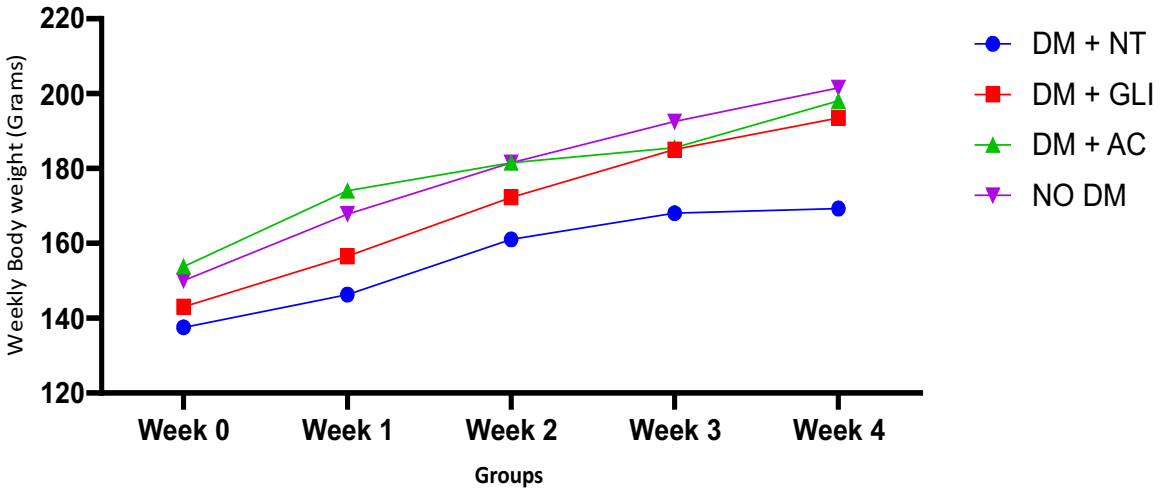

Fig 2: Line graph showing the weekly body weight in gram of the diabetic groups and normoglycaemic group, although not statistically significant but prominent is the DM + NT group with less steeply graph compared with the other groups (NO DM, DM + GLI and DM + AC).

Weekly Glucose Result

Figure 3 showed the weekly glucose level of the diabetic groups and normoglycaemic group, at weeks under study. The Diabetic group has blood glucose level above the 200mg/dl reference range for diabetic patient and the No DM group has a blood glucose level below the 200mg/dl. At week 1, 2, and 3, the Diabetic groups still has blood glucose level above 200mg/dl. At the end of the study at week 4, the DM+GLI and DM+AC had reduced blood glucose level below the 200mg/dl mark indicating an effect of glibenclamide as a standard drug for treatment of Diabetes Mellitus and also AC extract as a potential treatment for DM.

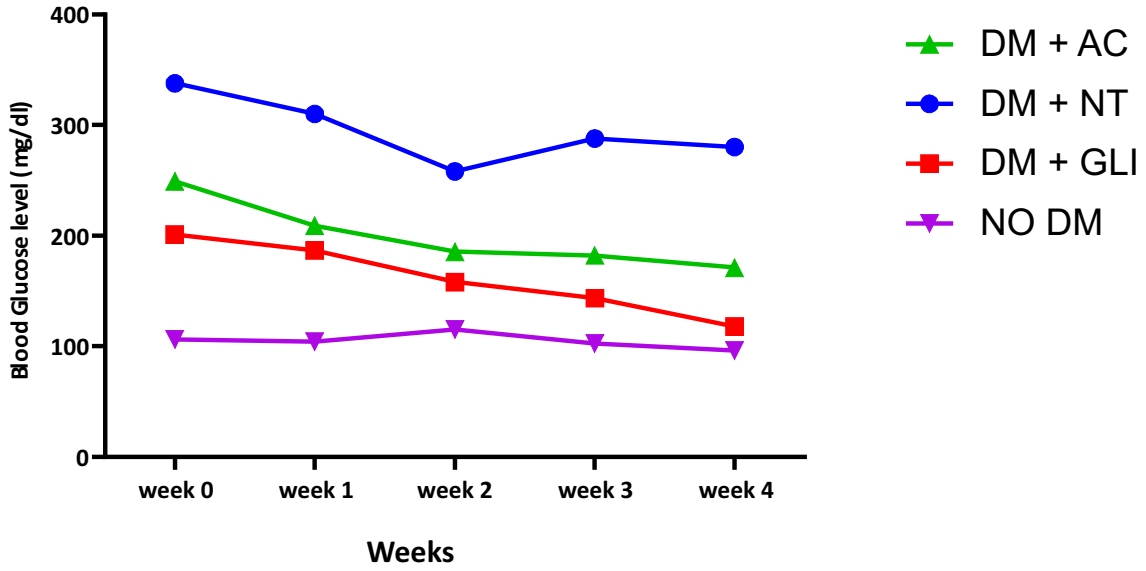

Fig 3: Line graph showing the weekly glucose level of during the period of experimentation

Haematological Results

The haematological parameters were analysed and expressed in mean±SEM per group and multiple comparison inputted as a superscript on the values and shown in table 1. The White blood cell counts was significant when comparing No DM group with DM + NT group ($p>0.05$) with increased white blood cell counts in the Diabetic without treatment group. Although not significant, there is ameliorative effect on the WBC counts in the standard treated groups with glibenclamide for 28 days. The AC extract treated group shows similar trends with the glibenclamide treated group with WBC value lower than the standard drug group.

Also, there was significant difference observed when comparing the RBCs parameter of No DM group with DM + NT group ($p>0.01$), DM + GLI group ($p>0.01$) and DM + AC group ($p>0.01$). Increased RBC count was observed in the Diabetic groups compared to the non-diabetic rat groups especially the DM + NT group. The RBC count of DM + AC was also slightly higher than the RBCs of group treated with standard drug but not significant.

The haemoglobin concentration of No DM with positive diabetic control significantly differs ($p>0.05$) with increase observed in the positive diabetic control group. Glibenclamide or AC extract slightly corrected the haemoglobin concentration observed in the DM + NT group but not significant.

Mean Corpuscular Volume (MCV) is a measure of size of Red Blood Cells during determination of haematological parameter, there was significant difference when No DM was compared with DM + NT ($p>0.05$), DM + GLI ($p>0.05$) and DM + AC ($p>0.05$). The significant difference was due to increased MCV in the No DM group.

Although not significant, there was increased Packed Cell Volume (PCV) in the DM + NT group compared to the other groups. Platelet was also observed to be high in DM +AC group but not significantly relevance.

Parameters	Groups			
	DM + NT	DM+ GLI	DM + AC	No DM
White Blood Cell	26.20±3.26	18.20±0.52	17.35±3.74	12.93±1.55[a]
Red Blood Cell	10.07±0.22	9.75±0.29	9.83±0.27	8.45±0.18[a, b, c]
Haemoglobin	16.98±0.29	16.33±0.57	16.43±0.53	15.13±0.49[a]
PCV	52.75±1.11	50.25±1.60	51.00±1.47	47.50±1.66
MCV	52.48±0.86	51.60±0.61	52.05±0.67	56.28±0.65 [a, b, c]
MCHC	32.10±0.35	32.40±0.18	32.13±0.24	31.75±0.08
Platelets	491.00±99.81	494.5±35.39	580.30±34.77	465.00±16.35
Neutrophil	2.25±0.48	1.25±0.25	4.50±1.85	3.75±0.85
Lymphocytes	85.25±2.49	85.00±0.91	80.00±1.58	63.25±19.11
Eosinophils	0	1.25±0.48	0.25±0.25	0.5±0.29
Basophils	0.25±0.25	0	0	0

Table 1: Table showing the haematological parameters of the diabetic groups (DM + NT, DM + GLI and DM + AC) and no diabetic group (No DM). The result was subjected to statistical analysis with multiple comparison across groups using Tukey as posthoc test. [a] - when No DM significantly differs with DM + NT, [b] – when No DM differs significantly with DM + GLI, [c] – when No DM differs significantly with DM + AC group.

Discussion

It is now well recognized that the abnormal metabolic state that accompanies diabetes is responsible for vascular dysfunction, and these abnormalities may include chronic hyperglycaemia, dyslipidaemia, and insulin resistance (Ferroni *et al.,* 2004). All these factors render arteries susceptible to atherosclerosis, being capable of altering the functional properties of multiple cell types, including endothelium and platelets (Colwell *et al.,* 1983).

In diabetes mellitus, feed intake has been shown to increase in diabetic rats than normoglycaemic rats (Oyedemi *et al.,* 2011) which is a symptom in type 2 diabetes in animal and human model. Interestingly, we observed herein a similar result reported by Oyedemi *et al.,* (2011), with increase in feed intake in diabetic group compare to the normoglycaemic rats which was however not significant. The increased feed intake might be due to availability of excess glucose in the blood

without efficient insulin to store into glycogen, this tricks the diabetic rats into consuming more food. Interestingly *Ageratum conyzoides* or glibenclamide treated groups shows the same trend with the increase feed intake making this plant a good candidate in diabetes treatment.
In checking feed conversion rate, the body weight is very important parameter to consider. In DM + NT, there is slight increase in body weight of the affected individual which has also been observed by Oyedemi *et al.,* (2011) and Cintra *et al,* (2017). Interestingly, there was obvious body weight increase in the *Ageratum conyzoides* or glibenclamide treated groups with better result observed in the *Ageratum conyzoides* treated group, probably due to increase intake.

In diabetes mellitus, the haematological indices are very important as well as the blood glucose level. *Ageratum conyzoides* has been reported by Ita *et al.,* (2007) to have haematopoietic effect on the bone marrow, and our findings reported herein showed a positive correlative effect with significant increase in RBC observed in diabetic rats treated with *Ageratum conyzoides* extract compared to non-diabetic group and diabetic treated with glibenclamide as standard drug. The significant increase in RBC observed might be as a result of the haemopoetic properties of *Ageratum conyzoides* which was also reported by Ita *et al.,* (2007). However, we observed significant increase in RBCs of DM + NT which is unusual and remains to be investigated. We however hypothesized that this could be due to the medication used to indice DM.

A significant increase in WBCs was observed in DM + NT group compared to the No DM group, which is a features of diabetes mellitus and also reported by Colak *et al.,* (2014). In the diabetes group treated with either *Ageratum conyzoides* or glibenclamide, WBCs were reduced close to the No DM group which reflect response to treatment, although, no significant difference occurred between the glibenclamide and the *Ageratum conyzoides* extract treated group. The increase in total leucocytes count in diabetic group might be due to increased lymphocytes count in diabetic rats (Colak *et al.,* 2014). We also reported herein that haemoglobin concentration significantly increases in the positive diabetic control group compared to No DM group similar to earlier report of Al-Ali (2016), and that the packed cell volume (PCV) of *Ageratum conyzoides* treated group have increased PCV but not significant. Similar findings concerning PCV have also been reported by Al-Ali, (2016) with no significant difference in diabetic and non-diabetic groups. However, WBC count and haemoglobin concentration were found to be significantly increased ($p< 0.01$) in diabetic rats than non-diabetic rats (Al-Ali, 2016) in a cross-sectional study in diabetes patients with long period of suffering from diabetes. We report herein similar findings.

In conclusion, *Ageratum conyziodes* extract just like glibenclamide increase feed intake, body weight, red blood cells and packed cell volume of diabetic rats. Interestingly, these effects were better observed in the *Ageratum conyzoides* extract group. Also, the ameliorative properties of *Ageratum conyzoides* was observed more in correcting the increased haemoglobin concentration and the white blood cell in diabetic rats than the glibenclamide treated group. Thus *A. conyzoides* at the dosage of 500mg/kg can proffer better results comparative to glibenclamide in ameliorating the haematological indices in diabetic rats and at a cheaper cost.

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Competing Interests
The authors have no financial or non-financial interests to disclose.

Author Contributions
All authors contributed to study design and conception. Material preparation, data collection and analysis were performed by Usende Ifukibot Levi, Ejeh Sunday Augustine and Mobolaji Abdulateef Ayoola. The first draft of the manuscript was written by Mobolaji Abdulateef and Usende Ifukibot Levi and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. Funding was acquired by Mobolaji Abdulateef

Ethics approval
Animal experiments received ethical acceptance from University of Abuja Ethics Committee for Animal Use (UAECAU/2019/018) and according to ethical standard of ARRIVE guidelines, in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 and EU Directive 2010/63/EU for animal experiments.

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An Assessment of Protracted Criminal Litigation within the Context of the Administration of Criminal Justice Act (ACJA), 2015) in Nigeria.

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Abstract

This project examined the challenges and prospects of the administration of the Criminal Justice System within the context of the ACJA (2015). The work aimed at not just underscoring the issues around protracted criminal litigation in Nigeria, but unearthed the factors responsible with the intention of suggesting probable solutions to them. The study used a mixed-method approach comprising the doctrinal methodology as well as a quantitative descriptive data analysis of opinions elicited from respondents using the purposive sampling technique (this includes Criminal Justice System stakeholders such as the Police, Prisons, Judiciary, Legal Practitioners, and Guardians of Awaiting Trial victims). Findings from the study show that the enactment of the Administration of Criminal Justice Act (ACJA) in 2015 was a significant step toward addressing the challenge of protracted criminal litigation in Nigeria. This is because the ACJA introduced several reforms aimed at expediting criminal trials and ensuring a more efficient and fair justice system. One of the key provisions of the ACJA is the limitation of adjournments to prevent unnecessary delays in court proceedings. It also introduced the concept of continuous trial, which requires courts to hear criminal cases on a day-to-day basis until they are concluded, except in exceptional circumstances. The study also found that the ACJA introduced alternative dispute resolution mechanisms such as plea bargaining, restorative justice, and the use of technology to streamline the criminal justice process. These mechanisms provide avenues for resolving cases more quickly and reducing the backlog of cases in the courts. While the ACJA has made significant strides in addressing protracted criminal litigation, the study discovered that some challenges still exist. Implementation of the Act has been uneven across different jurisdictions, and there is a need for adequate training and capacity building for justice sector actors to fully utilize the provisions of the Act. Furthermore, the dearth of infrastructures, such as inadequate courtrooms and case management systems, continues to hamper the efficient administration of justice. Amongst others, the work recommends that it is essential for draftsmen to reassess the Act and address the identified shortcomings. Conducting a comprehensive review and harmonization of the ACJA with other relevant laws is necessary to rectify inconsistencies and promote a cohesive and efficient criminal justice system.

Keywords: Justice, Criminal Litigation, Criminal Procedure, ACJA, Awaiting Trial

INTRODUCTION

Study Background

Before enacting the Administration of Criminal Justice Act (ACJA) in 2015, criminal administration in Nigeria hinged on two distinct procedures; the Criminal Procedure Act in the South and the Criminal Procedure in the North, and the Administration of Justice Commission Act. Hence the prosecution and management of criminal offences in Nigeria were not codified as the southern and northern regions have different procedures for prosecuting criminal cases. Thus, the Administration of Criminal Justice Act (ACJA) was not only revolutionary, but its essence is also to ensure a unified, efficient, speedy process of criminal administration in Nigeria's judicial process.

The Administration of Criminal Justice Act (ACJA), 2015, seeks to ameliorate the Institutional challenges of criminal administration procedures in Nigeria. ACJA is centered on improving the institutional networks that would observe and enforce the principle of human dignity. It seeks to eliminate inhumane practices in criminal prosecution in the Nigerian justice system. The proper implementation of ACJA would reduce the obnoxious practices of arbitrary arrests and human rights abuse. The Act introduced a justice system in the interest of a just and fair trial and protects the rights of the suspect/accused, defendant, and victim of crime (ACJA, 2015).

Accordingly, Section [1] of the ACJA explicitly explains the focus of the Act hence: "The purpose of this Act is to ensure that the system of administration of criminal justice in Nigeria promotes efficient management of criminal justice institutions, speedy dispensation of justice, protection of the society from crime and protection of the rights and interests of the suspect, the defendant, and the victim" (ACJA, 2015).

Thus, the Administration of Criminal Justice (ACJA) was not only revolutionary, but its essence is also to ensure a unified, efficient, and speedy process of criminal administration of justice in Nigeria and the judicial process. Section [7] states, "A person shall not be arrested in place of a suspect". This provision outlaws the despicable practices of Nigerian law enforcement agencies. The above provision seeks to promote human rights and dignity, within criminal prosecution procedures. Furthermore, section [396] sub-section (4&5) states that "Where the day-to-day trial is impracticable after arraignment, no party shall be entitled to more than five adjournments from arraignment to final judgment provided that the interval between each adjournment shall not exceed 14 working days (ACJA, 2015). "Where it is impracticable to conclude a criminal proceeding after the parties have exhausted their five adjournments each, the interval between one adjournment to another shall not exceed seven days inclusive of weekends" (ACJA, 2015). The above sections provide that prosecution and adjournment of criminals shall be executed promptly and quickly. The question of whether speedy compliance with the legal instruments governing criminal administration in Nigeria is significant occupies the nub of this research project.

Statement of the Problem

Despite the noble intent and provisions of the Administration of Criminal Justice Act (ACJA, 2015), the institutional process of Criminal prosecution in Nigeria remains systematically disorganized. The challenges the ACT aims to redress remain the Criminal Justice System (CJS) norms. The constitution and law prohibit arbitrary arrest and detention which is a significant factor in the proliferation of awaiting-trial inmates. In some cases, Nigerian law enforcement agencies arrest and detain suspects, despite not having enough evidence to prosecute the case and plea for the court to reprimand suspects. The growing recognition influenced the provision of the section, which mandated that the chief justice of each state or any magistrate assigned by the chief judge, shall conduct monthly inspections and audit of police stations and other places of detention including Correctional Facilities, and may also inspect records of arrests.

Consequently, the Nigerian correctional service is filled with inmates who are victims of the felonious criminal justice system. On the 9th of April 2020 the head of the Nigerian correctional service, Mr. Ja'afaru Ahmed, said that a total number of 51,983 inmates are awaiting trial out of the prison's total population of 73, 726 inmates. Therefore, about 70 per cent of the total population in Nigerian prisons is awaiting trial (Prison Insider, 2020). The project will query the institutional impediments and hindrances against the compliance of the Administration of Criminal Justice Act, 2015. It will be quite particular with the searchlight beamed on the protracted cases of victims awaiting trial in the country This is the ultimate preoccupation of this research project.

Research Questions

This study will provide answers to the following research questions:

I. What is the extent of implementation of the Administration of Criminal Justice Act in Nigeria?
ii. What are the factors that have led to protracted cases of criminal litigations in Nigeria?
iii. What are the possible policy/legal solutions to the cases of protracted criminal litigations under the Act?

Aim and Objectives

This research aims to appraise protracted criminal litigations within the context of the Administration of Criminal Justice Act (2015). The work desires to achieve the following specific objectives:

i. Appraise the extent of the implementation of the Administration of Criminal Justice Act in Nigeria;
ii. Examine the factors that have led to protracted cases of criminal litigations in Nigeria;
iii. Suggest possible policy/legal solutions to the cases of protracted criminal litigations under the Act.

Literature Review

Several empirical studies on the Nigerian Criminal Justice System have been reviewed for ease of clarification, and contribution to the body of knowledge. Within the intent of underscoring the existing gap, they are presented thus. In a study by Ukwayi and Okpa (2017) entitled "Critical Assessment of Nigeria Criminal Justice System and the Perennial Problem of Awaiting Trial in Port Harcourt Maximum Prison, Rivers State", it was affirmed that the essence of incarceration is for correctional purposes, however, the ineffectiveness of the Nigeria Criminal Justice System (NCJS) has denied most suspects the privilege of enjoying these correctional privileges. This study critically appraised the Nigerian criminal justice system and the problem of awaiting trial in Port Harcourt Maximum Prison, Rivers State.

Findings from the study indicated that rigidity of the penal law, holding charges, and delay in the disposal of cases by the agencies of NCJS has contributed to the problem of awaiting trial in Port Harcourt Maximum Prison, Rivers State, Nigeria. The study suggested that there should be more professional commitment, on the part of stakeholders, to check the rise in awaiting trial problems in Port Harcourt Maximum Prison.

Additionally, an article by Olubiyi and Okoeguale (2016) accentuated the fact that given the journey thus far in the Criminal Justice System (CJS) in Nigeria which culminated in the enactment of the Administration of Criminal Justice Act (ACJA), 2015, it has become imperative to take stock of the gains as well as highlight the shortcomings of the Act. The paper which had sought to espouse the

innovations in the Act and point out the challenges the new provisions would pose for the system examined the innovative provisions of the ACJA as well as those that seek to cure the mischiefs that had bedevilled the Nigerian Criminal Justice system for over a century under the Criminal Procedure Act and the Criminal Procedure Code. The research found that despite the prospects of the ACJA, certain provisions undermine its lofty aim of promoting efficient management of criminal justice and affording justice to all.

There are also challenges in the implementation of the Act. It, therefore, suggests solutions to these challenges. The paper concludes on the note that despite these setbacks, the ACJA is important to improving the Nigerian criminal justice system therefore all States of the Federation should enact it in their jurisdiction for the benefit of all citizens.

Olonisakin, Ogunleye, and Adebayo (2016) also argued that in the wake of seemingly normalized criminality and its unabated wave in Nigeria and the need for concerted efforts to understand its pervasiveness, there is a seeming connection between the Nigeria criminal justice system (CJS) and criminal behaviour control. In their paper, the effectiveness of the CJS was analyzed as an instrument of social justice and criminal behaviour control. From the point of view of some social-psychological theories and concepts, the paper submitted that the lack of credibility on the part of the communicators, the Nigeria CJS (i.e. the police, lawyers, judges, and the prisons), in their administration of justice and the laws have been responsible for an avalanche of social injustice, lack of discipline and lawlessness in Nigeria and Nigerians.

They also opined that the Nigeria CJS, who constitutes the supposed custodians of the laws, is largely indicted, therefore responsible for the ineffectiveness of the system in criminal behaviour control. The paper concludes that once the image of the Nigeria CJS is rebuilt, through positive behavioural change, for its actors to be accepted as legitimate and credible instruments in ensuring compliance with the law, it then becomes easy to control criminal behaviours among Nigerians as Nigeria CJS actors are significant models for social influence and behavioural change.

Given all of the above scholarly submissions, there is an obvious gap in the analysis of the role of key stakeholders in ensuring that injustice is not occasioned through the continued delay in the administration of criminal justice in the country. The gap opens a vista for the conversation to be continued via this research as an institutional mechanism for eschewing the pillage of criminal cases and pretrial detainees would be prescribed through the auditing and documentation of evidence surrounding the litigation process in criminal cases in the country.

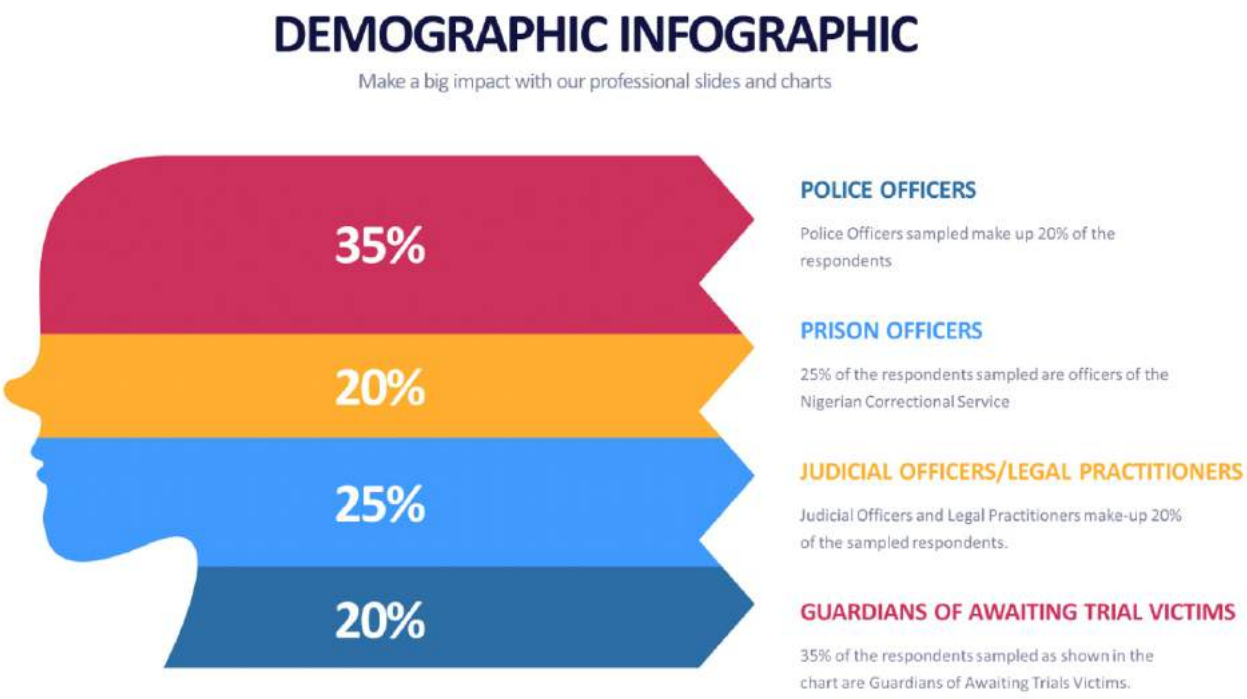
METHODOLOGY

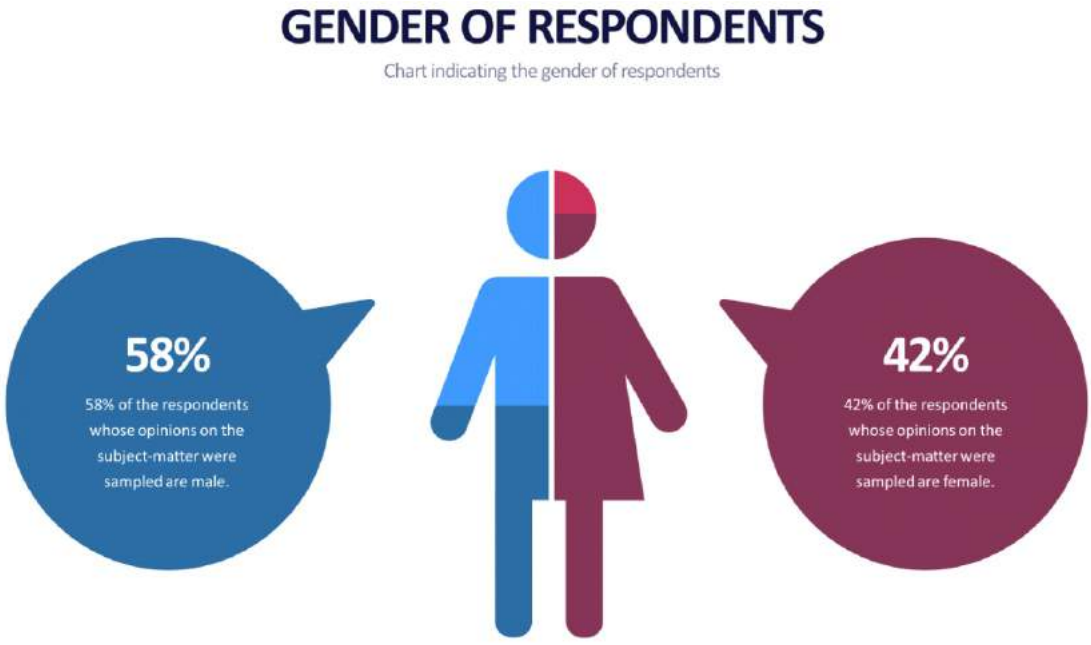
The project adopts a mixed method which includes the doctrinal approach and qualitative-descriptive analysis of the issues around the subject matter. Beyond desk review of the themes as expressed in the research questions, data will be collected from legal and paralegal stakeholders in the Administration of Criminal Justice Act. Specifically, the Police, Judiciary, Prison Officers, Legal Practitioners, and Guardians of Awaiting Trial Victims will be purposively sampled. The instruments for data collection will include interviews and the distribution of questionnaires on the factors that have led to the protractions of criminal litigations in Nigeria within the context of the Administration of Criminal Justice Act (2015). The two research instruments will be designed using the themes in the research questions to adequately measure the variables contained therein. Findings from the work will be

presented descriptively using charts and figures. They are presented in themes which resonates with the research questions presented. The findings from the field are triangulated with extant regulations and laws on the Administration of Criminal Justice Act.

DATA PRESENTATION, ANALYSIS, AND DISCUSSIONS OF FINDINGS

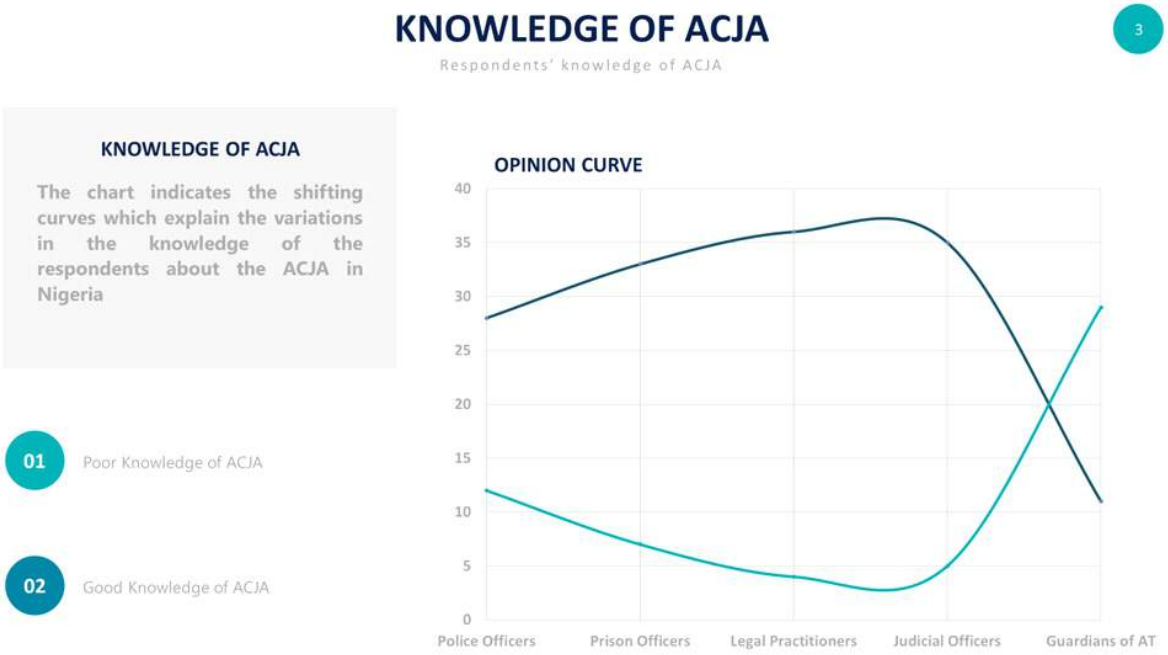
Demography of Respondents





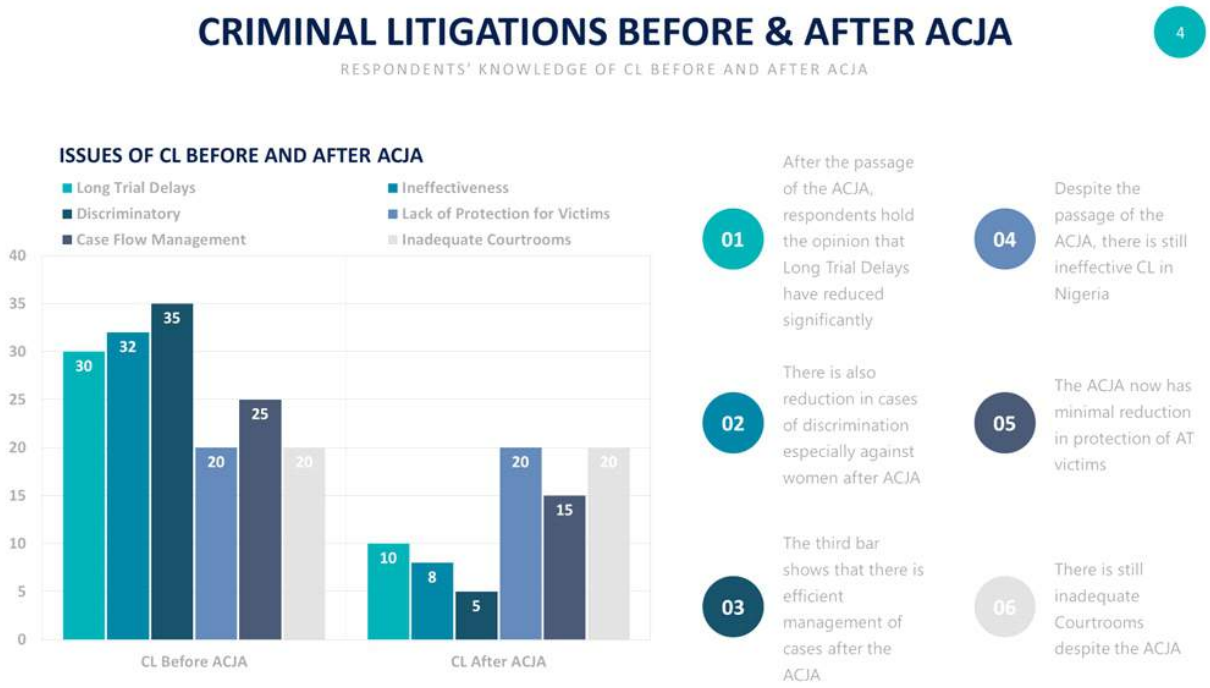
In the past, Nigeria's criminal procedure was governed by two separate laws: The Criminal Procedure Act for the South and the Criminal Procedure Code for the North, including the Federal Capital Territory Abuja. The universal goal of the criminal justice system is to uphold law, peace, and order in society. It recognizes that human behaviour is constantly evolving and, therefore, the criminal justice system must be adaptable and proactive to effectively address the unique behaviours of its citizens. Over time, societal changes, technological challenges, and the lack of reform rendered certain provisions in both the Criminal Procedure Act and the Criminal Procedure Code inadequate in meeting the evolving needs of Nigeria's criminal justice system. Consequently, trials experienced significant delays, courts became congested, and numerous offenders were able to evade justice. As a result, public trust in the criminal justice system was severely diminished.

To address these issues and align with the changing landscape of anti-social behaviours and crimes, and meet the measure of the global required best practices, the Administration of Criminal Justice Act/Law was enacted. This legislation aims to bridge the gap, regulate and effectively manage criminal activities in the country. By implementing the Administration of Criminal Justice Act/Law, the objective is to enhance the efficiency, fairness, and effectiveness of Nigeria's criminal justice system.



The Overview of the Criminal Procedure Laws Before and After ACJA

Before the enactment of the Administration of Criminal Justice Act (ACJA) in 2015, the criminal procedure laws in Nigeria were governed by several different statutes, including the Criminal Procedure Act (CPA), the Criminal Procedure Code (CPC), and the Administration of Justice Commission Act. These statutes were enacted at different times and in different parts of the country, and they often contained conflicting provisions. This made it difficult to ensure that criminal cases were handled consistently and fairly.



Implications of the Old Laws on Criminal Litigation

The old criminal procedure laws, except the ACJL of Lagos, had several negative implications for justice delivery in Nigeria. These included:

1. ***Long trial delays:*** The old laws did not contain any provisions for speedy trials, and this led to long delays in the resolution of criminal cases. This was a major problem for defendants, who often spent years in pretrial detention awaiting trial. There are cases where the courts appeared to deprecate or chide protracted litigations. Some of these cases, as noted by Shima & Aboho, lasted for five, seven, or even up to fourteen years. In *Atejioye v. Ayeni*, for instance, the case lasted for fourteen (14) years. This length of delay sadly has pernicious consequences on the body of evidence, the parties, and the court's memory, amongst other things.

2. ***Ineffective pretrial detention system:*** The old laws did not provide adequate safeguards for defendants who were detained pretrial. This led to several abuses, including overcrowding, poor conditions, and lack of access to legal representation.

3. ***Discrimination against women:*** The old laws contained several provisions that discriminated against women, including the requirement that women obtain the consent of their husbands before they could travel abroad.

4. ***Lack of protection for victims of crime:*** The old laws did not provide adequate protection for victims of crime. This made it difficult for victims to access justice and to receive compensation for their injuries.

Recent Laws on Criminal Litigation in Nigeria that have been inspired by ACJA

a. ***The Nigeria Police Force (Establishment) Act, 2020:***

The Nigeria Police Force (Establishment) Act, 2020, enacted on September 17, 2020, replaced the Police Act of 2004 and introduced significant improvements and novel provisions. The overarching

aim of the new Act is to establish an effective police service based on principles of accountability, transparency, protection of human rights, and collaboration with other security agencies. This part of the study examines the key enhancements and novel provisions brought about by the Nigeria Police Force (Establishment) Act 2020.

b. ***The Nigeria Correctional Service Act, 2019***

The Nigeria Correctional Service Act 2019, enacted on August 14, 2019, brought about significant changes to the management and administration of correctional facilities in Nigeria. Formerly known as the Nigeria Prisons Service, the Nigeria Correctional Service is a government institution responsible for supporting the criminal justice system and ensuring public security through the reformation, rehabilitation, and reintegration of individuals who have violated criminal laws. The Act was passed to facilitate comprehensive reforms within the correctional system.

The objective of the service now is Rehabilitation, Reformation, and Reintegration, and accordingly, the service is structured to meet up with these realities. These laudable objectives, as encapsulated in Section 2 of the Act, direct and guides the Correctional Service to inter alia:

(a) Ensure compliance with international human rights standards and good correctional practices;
(b) Provide an enabling platform for the implementation of non-custodial measures;
(c) Enhance the focus on corrections and promotion of reformation, rehabilitation, and reintegration of offenders and,
(d) Establish institutional, systematic, and sustainable mechanisms to address the high number of persons awaiting trial.

Overview of the ACJA, 2015

The Administration of Criminal Justice Act 2015 (ACJA) is currently one of the most prominent and influential laws in Nigeria. Its widespread applicability and revolutionary nature make it highly relevant and valuable for both legal professionals and non-lawyers.

Enacted in May 2015, the ACJA is a comprehensive law consisting of 495 sections divided into 49 parts. It primarily focuses on the administration of criminal justice and related matters within the Federal Capital Territory and other Federal Courts in Nigeria. The introduction of this law establishes a unique and unified framework applicable to all federal courts and offenses governed by Federal Legislation. It replaces the former Criminal Procedure Act applied in the South, the Criminal Procedure (Northern states) Code applied in the North, and the Administration of Justice Commission Act.

By merging key provisions from these two primary criminal justice legislations in Nigeria, namely the CPA and CPC, the ACJA preserves existing criminal procedures while simultaneously introducing new measures to enhance the efficiency of the justice system and address the observed gaps that have accumulated over several decades.

The ACJA has been hailed as a long-awaited revolution in the criminal justice arena. The preceding criminal justice system had lost its ability to respond swiftly to societal needs, effectively combat the increasing waves of crime, expedite the process of bringing criminals to justice, and adequately protect crime victims.

Section 1 of the ACJA explicitly articulates the Act's purpose thus:

> …to ensure that the administration of criminal justice in Nigeria promotes efficient management of criminal justice institutions, an expeditious dispensation of justice, protection of society from crime, and safeguarding the rights and interests of suspects, defendants, and victims.

One notable characteristic of the ACJA is its paradigm shift from a punitive approach to criminal justice to one that emphasizes restorative justice. This new approach places significant emphasis on addressing the needs of society, prioritizing the rights of victims and vulnerable individuals, and upholding human dignity as a core principle. Throughout the Act, there is a clear focus on human dignity, evident from the adoption of the term "defendant" instead of "accused," provisions for humane treatment during arrest, numerous measures to facilitate speedy trials, alternatives to conventional sentencing such as suspended sentencing, community service, parole, compensation to victims of crime, and more.

Succinctly, the Administration of Criminal Justice Act 2015 marks a significant and transformative milestone in Nigeria's criminal justice system. Its comprehensive provisions aim to establish an efficient and responsive system that promptly addresses societal needs, tackles rising crime rates, ensures the swift prosecution of criminals, and protects the rights of suspects, defendants, and victims.

Causes of Protracted Criminal Litigations in Nigeria

1. The Problem of Case Flow Management

The primary objective of Case flow Management is to ensure a fair and prompt resolution for every case presented before the court. The court's processes must be transparent, efficient, comprehensible, and accessible to all. Case flow management processes play a crucial role in achieving these objectives while also improving the working environment for court personnel and serving the interests of the public (Alabi, 2004).

Each judge bears the responsibility of effectively managing the cases assigned to them to prevent congestion within their court. However, in some jurisdictions, rapid influxes of new cases can lead to unavoidable congestion. Nevertheless, even under such circumstances, it becomes evident whether a judge is diligent or lax in their work (Agbonika, 2014). A judge with low output may allow pending cases to accumulate despite not necessarily being overwhelmed with an excessive caseload. Some judges may be slow in their written work, engage in unnecessary arguments with counsel during hearings, or struggle to maintain prolonged focus. These factors, among others, hinder the expeditious processing of criminal trials.

2. Inadequate Courtrooms and Infrastructure facilities;

The delay in court proceedings caused by inadequate courtrooms and infrastructure facilities, as well as poor working conditions, is a significant challenge in the justice system. These issues contribute to the adjournment of trials and the prolonged resolution of cases. Several factors according to Agbonika (2014) contribute to this problem:

i. Non-arrival of accused persons: Trials are often delayed because accused persons, who are remanded in prison custody, either arrive late or do not appear in court on the scheduled dates. This is primarily due to the lack of readily available vehicles to transport the accused to court. The unavailability of transportation leads to delays and disruptions in court proceedings.

ii. **Inadequate infrastructural facilities**: Many courts, especially at the Magistrate level, lack sufficient infrastructure to effectively carry out their functions. For example, the absence of well-equipped library facilities hampers the prompt discharge of judicial findings. This results in long adjournments during trials when there is a need to write well-considered rulings. The lack of necessary infrastructure contributes to delays in case proceedings.

iii. Insufficient courtrooms: Some states suffer from a shortage of courtrooms, forcing multiple judicial officers to share the available facilities. As a result, individual magistrates may only be able to sit for a few hours each day instead of the expected six hours. This leads to unnecessary adjournments of criminal cases, which could have been resolved within a shorter period if adequate courtrooms were available. Sharing courtrooms among multiple judges negatively affects the quick dispensation of justice.

iv. Lack of staff quarters: Judicial officers, including judges and magistrates, often face delays and inconvenience due to the failure to promptly allocate them official staff quarters. Some of these officers choose not to reside in rural areas, where their duty posts are located, resulting in time wasted on commuting between their residences and the courts. Traveling long distances daily significantly hampers the efficient use of human resources.

v. Shortage of judicial personnel: Some states experience a shortage of judicial personnel, including magistrates. As a result, these magistrates have to sit in multiple courts throughout the day, leading to frequent adjournments of cases listed before them. The scarcity of judicial personnel exacerbates delays in court proceedings and affects the timely resolution of cases.

3. Long Adjournment of Cases

Protracted criminal litigation in Nigeria is also caused by the long adjournment of cases by our courts. There are cases that have been adjourned for months and years. In the case of *Ndu v. The State*, the proceedings were plagued with numerous adjournments, often requested by the defense counsel. These adjournments were sought for various reasons, including non-payment of fees, ill health, attempts to secure witnesses, and the need to travel outside the jurisdiction. Many of these reasons were deemed frivolous. The accused subsequently appealed, claiming that they were not granted a fair hearing. In his judgment, Honourable Justice Obaseki expressed his dissatisfaction with the lackadaisical attitude displayed by the defense counsel. He remarked that the defense counsel had shown a reluctance to proceed with the defense since the prosecutor closed their case. The frequent applications for adjournment were described as both sickening and unbecoming for a counsel tasked with defending an individual accused of murder.

4. Paucity and Transfer of Other Judicial Officers

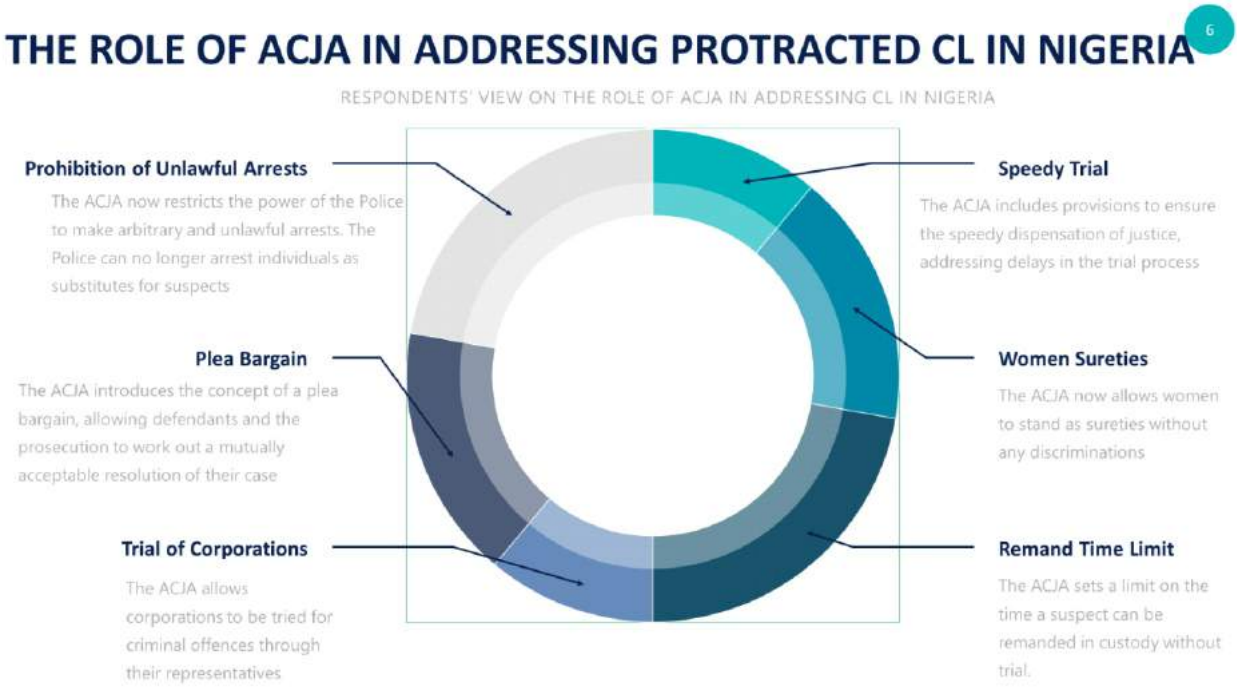
The Nigerian Police Force operates under a federal structure, allowing officers to be transferred anywhere in the country at any time. This frequently leads to a shortage of officers in rural and semi-urban areas and disrupts ongoing investigations and court cases. When officers are transferred, it often causes delays in trials as new officers need to familiarize themselves with the cases or transferring officers face difficulties in attending court proceedings. These delays undermine the administration of justice and erode public trust. To address this issue, better systems for managing transfers, improved coordination between stations, and adequate officer numbers in remote areas are needed. Training and professionalism should be emphasized to mitigate the impact of transfers (Akanbi, 1996).

5. The problem from the Correctional Service

The issue of delay in the administration of criminal justice is further compounded by the actions of prison authorities, particularly pretrial detention. In some cases, individuals accused of crimes are held in prison while awaiting their trial. Due to the prevalence of deviancy and criminality in society, the number of pretrial detainees has significantly increased.

It is concerning that a substantial number of suspects, particularly those involved in armed robbery and culpable homicide cases, remain in prison custody awaiting their trial. The common justification for their continued detention is that investigations into their cases are still ongoing. However, what is particularly troubling is that some of these accused persons have been in prison for more than five years without their trial taking place.

This situation raises serious concerns about the rights of the accused, as prolonged pretrial detention can infringe upon the principle of "innocent until proven guilty." It also highlights a systemic issue within the criminal justice system, where delays in completing investigations and conducting trials contribute to the prolonged incarceration of individuals who have not yet been convicted. There is the issue of prison congestion.



The Role of ACJA in Addressing Protracted Criminal Litigation in Nigeria

These are some provisions of the Administration of Criminal Justice Act (ACJA) in Nigeria that have brought significant changes to the criminal justice system:

1. Prohibition of Unlawful Arrests:

The ACJA restricts the power of the police to make arbitrary arrests. Previously, the police could arrest individuals without a warrant if they had no apparent means of sustenance or could not give a satisfactory account of themselves. This provision was often abused, leading to indiscriminate arrests. However, under the ACJA, the police can no longer arrest individuals as substitutes for suspects. The Act also ensures that suspects are notified of the cause of their arrest and are treated with dignity. The Act has also outlawed the arrest of persons for civil wrongs. A provision that was not available in the old criminal procedure laws.

2. Plea Bargain:

The ACJA introduces the concept of plea bargaining, which allows defendants and the prosecution to work out a mutually acceptable resolution of the case. This may involve the defendant pleading guilty to a lesser offense in exchange for a lighter sentence. Plea bargaining helps expedite the legal process, saving time and resources that would otherwise be spent on a trial.

3. Trial of Corporations:

Previously, corporations were shielded from criminal liability because criminal charges required proof of both mens rea (criminal intent) and actus reus (criminal Act), which were difficult to attribute to corporate entities. However, the ACJA allows corporations to be tried for criminal offenses through their representatives. This provision holds corporations accountable for their actions and treats them as adult defendants.

4. Suspended Sentence and Community Service:
In line with its reformative and restorative approach, the ACJA allows courts to suspend a convict's sentence, particularly for simple offenses that do not involve the use of weapons or exceed a three-year imprisonment term. The court may impose conditions for the suspension or sentence the convict to community service. These measures aim to reduce prison congestion, rehabilitate offenders through productive work, and prevent them from mixing with hardened criminals.

5. Speedy Trial:
The ACJA includes provisions to ensure the speedy dispensation of justice, addressing delays in the trial process:

a. Stay of Proceedings: Applications for a stay of proceedings in criminal matters are no longer permitted. This prevents delays caused by interlocutory applications to stay proceedings pending appeals on preliminary matters.

b. Day-to-Day Trial: Upon arraignment, the trial proceeds from day to day until its conclusion. If the day-to-day trial is not feasible, the Act allows only five adjournments for each party, with intervals between adjournments not exceeding two weeks. If the trial is still not concluded, the interval for adjournments is reduced to seven days each.

c. Assignment of Information and Notice of Trial: The Chief Judge is required to assign filed information to courts within fifteen days. The assigned judge must issue a notice of trial within ten working days.

d. Objection to Validity of Charge: Any objections raised by the defendant regarding the validity of the charge or information are considered alongside the substantive issues and ruled upon at the time of delivering the judgment.

6. Women Sureties:
The ACJA ensures that women cannot be denied the right to stand surety for a bail applicant solely based on their gender. This provision has been widely praised.

7. Electronic Recording of Confessional Statements:
To address issues surrounding denial or alleged coercion in confessional statements, the ACJA allows for the use of electronic recording methods, such as video compact discs, to capture confessions. This aims to make the process more reliable and reduce the need for lengthy trial-within-trial proceedings.

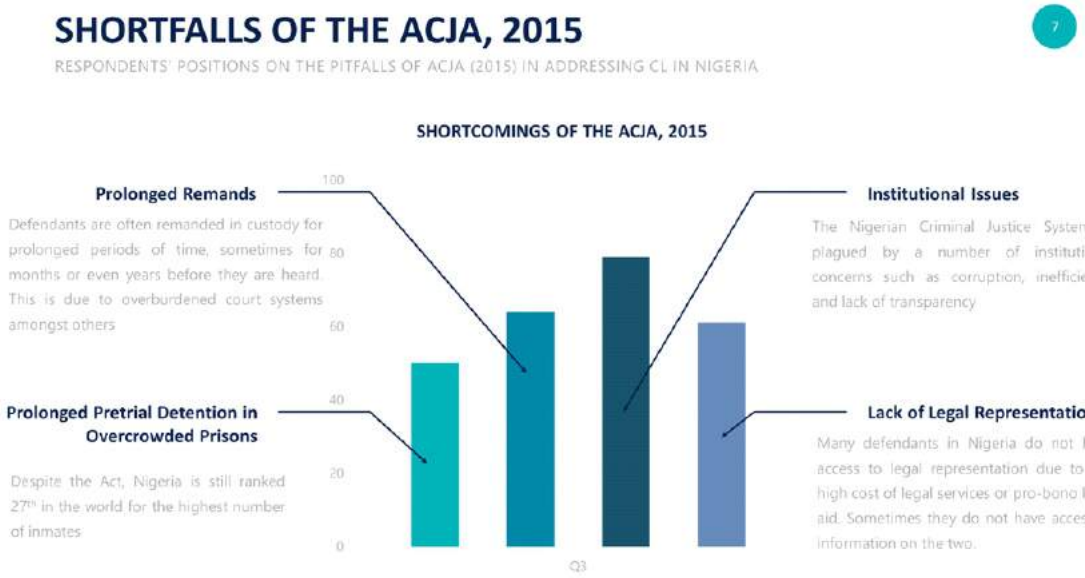
8. Prosecution of Offences: An Exclusive Job of Lawyers:
Section 106 of the ACJA stipulates that the prosecution of cases is exclusively reserved for lawyers, removing the authority of police personnel who are not lawyers to prosecute. This provision aims to prevent mismanagement of cases in court due to inadequate prosecution.

9. Remand Time Limit:
The ACJA sets a limit on the time a suspect can be remanded in Custody without trial. Initially, a suspect can be remanded for a maximum of 14 days, renewable for another 14 days upon showing "good cause." If legal advice is not issued by that point, the court will inquire into the matter and consider the release of the suspect.

10. Compensation to Victims of Crime:
The ACJA empowers the court to award compensation to victims of crime when the defendant is found guilty. This provision allows for the court to order the convict to pay compensation to the injured party, a purchaser affected by the offense, or for medical expenses incurred by a victim.

This section also by extension, overrules the Supreme Court decision in FRN v Osahon (2006) 5 NWLR (Pt. 973).

Conclusively, the ACJA is seen as a progressive and timely law that aims to address shortcomings in Nigeria's criminal justice system. However, successful implementation remains a challenge, as is often the case with laws in Nigeria. The hope is that the ACJA will be effectively implemented to achieve the desired goals of improving the justice system in the country.



Shortfalls of ACJA in Addressing Protracted Criminal Litigation in Nigeria

1. ***The Continuation of the Culture of Prolonged Pretrial Detention and Overcrowded Prisons***

Despite the Act, Nigeria is still ranked 27th in the world for the highest number of inmates. There were 74,059 inmates as of January 31, 2023, as reported by World Prison Report (Marcus, 2023). That is to say, about 51,939 inmates accounting for 69.4% of the Nigerian Prison Population, are awaiting trial. According to the Open Justice Society Initiative, about 70 percent of detainees are in pretrial Custody, and one-fifth of them have been held for over a year. Studies show that it is not uncommon for those accused of capital offenses to spend over ten years in pretrial detention (Open Justice Society Initiative, 2023). NULAI corroborated this when they noted recently that about 75% of the inmates in Custody are pretrial detainees.

Dr. Nasiru Mukhtar, ED of NULAI, noted at a workshop organized in Nassarawa State on Pretrial Detention in Nigeria on May 12, 2023, when he explained that:

> What I mean by 75% is that for every 100 people in the correctional center, 75% of them are pretrial detainees. This means that their cases have not been decided, nor have they been convicted. Only 25 percent fall under those convicted (Amos, 2023:3).

2. ***Prolonged Remands:***

Defendants are often remanded in Custody for prolonged periods, sometimes for months or even years before their cases are heard. This is due to several factors, including the overburdened court system, the lack of adequate detention facilities, and the high cost of bail. Prolonged remands can

have several negative consequences for defendants, including the loss of their jobs, the disruption of their families, and the risk of physical and psychological harm (Justina, 2019).

3. ***Institutional Issues:***
The Nigerian criminal justice system is plagued by several institutional issues, including corruption, inefficiency, and a lack of transparency. These issues make it difficult to implement the ACJA effectively and to ensure that defendants are treated fairly (Justina, 2019).

4. ***Lack of Legal Representation:***
Many defendants in Nigeria do not have access to legal representation. This is due to the high cost of legal services and the lack of legal aid. Defendants who do not have legal representation are at a significant disadvantage in the criminal justice system. They may not be able to understand their rights, they may not be able to present a strong defense, and they may be more likely to be convicted. The issue of lack of legal representation continues even with the schemes adopted by ACJA.

5. Poor Implementation Level:
The ACJA has been implemented inconsistently across Nigeria. This is due to several factors, including the lack of training for judges, prosecutors, and other criminal justice officials, the lack of resources, and the political will to implement the ACJA effectively.

The problems associated with the implementation of the ACJA have some negative consequences for defendants, the criminal justice system, and society as a whole. These problems need to be addressed to ensure that the ACJA is implemented effectively and that defendants are treated fairly. Imagine having states in Nigeria who have not domesticated ACJA not to talk of implementation.

Summary of Findings
Arising from the position of extant literature and the discovery made from desk research on the subject, this study observed the following:
1. The Nigerian criminal justice system is plagued by a high occurrence of protracted criminal litigations, resulting in significant delays and inefficiencies. These delays can be attributed to a range of factors, including administrative challenges, limited resources, and procedural complexities. Consequently, there is a backlog of cases in the courts, leading to prolonged waiting periods for justice and a denial of justice for both the accused and the victims involved.
2. Despite the provisions of the ACJA, its effective implementation has faced a plethora of obstacles and challenges. Limited awareness and understanding of the Act among legal practitioners, law enforcement agencies, and judicial officers have hindered its full realization and effectiveness. The Inconsistent application of the Act's provisions across different jurisdictions raises concerns regarding the uniformity and effectiveness of the Act in achieving its intended goals. The variations in interpretation and implementation of the Act's provisions can lead to disparities in how criminal cases are handled and resolved in different regions, undermining the fairness and integrity of the criminal justice system as a whole.
3. The ACJA in its hurried enactment by the legislature, has led to certain gaps and inconsistencies within the Act. One such example is the clash between sections of the ACJA and other existing laws. For instance, Section 106 of the ACJA conflicts with Section 23 of the Police Act regarding who can institute criminal proceedings in the case of a police officer. The ACJA does not make provisions for police officers to institute criminal proceedings, while the Police Act does. This discrepancy creates confusion and ambiguity in the application of the law, potentially leading to inconsistent practices and interpretations across different jurisdictions.

Conclusion

The study assessed protracted criminal litigations in Nigeria within the context of the Administration of Criminal Justice Act (ACJA). It brought to revelation several challenges and areas that call for improvements. The ACJA, with its progressive provisions and emphasis on restorative justice and human dignity, presents a framework that can address these challenges. However, the effective implementation of the Act remains a critical factor in achieving its intended objective. it is crucial to address the inconsistent application of the ACJA's provisions across different jurisdictions. Harmonization of the Act with other relevant laws should be undertaken to ensure uniformity and clarity in its implementation. This will promote fairness and integrity in the criminal justice system, regardless of the region or jurisdiction. Addressing the challenges of prolonged criminal litigations in Nigeria requires a comprehensive and multi-faceted approach. By focusing on capacity building, coordination, harmonization, and monitoring, the criminal justice system can be transformed to ensure timely and fair dispensation of justice, uphold human dignity, and restore public confidence in the administration of justice in Nigeria.

Recommendations

Arising from the foregoing, the study makes the following recommendations:

1. The protracted nature of criminal cases has rendered the legal process an arduous task. To expedite the resolution of cases, this study recommends the active implementation of case management strategies by both judges and legal practitioners within the criminal justice system. This can be achieved by establishing a reliable system for tracking and monitoring the progress of cases at every stage of the process. Moreover, a system for prioritizing cases based on their severity and urgency should be developed. Such an approach ensures that cases involving serious offenses or vulnerable victims are given higher priority, while minor or non-violent offenses are handled expeditiously. Furthermore, better coordination and collaboration among stakeholders involved in the criminal justice system should be fostered. Regular communication and sharing of information

between prosecutors, defense attorneys, law enforcement agencies, and other relevant parties should be encouraged to streamline case progression. These measures would not only expedite the resolution of cases but would also enhance the efficiency and effectiveness of the criminal justice system. By adopting a proactive approach, the criminal justice system can overcome the challenges posed by lengthy and protracted criminal cases and ensure that justice is served swiftly and effectively.

2. To address the difficulties encountered in the effective implementation of the ACJA and ensure its consistency in application across jurisdictions, the study suggests the implementation of a comprehensive awareness program for legal practitioners, law agencies, and judicial officers on the requirements and provisions of the ACJA concerning existing laws. This will enhance their understanding of which sections or portions of the ACJA to apply effectively. Additionally, encouraging collaborations among legal practitioners across jurisdictions can help identify efficient practices that can be replicated in other jurisdictions, resulting in improved implementation of the ACJA overall.

1. Indeed, while the ACJA introduces daring innovations aimed at expediting the dispensation of justice, it is essential for draftsmen to reassess the Act and address the identified shortcomings. Conducting a comprehensive review and harmonization of the ACJA with other relevant laws is necessary to rectify inconsistencies and promote a cohesive and efficient criminal justice system. By undertaking this review, conflicting provisions can be identified and resolved, ensuring that the ACJA aligns with existing legislation and maintains clarity and consistency. This harmonization process will contribute to enhancing the effectiveness of the Nigerian legal system, resulting in a more streamlined approach to criminal proceedings. Ultimately, the objective should be to create a robust and comprehensive legal framework that upholds the principles of justice, fairness, and efficiency. Through continuous evaluation and improvement of the ACJA, Nigeria can enhance its criminal justice system and ensure that it meets the evolving needs and challenges of society.

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TABLE OF STATUTES

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A Novel Technique for Determining Handedness in Primary School Children in FCT Abuja, Nigeria.

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Abstract

Handedness is the tendency to be more skilled and comfortable using one hand instead of the other for tasks such as writing and throwing objects. Society expects that most people should be right-handed but some are not. About 10-12.2% of Nigerians are left-handed. In certain cultures, people think that it is abnormal to be left-handed. It is therefore important to identify lefthanders in the population, support them and devise some methods of minimizing wrong social perceptions on the issue. A Descriptive Cross-sectional survey was utilized in this study. The population of this study were 190 primary school children between the ages of 5 -12 years selected from both a public and private school in Gwagwalada, Abuja after securing parental consent. Data was collected via direct observation and with the aid of a short questionnaire survey. The participants' pattern of "arm crossing", "hand clasping" and "feet crossing" were observed. Their hand preferences for performing certain tasks as well as the time they spent writing or drawing with both hands were recorded. There was a significant relationship between the pattern of "Feet crossing" and the handedness of the participants. This shows that "Feet crossing" can be used to determine handedness. However, the test showed a low specificity despite exhibiting a high sensitivity. No significant relationship was found between the pattern of "Arm crossing" and "Hand crossing" and the handedness of the participants. Reported hand preference was an actual indicator of the subjectively perceived handedness of the participants.

Key Words: Handedness, Children, Technique, Determining

INTRODUCTION

1.1 Background to the Study

Handedness is the tendency to be more skilled and comfortable using one hand instead of the other for tasks such as writing and throwing objects. An individual can be left-handed, right-handed or ambidextrous (if he/she can use both hands to perform said tasks). Researchers have shown that the determination of handedness in an individual is influenced by an interplay between genes and the external environment the individual is exposed to while growing up.

1.2 Statement of the Problem

Society expects that most people should be right-handed but some are not. About 10-12.2% of Nigerians are left-handed (Iyiola *et. Al.*, 2015; Oremosu et al, 2011). In certain cultures, people think that it is abnormal to be left-handed. It is therefore important to identify lefthanders in the population (optimally at an early stage in development), support them and devise some methods of minimizing wrong social perceptions on the issue.

1.3 Research Questions

1. Can a simple technique be used to ascertain handedness in a given subject?
2. Can a questionnaire survey determine handedness?

1.4 Research Objectives

1. To establish a new and easy technique for determining handedness.
2. To show that a questionnaire can be used to determine handedness.

1.5 Research Hypothesis (stated as null)

1. A simple technique cannot be used to determine handedness in a given subject.
2. A questionnaire survey cannot be used to determine handedness in a given subject.

1.6 Significance of the Study

A quick and easy technique to determine handedness will help those who are left-handed to overcome the psychological challenges associated with left-handedness and help to educate the community and advocate for them to be accepted as being normal or a variant of normal. The technique will help parents to ascertain the handedness of their children at an early stage, thereby making it easy for their children undergo a normal development.

1.7 Literature Review

1.7.1 Conceptual Issues

Ogah I. et al. (2012) showed that there was a correlation between the degrees of lateral preference for hand clasping and arm folding.

Tran U. S. et al. (2014) worked on two large Middle-European samples and found that right-handedness was associated with right hand clasping and left arm crossing while left and mixed –handedness with left hand clasping and right arm folding.

Looking at the work done by Marian A. (1972) & McManus et al (1992), it is expected that a combination of observation of hand clasping, arm folding and questionnaire survey should sufficient to determine handedness.

1.7.2 Theoretical Review

Marian Annett (1972) propounded the Right Shift theory which postulates that a hypothetical RS+ gene develops the motor cortex and speech processing systems of the left side of the brain, leading to a preference for the right side of the body – a "right shift". The RS- gene which is the other form is found in left-handers and is indifferent to the direction of both language and motor dominance.

McManus I. C. & Bryden M. P. (1992) propounded the Dextral/Chance theory which postulates that a "dextral" allele – D, which favors right-handedness and the control of speech towards the left cerebral hemisphere. An alternate gene "chance" allele – C, is presumed directionally neutral. The theory posits that DD genotype gives rise to right-handers, CC genotype gives rise to a random combination 50% right-handers & 50% left-handers, while the heterozygotic DC genotype produces 75% right-handers and 25% left-handers.

1.7.3 Theoretical Framework

Handedness can be seen as a phenotype, which means that its existence is dependent on a number of genes or more accurately, an interplay between some genes and the external environment. It's possible that the external environment in this case can have a greater influence than the gene.

A combination of the various methods outlined in this novel technique (hand clasping pattern, arms folding pattern and leg crossing pattern) coupled with the simple questionnaire survey (hand preference for writing, throwing objects, eating, brushing teeth, sharpening pencil) should be able to predict handedness in subject with all other factors being favorable.

1.7.4 Empirical Review

Koller, U. K. (2007) attempted to create and validate a test for measuring the handedness of pre-school children. The new test consists of 14 activities for checking different aspects of hand preference and was administered to 120 children from Vienna with ages ranging from 4 – 6.5 years. The handedness of the children in the study was assessed by administering a questionnaire to their parents, observing the hand they used while drawing and testing their visual-motor skills & level pf development with the aid of Viennese Development Test (WET, Kastner-Koller & Deimann, 2002). The test proved to be reliable (α=0.97).

Olfield, R. C. (1971). Published the Edinburgh Handedness Inventory which can be used by an observer assessing the subject or by the subject self-reporting hand preference. In this inventory, participants are given a list of tasks with adjacent columns labelled "left" and "right". They are expected to insert a "+" or "++" depending on either the left or right column or on both columns in response to the hand preference for the activity.

Veale J. F. (2013). Published a revised version of the Edinburgh Handedness Inventory dubbed "Edinburgh Handedness Inventory – Short form". It consisted of just 4 items – Writing, throwing, Toothbrush & Spoon and also boasted of brief and simpler instructions as compared to the original inventory.

Methodology

2.1 Research Design

This research utilized a descriptive, cross-sectional, questionnaire-based study design.

2.2 Population of the Study

The population of this study were primary school children between the ages of 5 -12 years. This population was chosen because, the study will be more beneficial to them if their handedness is discovered at this early stage.

2.3 Sample of the Study

All consenting children attending primary schools located in Abuja. Sample size was determined by using the following formula:

$$N = \frac{Z\alpha^2 pq}{d^2}$$

N = Sample size
$Z\alpha = 1.96$

p = Prevalence of left-handedness in the population – 12.2% (Iyiola et al.)
q = 1 – p
d = degree of precision (0.05)

$$N = \frac{1.96^2 \times 0.122 \times 0.878}{0.05^2}$$

N = 164 + 16 (for non-response) = 180 individuals
N is rounded up to **200 individuals**

2.4 Sources of Data

Data was collected from school children with the support of their school authority and their parents. It was collected during school visits or during PTA meetings. Observation data, along with the Questionnaire survey were collected.

2.5 Methods of Data Collection

1. Observation method
2. Short Questionnaire survey

2.6 Techniques of Data Analysis

Data was analyzed using Microsoft Excel and SPSS. This was done for each specific objective (1-2)

Results

A total of 190 primary school students participated in this study, 85 (44.7%) of the study participants were female while 105 (55.3%) were male. Participants ethnicity indicate that 18.5% were Yoruba, 23.3% Hausa, 15.3% were Igbo, 1.1% were Gbagyi and other tribes accounted for 41.8% of the study participants as shown in Table 1 below. Concerning the parent handedness, 175 (92.6%) of the participants had fathers that were right-handed while 179 (94.7%) had mothers who were right-handed as shown in Table 1 below.

Table 1: General characteristics respondents

Biodata	Frequency (percentage)
Sex	
Female	85 (44.7)
Male	105 (55.3)
Ethnicity	
Yoruba	35 (18.5)
Hausa	44 (23.3)
Igbo	29 (15.3)
Gbagyi	2 (1.1)
Others	79 (41.8)
Handedness of father	
Right	175 (92.6)
Left	11 (5.8)
Don't know	3 (1.6)
Handedness of Mother	
Right	179 (94.7)
Left	6 (3.2)
Don't know	4 (2.1)

The youngest participant was 5 years old while the oldest was 15 years old. The primary school level of participants ranged from Primary 1 to Primary 5 as shown in the table 2 below.

Table 2: Age and primary school distribution of respondents

	Range	Mean	Std. Deviation
Age	5-15	9.65	2.015
Primary School Class	1-5	3.79	0.920

Objective 1

In naturally performed tasks, 95 (50.6%) participants had their left forearm overlapping right forearm. When clasping their hands together, 102 (54.5%) participants had their left thumb overlapping right thumb while 148 (79.1%) had their right foot overlapping left foot while crossing their feet.

Table 3: Patterns of observed naturally performed tasks

Observed task	Right Overlap left (%)	Left overlap Right (%)
Crossing of Arms	92(49.2)	95(50.8)
Clasping of Hands	85(45.5)	102(54.5)
Crossing of Feet	148(79.1)	39(20.9)

The relationship between the different patterns of naturally performed tasks such as "Arm Crossing", "Hand clasping" and "Foot Crossing" were compared to the handedness of the participants to find a relationship. These relationships are demonstrated in tables 4-6 below. The tasks – "Arm crossing" and "Hand clasping" showed no significant relationship with the handedness of the participants but "Foot crossing" demonstrated a significant relationship with the handedness of the participants.

Table 4: Relationship between the pattern of "Arm crossing" and handedness of the participant

	Actual handedness				
Arm crossing pattern	Right (%)	Left (%)	Total	chi	p-value
"Right arm overlapping left arm" pattern	86(93.5)	6(6.5)	92		
"Left arm overlapping right arm" pattern	86(90.5)	9(9.5)	95	0.552	0.457

Table 5: Relationship between the pattern of "Hand Clasping" and handedness of the participant

	Actual handedness				
Hand clasping pattern	Right(%)	Left(%)	Total	chi	p-value
"Right hand overlapping left arm" pattern	80(94.1)	5(5.9)	85	0.966	0.326
"Left hand overlapping Right hand" pattern	92(90.2)	10(9.8)	102		

Table 6: Relationship between the pattern of "Feet Crossing" and handedness of the participant

	Actual handedness				
Feet crossing pattern	Right (%)	Left (%)	Total	chi	p-value
"Right foot overlapping left foot" pattern	140(94.6)	8(5.4)	148		
"Left foot overlapping Right foot" pattern	32(82.1)	7(17.9)	39	6.582	0.01

Since there was a significant relationship between the pattern of "Foot crossing" and the handedness of the participant. The validity of this pattern as a measure for handedness was ascertained. This test showed a high sensitivity but a low specificity with an accuracy of 98.6% as shown in Table 7 below.

Table 7: Validity of using the Pattern of "Crossed Feet" as a proxy for determining handedness.

	Cross Foot	[95 Confidence Interval]	
Prevalence Pr. (C)	79.00	73	84.7
Sensitivity Pr. (+C)	94.60	89.6	97.6
Specificity Pr. (-N)	17.90	7.54	33.5
ROC area (Sens. + Spec.)/2	0.563	0.499	0.626
Accuracy	78.6%		

The average time spent by the participants to write down a certain block of characters and trace the dots of an incomplete circle are represented in Table 8.

Table 8: Time spent writing with both the left and right hand and number of dots traced on the circle.

	Minimum	Maximum	Total	Mean	Std. Deviation
Time spent writing with Right Hand	5.17	57.00	2986.46	15.8854	7.41594
Time spent writing with Left Hand	10.00	107.00	7127.78	37.9137	14.87747
Trace this circle with RIGHT hand	0	8	622	3.31	1.333
Trace this circle with LEFT Hand	0	8	534	2.84	1.311

Objective 2

By using a questionnaire to assess hand preference, it was observed that 173 (92.5%) participants ate with their right hand, 171 (91.4%) responded that they wrote with their right hand, 162 (86.6%) brushed their teeth with their right hand, 152 (81.3%) threw objects with their right hand and 151 (80.7%) kicked a football with their right foot as shown in Table 9 below.

Table 9: Participant hand preference in performing everyday activities

Everyday activity	Right (%)	Left (%)	Both (%)
Preferred hand to eat	173(92.5)	5(2.7)	9(4.8)
Preferred hand to write	171(91.4)	15(8)	1(0.5)
Preferred hand to brush	162(86.6)	14(7.5)	11(5.9)
Preferred hand to throw	152(81.3)	18(9.6)	17(9.1)
Preferred foot to kick	151(80.7)	20(10.7)	16(8.6)

As shown in Table 10 below, the relationship between the reported hand preference and the handedness of the participant was analyzed. The low p value ($p<0.0001$) indicate a significant relationship. This implies that, reported hand preference can be used in determining the actual handedness of the child.

Table 10: Hand preference and Actual hand edness

	Actual handedness				
Hand preference	Right (%)	Left (%)	Total	chi	p-value
Right	165(97.6)	4(2.4)	169		
Left	1(9.1)	10(90.9)	11	110.13	<0.0001
Both	6(85.7)	1(14.3)	7		
Total	172	15	187		

In Table 11, the validity of reported hand preference as a tool for determining handedness was examined. The sensitivity of the reported hand preference is 97.6% while specificity is 90.9% with accuracy of 97.2% this shows that it has good ability in determining the handedness of a child.

Table 11: Validity o f using reported hand preference for daily routine activities as a proxy for determining handedness

	Hand preference for daily activities	[95 Confidence Interval]	
Prevalence Pr (B)	94.00	89	96.9
Sensitivity Pr (+B)	97.60	94.1	99.4
Specificity Pr(-N)	90.90	58.7	99.8
Accuracy	97.2%		

The relationship between the handedness of the parents and the handedness of the participants were compared as shown in Table 12 and 13. There was no significant relationship observed between the handedness of the parents and that of the child.

Table 12: Relationship between handedness of Father and handedness of participant

	Actual				
father	Right (%)	Left (%)	Total	chi	p-value
Right	161(92.5)	13(7.5)	174		
Left	9(81.8)	2(18.2)	11	1.88	0.39
Don't	2(100)	0(0)	2		

Table 13: Relationship between handedness of Mother and handedness of participant

	Actual				
mother	Right (%)	Left (%)	Total	chi	p-value
Right	163(91.6)	15(8.4)	178		
Left	6(100)	0(0)	6	0.916	0.633
Don't	3(100)	0(0)	3		

Discussion

The participants in this study were selected from Primary school levels of 1-5, the majority of them are males and the Hausa ethnic group had more representation. The majority of the parent of the participants were right-handed. A greater part of the participants was right-handed and this was in tandem with the trend previously reported in the works of Iyiola et al., on the "prevalence of Left-handedness in Nigeria" (Iyiola et al., 2015) and the works of Ademola *et. al.* on the "prevalence of left-handedness among medical students in University of Lagos" (Ademola et al., 2011).

No significant relationship was found between the pattern of "Arm crossing" and "Hand crossing" and the handedness of the participants. This is similar to the results gotten by Ogah et al. in 2012 (Ogah et al., 2012) and by Forrai & Bankovi in 1969 while examining children of Hungarian descent (Forrai & Bánkövi, 1969). Lutz also reported a similar finding earlier on (Lutz, 1908). However, Tran et al. reported a relationship between certain patterns of "Arm crossing", "Hand clasping" and handedness (Tran et al., 2014).

There was a significant relationship between the pattern of "Feet crossing" and the handedness of the participants. This shows that "Feet crossing" can be used to determine handedness. However, the test showed a low specificity despite exhibiting a high sensitivity. A study conducted by Eligar in India and published in 2011, also reported a similar finding and showed a correlation between "foot overlapping" and handedness among the participants observed (Eligar, 2011).

Hand preference was an actual indicator of the subjectively perceived handedness of the participants. This corresponds with the findings of Koller et al., that hand preference tests can be used to predict handedness in children (Koller *et al*., 2007).

The handedness of the mother or father of the participant was a poor predictor for the handedness of the participant as they had no significant relationships when compared to the actual handedness. This is similar to the result obtained by Shugaba et al., where the "relation between the handedness of first-degree relatives and footballers" were compared (Shugaba et al., 2013).

Conclusion

Self-reported hand preference for performing certain tasks and pattern of "feet crossing" are good indicators of handedness in primary school children in Abuja. Patterns of "hand clasping" and "arm crossing" did not prove to be good indicators for determining handedness. This implies that self-reported hand preference questionnaire and pattern of "feet crossing" can be used as tools for determine handedness in children. Further studies are needed to understand why pattern of "feet crossing" is a good indicator of handedness in children.

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Assessment of Climate Smart Farming System in Federal Capital Territory (FCT) Abuja

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Abstract

Climate-Smart Agriculture (CSA) is one key agricultural development approach aimed at sustainably increasing productivity. Worldwide emphasis has been placed on designing approaches with regard to the needs of sustainable development. This study entails the assessment of Climate Smart Farming System (CSFS) in the Federal Capital Territory (FCT) Abuja. Data was collected using an informed questionnaire to determine the extent of farmers' adoption of Climate Smart Farming System in Gwagwalada (GWA), Kwali (KWA) and Abuja Municipal (AMAC) Area Councils in the Federal Capital Territory (FCT) Abuja. The result showed that a large proportion of respondents (82%) did not know about Climate Change although about 94.7% of them noticed changes in rainfall pattern and rise in temperature over a long period. All these farmers (94.7%) were not aware of most of the CSFS practices and so, adoption of Climate Smart practices is very low (5.3%) in these areas. Farmers, due to changes in temperature and rainfall, made changes to their farming systems by practicing crop rotation, early planting, mixed cropping, planting of trees, cover cropping to mitigate the effects. Sustainable agriculture will require a wider societal change towards appreciating the balance between agriculture and environmental change. Based on these findings, it is recommended that efforts such as sensitization campaigns, training and supportive programs on Climate-Smart Agriculture (CSA) be made to encourage farmers in the study area to adopt Climate Smart agricultural practices as a whole.

Keywords: Climate, Smart Farming System, Climate Smart Agriculture, Abuja

INTRODUCTION

Climate change refers to long term shifts in temperature and weather patterns which could be natural or human activities driven. Climate change can result to an increase in global temperature, causing sea levels to rise and change the amount and pattern of precipitation and an expansion of subtropical deserts (Oyerinde *et al*., 2013). Other effects of the warming includes more frequent occurrence of extreme weather events including heat waves, droughts heavy rainfall, species extinctions due to shifting temperature regimes and changes in crop yields (Oyerinde *et al*., 2013).

Climate-Smart Agriculture (CSA) is one key agricultural development approach aimed at sustainably increasing productivity. Climate Smart Agriculture (CSA) appeared as a concept on the policy agenda in 2009 and comes from an increased concern within the global development community in general. FAO in particular emphasized issues regarding the impacts of Climate Change on global food security, in combination with a steadily growing population, urbanization and consumption growth trends (FAO, 2013). The definition of CSA, as agreed upon by many international institutions such as the UN, IFAD, the World Bank and CGIAR, is that it integrates the three dimensions of sustainable development (i.e. economic, social and environmental) by jointly addressing food security as well as climate challenges and is as such composed of three main pillars or goals namely:

i. Sustainability in increasing agricultural productivity to support equitable increases in incomes, food security and development;
ii. Adapting and building resilience to Climate Change from the farm to national levels;
iii. Reducing and/or removing greenhouse gases emissions (GHG), where possible.

In order to make agriculture more productive and sustainable, the FAO has suggested five interconnected principles for the transition towards sustainable food and agriculture (FAO, 2010). They have the ambition to balance the social, economic and environmental dimensions of sustainability in agriculture, and provide a basis for developing policies, strategies, regulations and incentives to guide the transition to sustainability, while promoting resilience through an adaptive response to shocks and impact on crop productivity (FAO, 2010). Agriculture is significantly affected by temperature variability and changes in the other climatic factors all over the world including Nigeria (Oyerinde *et al*., 2013, 2014). Farmers are feeling the worst impacts of Climate Change on crop production, return on investment and sustainable livelihood (Oyerinde *et al*., 2013, 2014). All stakeholders in crop production must ensure nutritious food for all, through increasing production up to 60% in 2050 (Alexandratos and Bruinsma, 2012), while fighting changes in climate in the world. Climate resilience improvement is in common use nowadays to inform crop management options. In view of the current and future Climate Change and variability, interest among researchers to apply such technique is increasing to strengthen the climate resilience in crops of hot and dry areas (Ullah *et al*., 2017). Climate resilience is quite a resemblance to vulnerability and commonly defined as “the ability to bounce back after an external shock or stress”. Resilience of a system can also be illustrated through its components (Ahmad *et al*., 2018; Chuixiang and Nathan, 2021).

Agriculture system is affected by extreme weather events associated with Climate Change, therefore adaptive measures are needed to mitigate the negative impacts of Climate Change. The recent study was designed to x ray impact of Climate Change by bringing about Climate Smart practices for sustaining the productivity of crop and animal in the Federal Capital Territory, Abuja, Nigeria. This research focused on assessing the Climate Smart Farming System such as climate resilience method of land preparation, planting and other farm practices. Therefore, the aim of the research is to establish the impact of Climate Change on farming within the FCT, Abuja system at Federal Capital Territory (FCT), Abuja

2.0 MATERIALS AND METHODS

2.1 Description of Study Area

The study was carried out in the Federal Capital Territory, Nigeria. The Federal Capital Territory (FCT) is lying between Latitude 8.25° and 9.20° North of the equator and Longitude 6.45° and 7.39° East of Greenwich Meridian. The FCT has a landmass of approximately 7,315 km², of which the central city occupies 275.3 km^2. It is situated within the Savannah region with moderate climatic conditions (Ishaya and Hassan, 2013). It is under climate classification features classified as a tropical wet and dry climate, it experiences three weather conditions annually. This includes a warm, humid rainy season and a blistering dry season. In between the two, there is a brief interlude of harmattan occasioned by the northeast trade wind, with the main feature of dust haze and dryness. The rainy season begins from April and ends in October, when daytime temperatures reach 28°C to 30°C and night time temperature is around 22°C to 23°C. In the dry season, daytime temperatures can soar as high as 40°C and nighttime temperatures can dip to 12°C . Even the chilliest nights can be followed by daytime temperatures well above 30°C. The high altitudes and undulating terrain of the FCT act as a moderating influence on the weather of the territory. Rainfall in the FCT reflects the territory's location on the windward side of the Jos Plateau and the zone of rising air masses with the city receiving frequent rainfall during the rainy season from March to November every year (Ishaya and Hassan, 2013).

2.2 Descriptive Survey

Questionnaire was designed to obtain information on Climate Smart Farming Systems (CSFS) used in agricultural production in the Federal Capital Territory, Abuja, Nigeria. The questionnaire comprises of questions on environmental factors such as droughts, floods, new pests, pathogens and weed problems as well as their advantage and disadvantage in agricultural production in the selected areas. The questionnaires were administered by one hundred and fifty (150) farmers in rural communities in three Area Councils (AC) in the Federal Capital Territory (FCT), Abuja, namely: Gwagwalada (GWA), Kwali (KWA) and Abuja Municipal (AMAC). Responses obtained from all AC were collated and analyzed base on location of the farm and GPs record was also taken. Data on CSFS, as well as, factors aiding their occurrence were retrieved from the administered questionnaires. Also, an on-spot assessment of the situation was done on farms to authenticate information earlier collected.

Data collected from the respondents were analyzed using non-parametric and parametric statistical tools. These involve the use of descriptive and inferential analytical tools such as percentages, bar charts and correlation of factors associated with impact of Climate Change on farm productivity in the study area. The Data were analyzed using Excel 2020 and SPSS Version 22 Software.

3.0 RESULTS

3.1 Sex of farmers surveyed

The study was carried out to get information about climate smart agriculture. The survey involved 150 farmers in three randomly selected Area Councils in FCT with 109 males and 41 females which account for 72.7 % and 27.3% respectively (Figure 1).

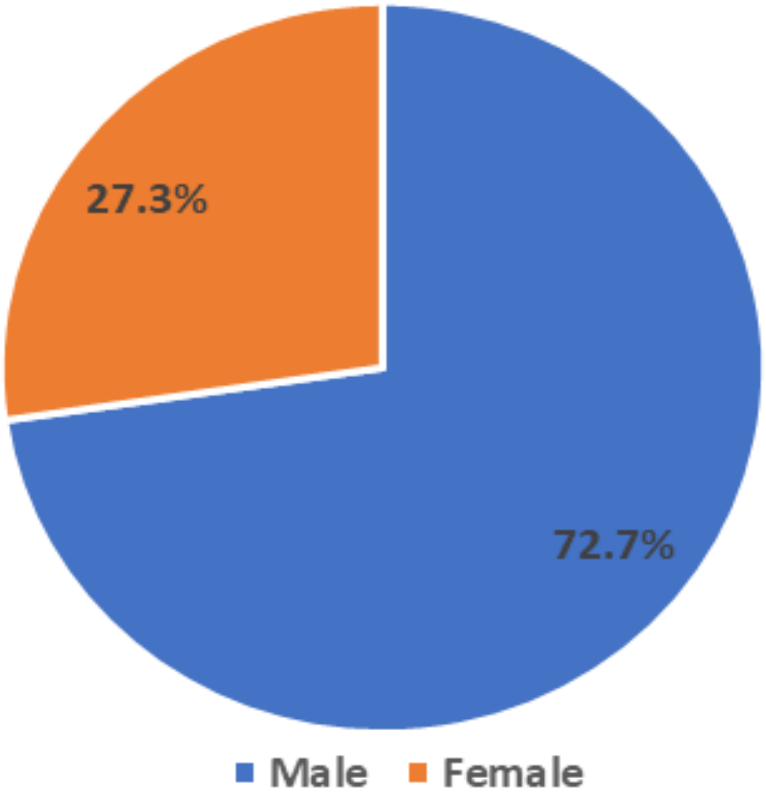

Figure 1: Sex Distribution of Respondents

3.2 Age Distribution of Respondent

The highest number of farmers in the selected Area Councils for the survey was within the ages of 21-30 accounting for 35.3% of the population surveyed. The least number (4.0%) of farmers was recorded within the age of 1-20 (Figure 2). Farmers between the ages of 31-40 were 31.3%, ages 41-50 were 16.7%, ages 51-60 were 6.7% and ages 60 above were only 6%.

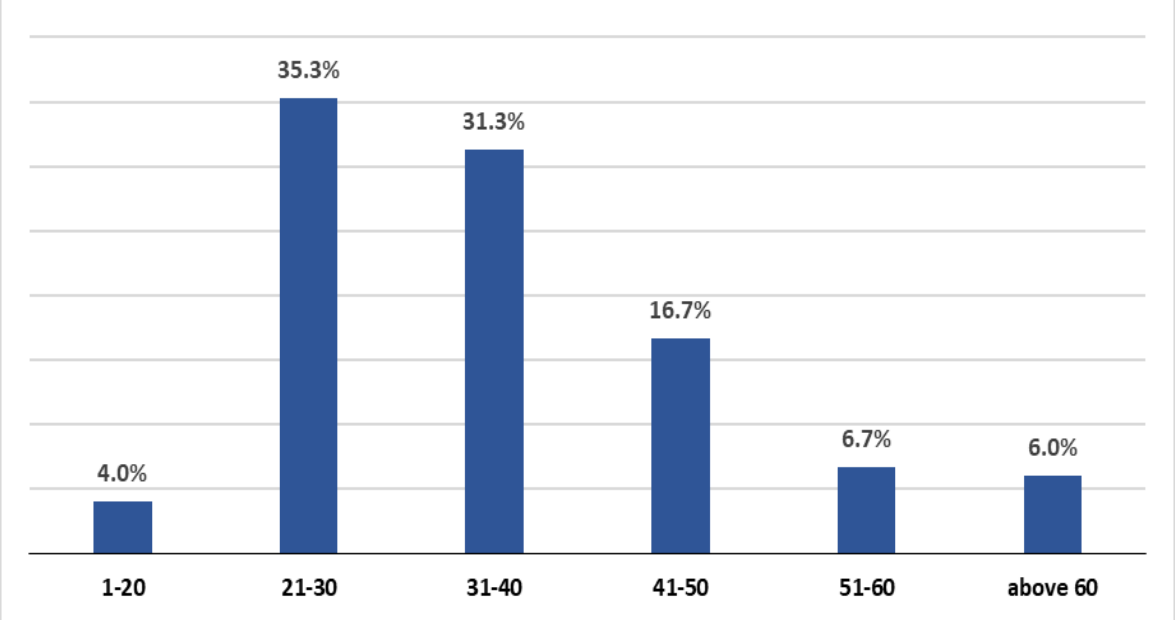

Figure 2: Age Distribution of Respondents

3.3 Educational Status of Farmers surveyed

A total of 61 farmers accounting for 40.7% of the farmers surveyed had Secondary school/vocational qualifications. 10% of the farmers, that is 15 of them, had no formal education. The percentage of farmers with M.Sc., College Education and Business study were 0.7% each, which were the least percentage (Figure 3).

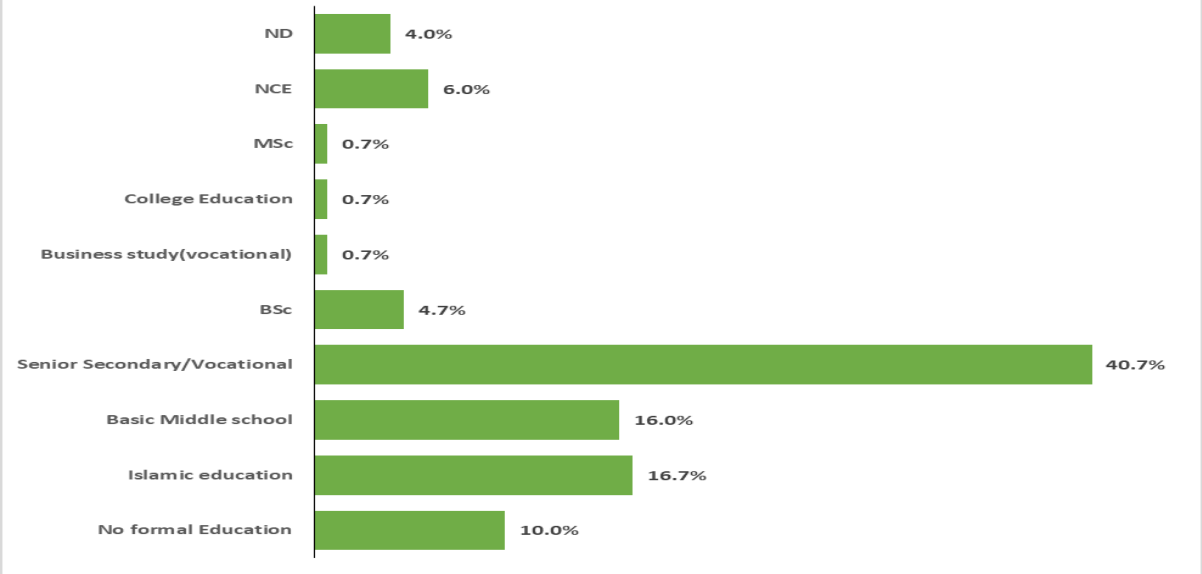

Figure 3: Educational Status of Respondents

3.4 Occupation of Respondents

Figure 4 shows the farmers that were surveyed practice different occupations such as crop farming, fish farming, livestock farm or combination of some of the farming system. Majority of the respondents 64% practice crop farming, while the minority of the respondents 0.7% practice crop and fish farming. 33.3% and 2% of the respondents practice crop and livestock farming and livestock farming alone, respectively.

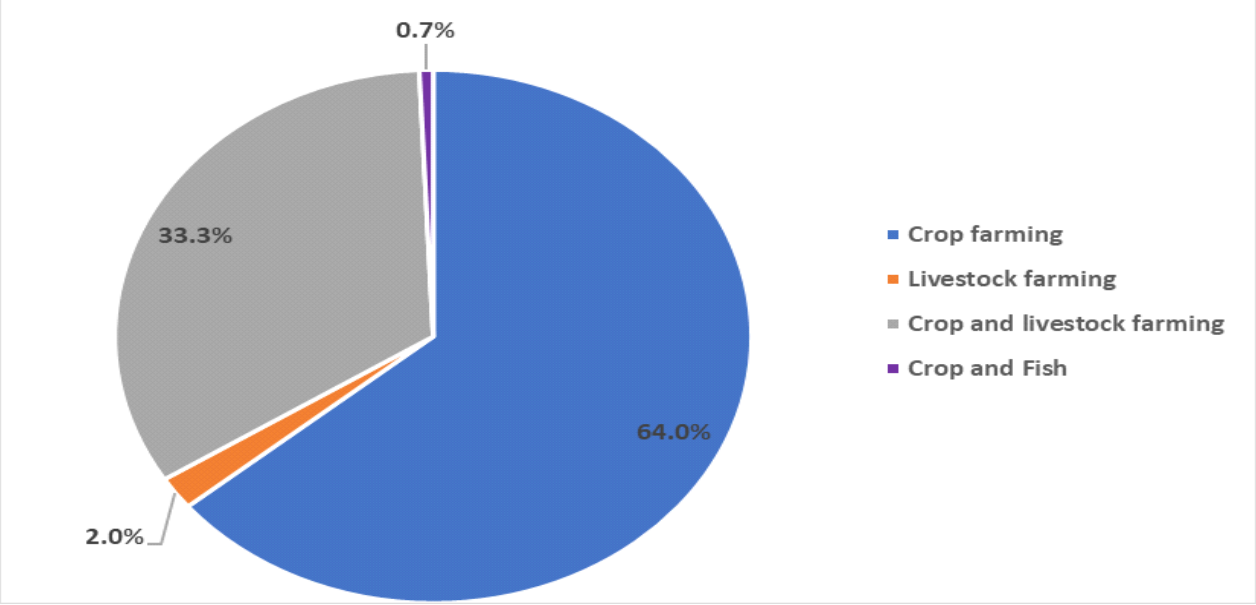

Figure 4: Type of Farming Occupation

3.5 Farming experience of participants

During the field survey, it was recorded that most of the farmers, 48.7% have been practicing farming for about 1-20 years ago. The least percentage was those that had been practicing for above 60 years. There was a gradual decrease in percentage as the years increase, but there was more percentage for respondents with 51-60 years of experience (4.0%), than 41-0 years of experience (2.7%) (Figure 5).

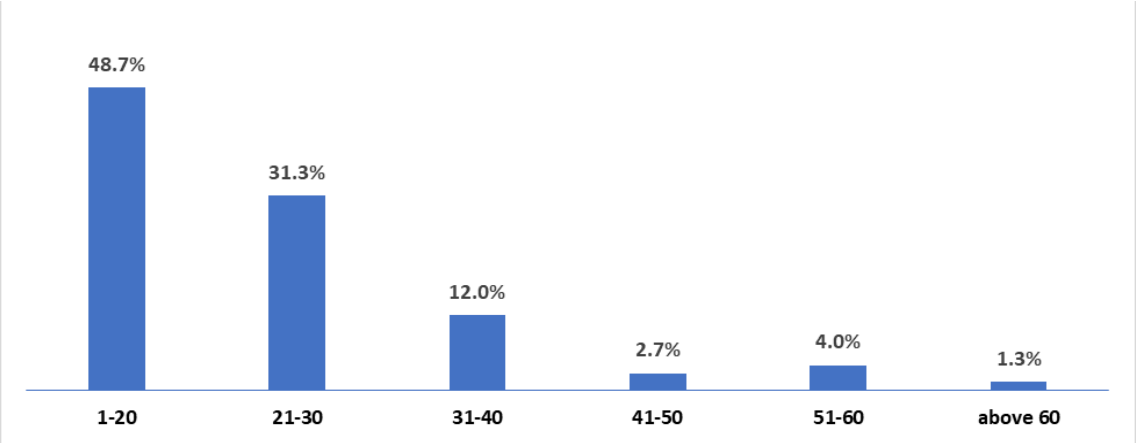

Figure 5: Farming Experience of Respondents

3.6 Topography of Farm Location

The highest frequency was recorded on farms located on lowland with the total number of 77 farms, accounting for 51% and the lowest frequency was recorded on farms located on hill (4%), which accounted for 6 farms. The farms near rivers was 45%, accounting for 67 farms (Figure

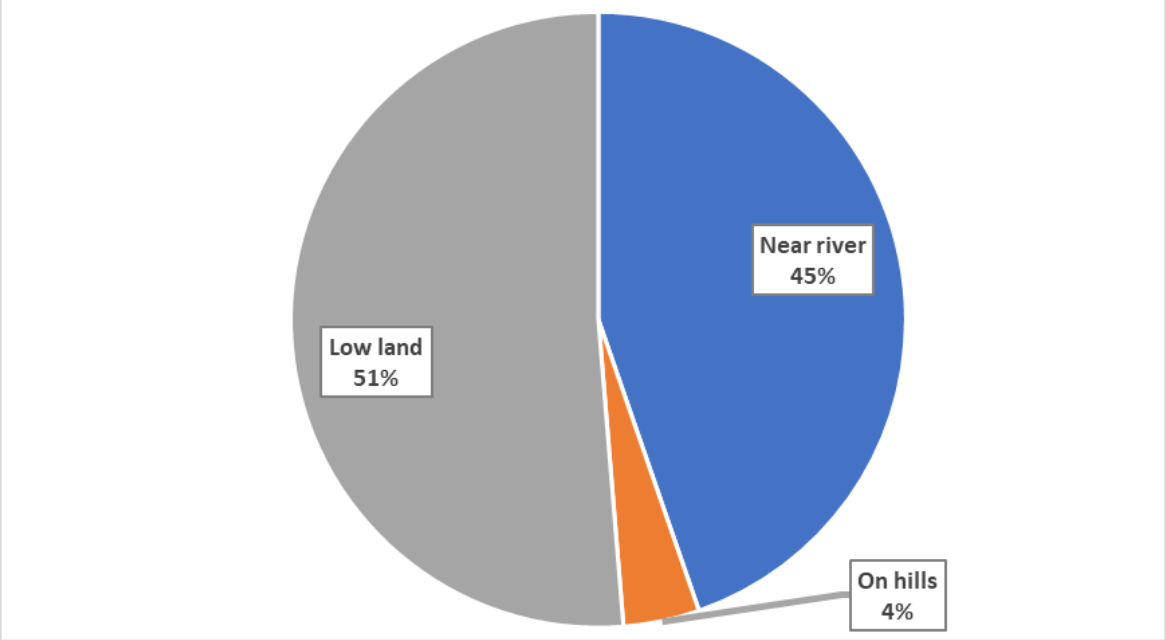

Figure 6: Topography of Farm Locations

3.7 Cropping System Practiced by Respondents

Figure 7 illustrate the various cropping systems practiced by farmers on their farms which are rainfed or irrigation. The highest number of 134 farmers accounting for 89.3% practice rainfed cropping. Only 1.3% practice irrigation farming. 9.3% of the farmers practice rainfed and irrigation together.

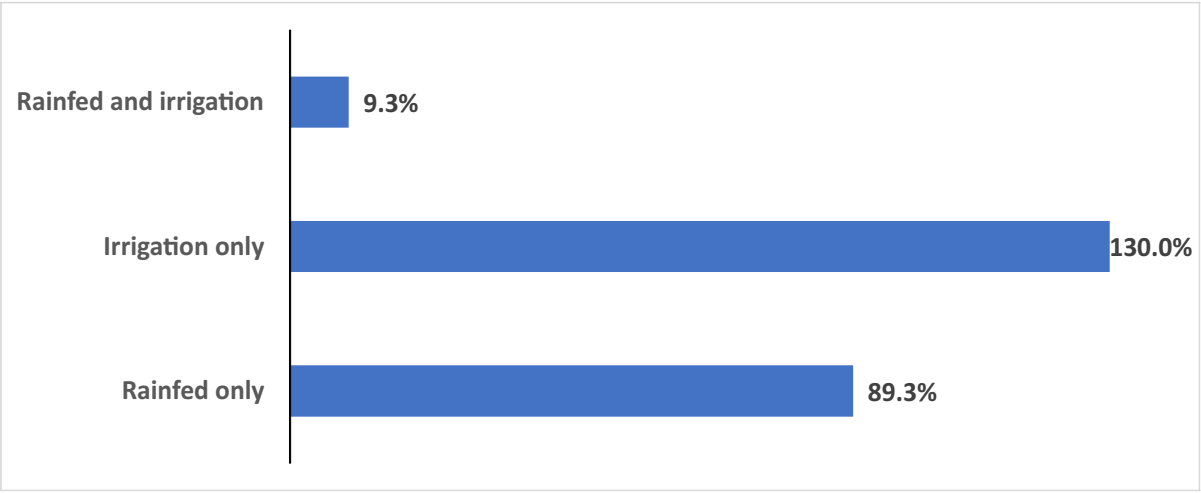

Figure 7: Cropping System Practiced by Respondents

3.8 Farmers Knowledge about Climate Changes and Global warming

Majority (123) representing 82% of the respondents does not know about Climate Change and Global Warming. 27 of the farmers, making up only 18% have knowledge on Climate Change and Global Warming (Figure 8).

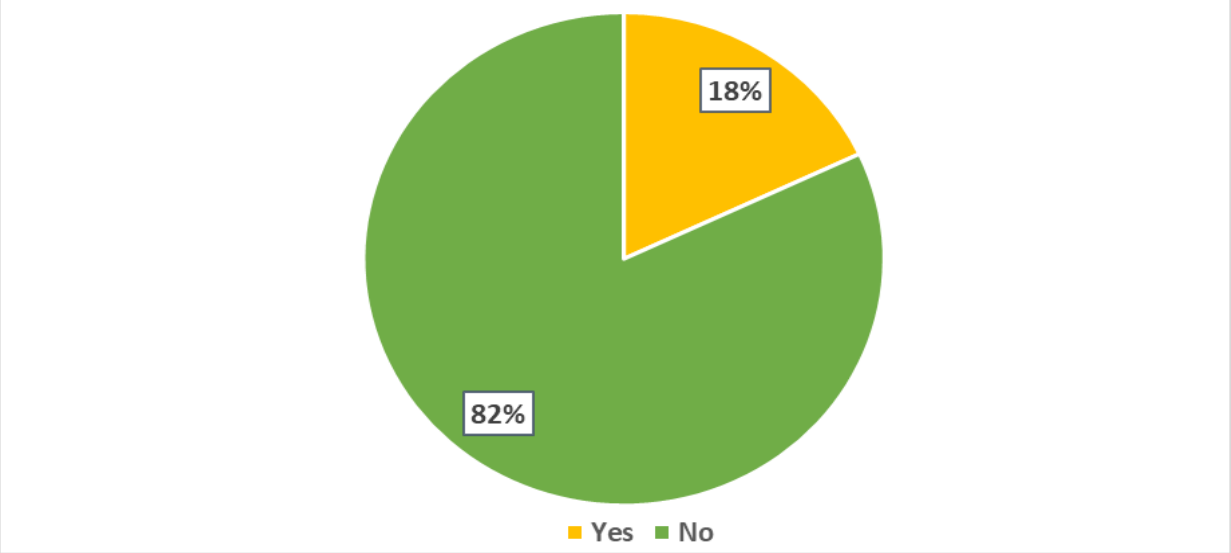

Figure 8: Farmers Knowledge on Climate Change and Global Warming

Medium of Information on Climate Change

The few numbers of farmers who were aware of Climate Change and Global Warming, majorly got the information on the Television programs or news. 1.3% of them got their information from the internet and another 1.3% from theirs friends (Figure 9).

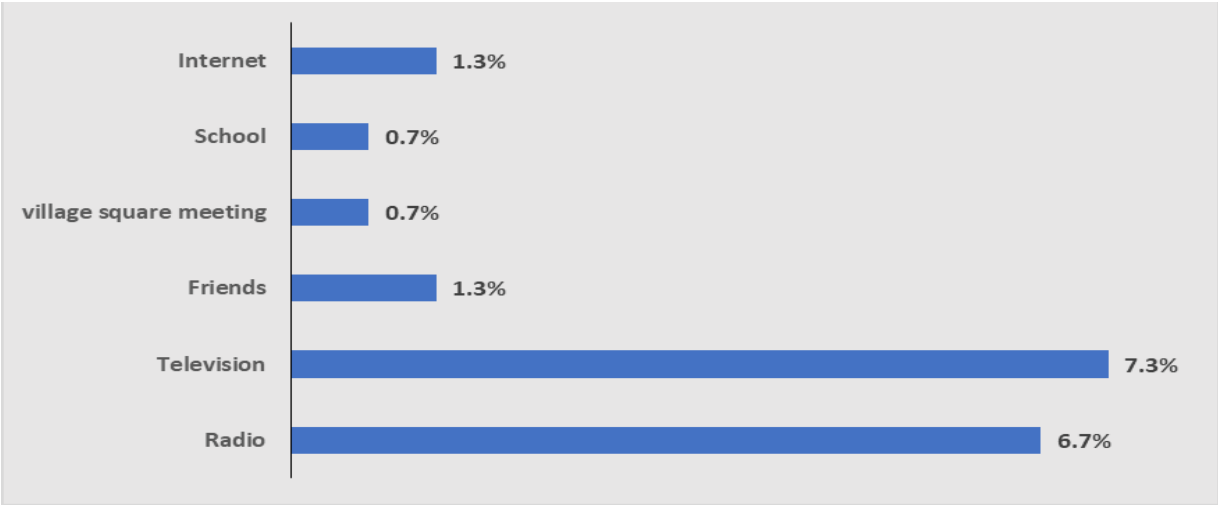

Figure 9: Medium of Information on Climate Change

3.9 Changes observed by the respondents

A total number of 142 farmers which made up 94.7% noticed changes in rainfall and temperature for the past 30years and others with which made up 5.3% noticed no change (Figure 10).

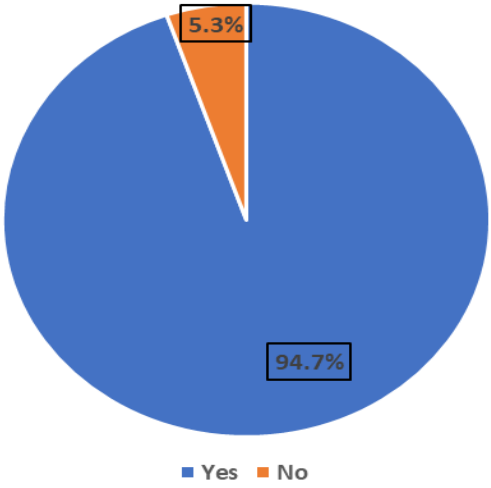

Figure 10: Observation of change in temperature and rainfall

Changes noticed by majority of the farmers includes short rainfall over the past years which accounts for 42% of the responses (Figure 11). 27.3% of them noticed excessive heat or high temperature, 24% noticed flooding and excessive rainfall. Only 1.3% noticed the long duration of dry season.

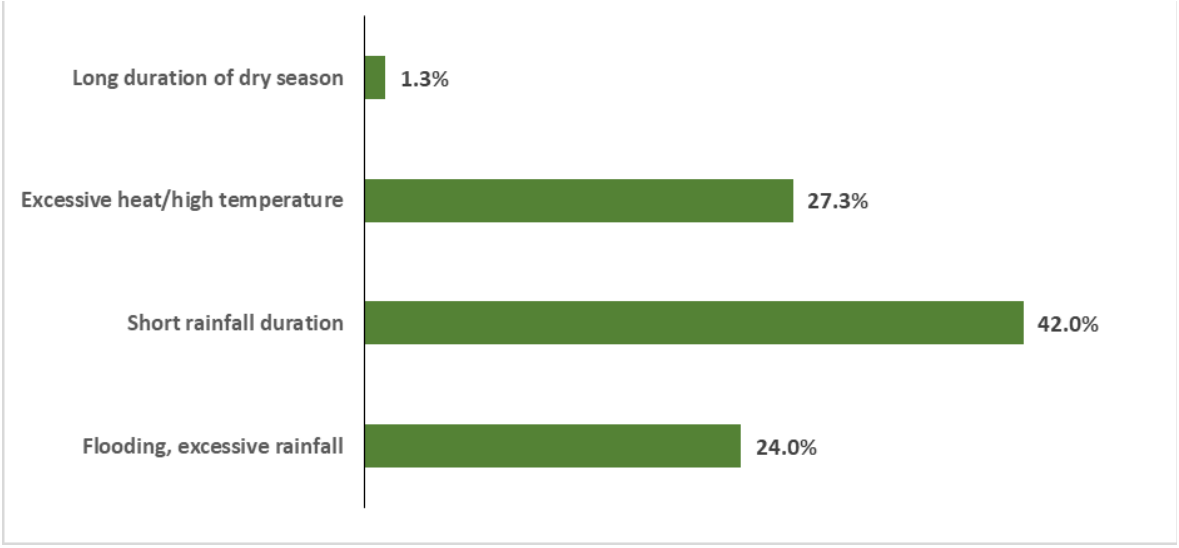

Figure 11: Changes observed by the respondents

3.10 Main opportunities (positive impact) created by the long-term changes in the mean of climates over 30years

As showed in Figure 12 below, we ask the farmers what have been the main opportunities in change in climate variables, which total number of 81farmers with 54.4% said it improved the groundwater and 31 farmers with 20.7% that floods increase fish harvest during the data collection.

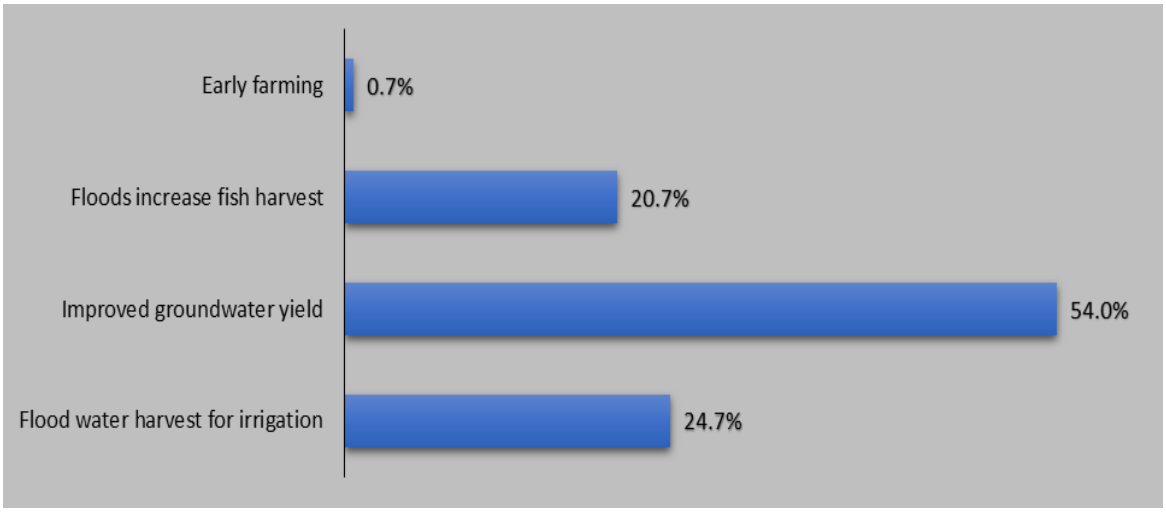

Figure 12: Main opportunities (positive impact) created by the long-term changes in the mean of climates over 30years

3.11 Means by which farmers capitalize on these opportunities or positive effects in future for better farm productivity

The highest frequencies for the opportunities or positive effects in future for better farm productivity is irrigate more which 75 farmers with 50% sees great opportunity in that while about 45 farmers with 30% Adopt irrigation practice as their own way of better farm productivity during the surveyed-on farmers.

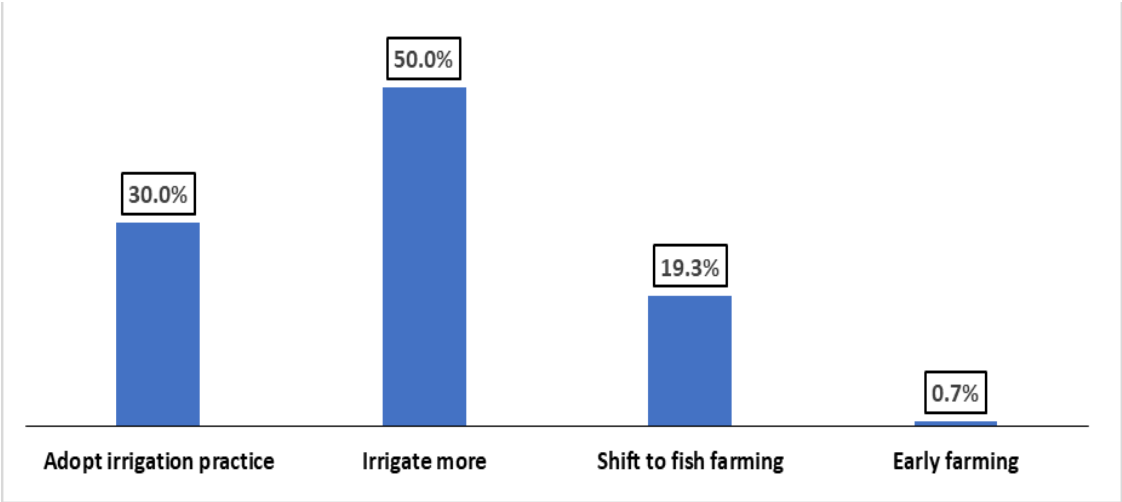

Figure 13: Means by which farmers capitalize on these opportunities or positive effects in future for better farm productivity

3.12 Changes in vegetation noticed over the last 30 years

The highest number of farmers with 99.3% noticed changes due to deforestation and grazing which is one of the factors which affect climate change and only 7% noticed with no changes.

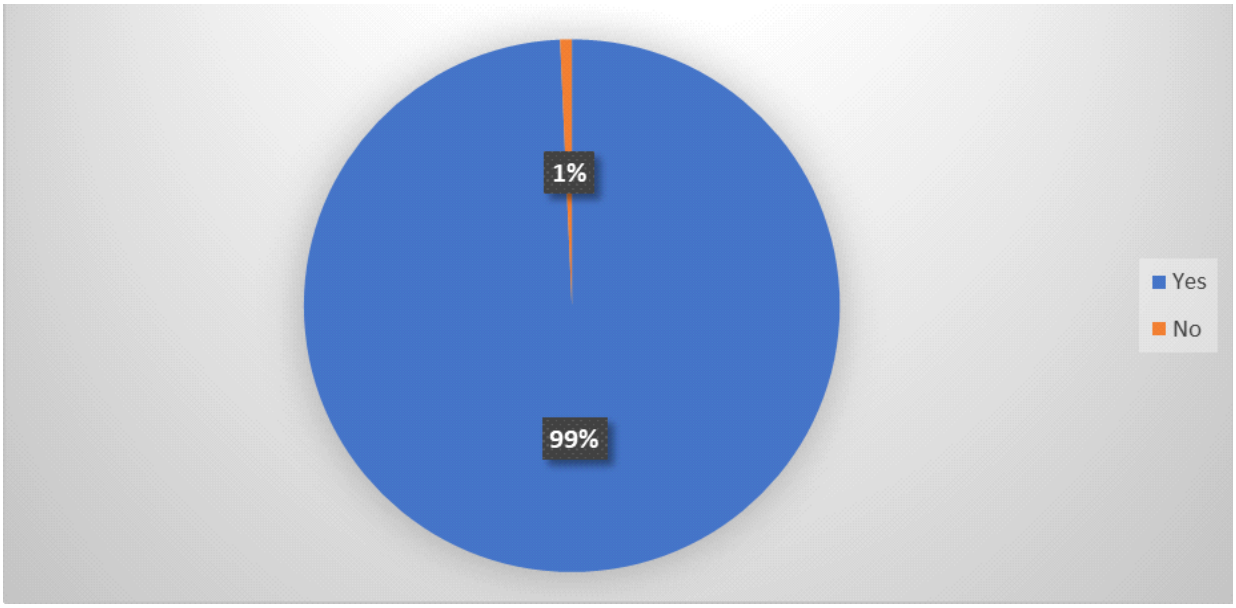

Figure 14: Changes in vegetation noticed over the last 30 years

3.13 Vegetation changes farmers noticed in the last 30 years

The frequency shows that there is decrease in vegetation cover in the last 30 years. A total number of 133 farmers with 88.7% said there is high decrease in vegetation cover and 16 farmers with 10.7% observed increase.

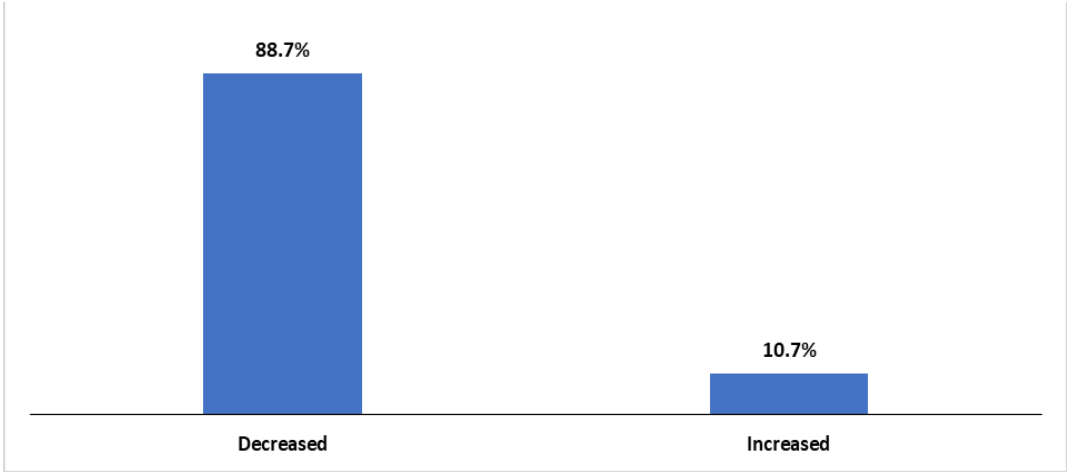

Figure 15: Vegetation changes farmers have noticed in the last 30 years

3.14 Changes in vegetation type over 30 years

The frequency showed decrease in vegetation type over 30 years, 88% respondents observed decreased while 11.3% noticed increase for the past 30years.

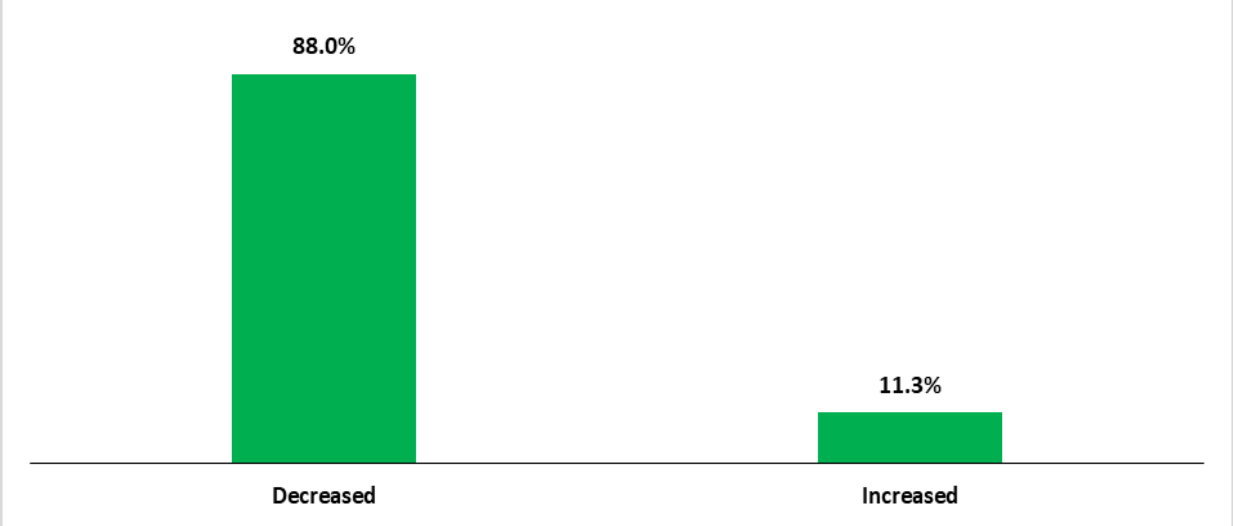

Figure 16: Changes in vegetation type over 30 years

3.15 Farmers use of fuel in home/farm

During the surveyed result analyzed showed that 96% farmers use fuel in their respective house and about 4% don't make use of fuel in their house or farm.

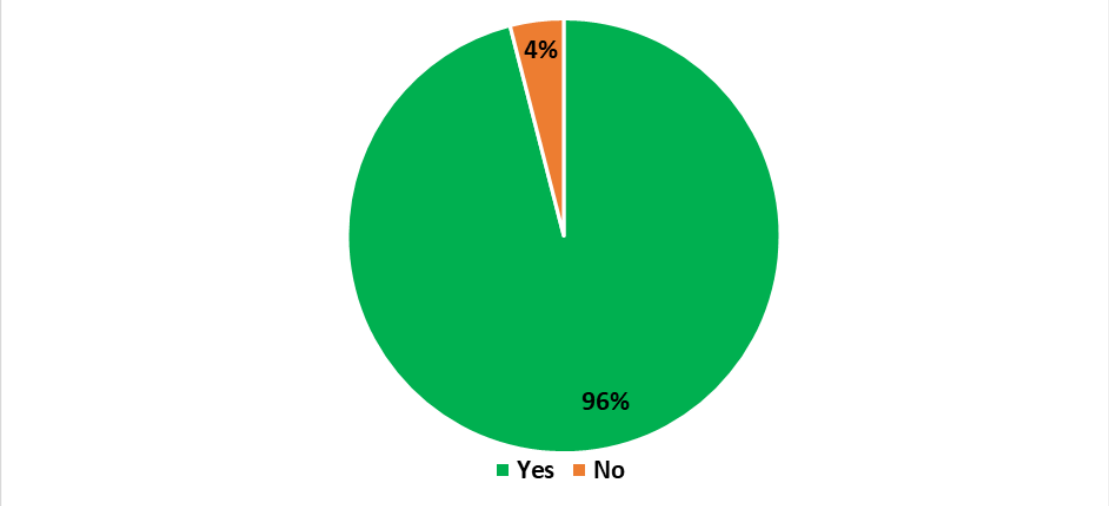

Figure 17: Farmers use of fuel in home/farm

3.17 Type of fuel used by farmers

Frequencies shows various type of fuel farmers use in their home or farm as shown in the Figure 18 below, 69.3% use firewood,10% use gas and 9% use kerosene in their farm or home.

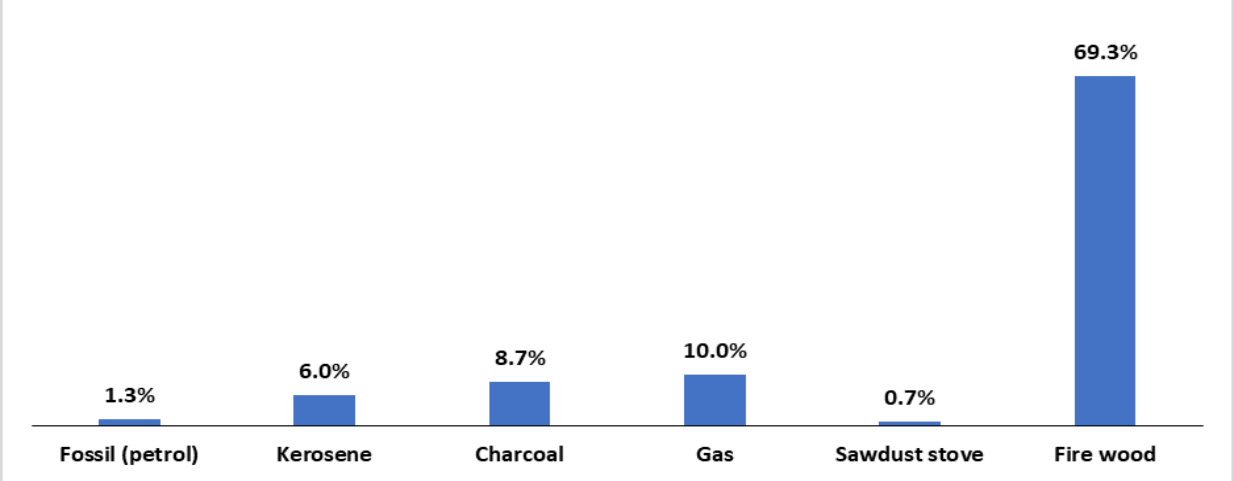

Figure 18: Type of fuel used by farmers

3.17 Farmer's knowledge on climate smart farming

The aim of carrying out this surveyed is to know the farmers who practice and know about climate smart cropping and during the surveyed a total higher number of 142 farmers with 94.7% the higher frequency didn't know about climate smart cropping 8 farmers with 5.3% know about it and practice it in the farm.

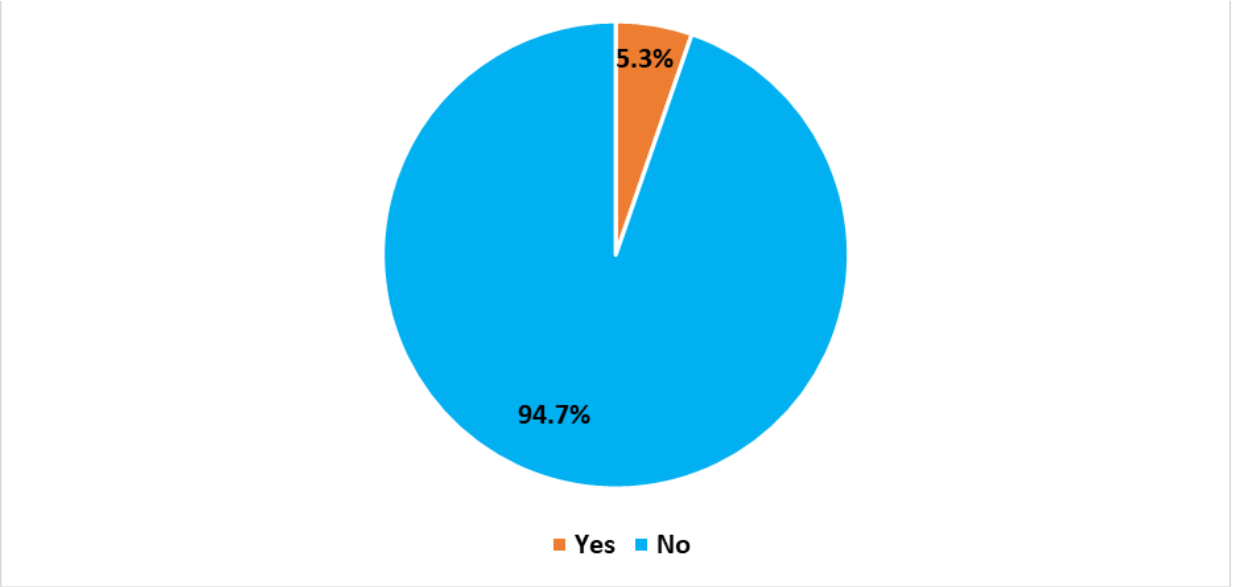

Figure 19: Farmer's knowledge on climate smart farming

3.18 Farmers adaptability to Climate change in over 10years

The highest number of 142 farmers with 94.7% has not made any changes in their farming because they don't know about climate smart cropping the little farmers with 5.3% have made change with their farming with the information.

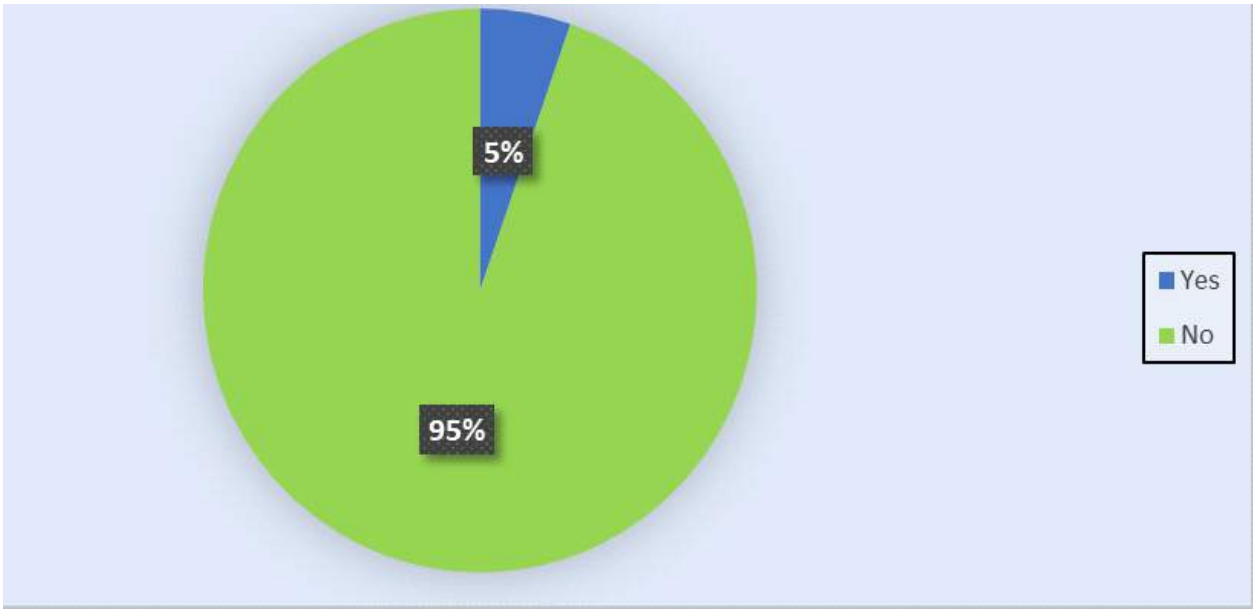

Figure 20: Percentage of farmers that made changes or adjustments in their farming ways in response to climate change and variability over 10years

3.19 Farmers adjustments in farming ways due to long terms shifts in temperature

Frequency shows that most farmers practices climate smart cropping but don't have much knowledge on it which we have about 34% practicing crop rotation, 24% mixed cropping 12.7 practicing mixed farming in the surveyed area during research.

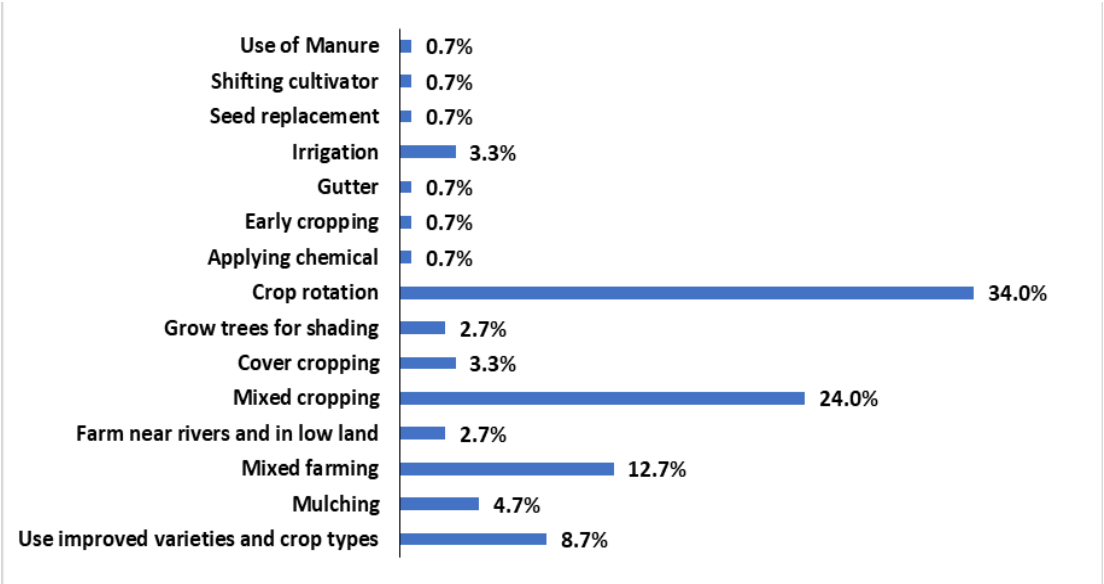

Figure 21: Farmer's adjustments in farming ways due to long terms shifts in temperature

3.20 Receive of support by farmers for climate Adaptation

Frequencies shows that a lot of farmers never receive support for climate adaptation in the area council covered. The highest numbers of 139 farmers with 92.7% don't receive support, only 11farmers accounting for 7.3% receives support for climate adaptation (Figure 22).

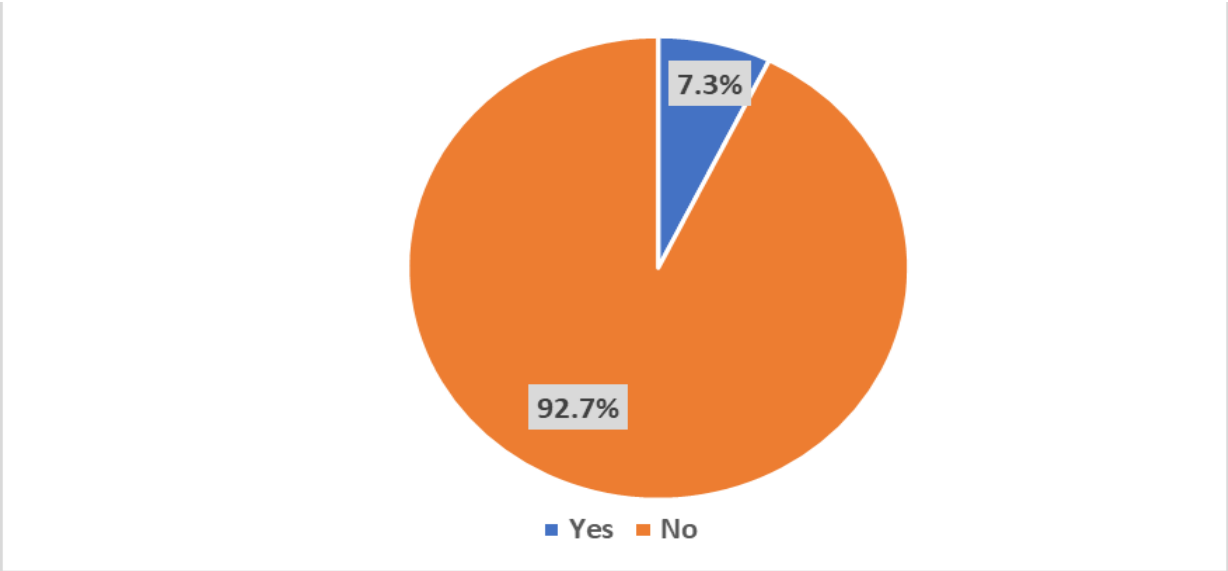

Figure 22: Receive of support y farmers for climate Adaptation

3.21 Form of support received by farmers

The farmers who got support for climate adaptation is also surveyed to know the form which the support come from to the. Most farmers accounting for3.3% gets their support from subsidized farm input while 2.0% gets supports from material support and 92.6 of the farmers do not get support at all in climate adaptation.

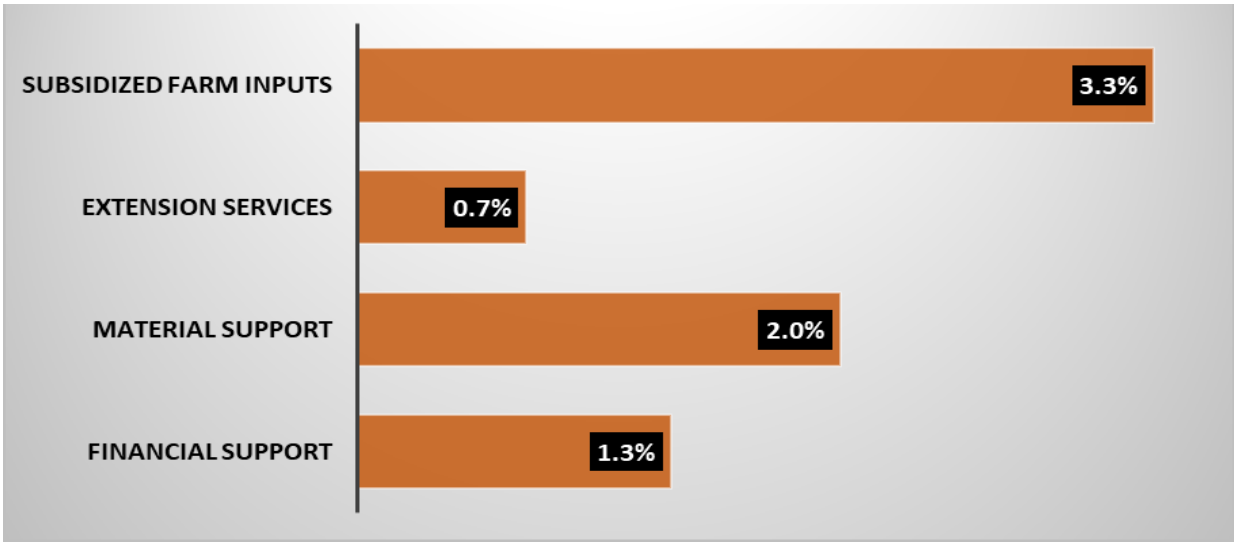

Figure 23: Form of support received by farmers

3.22 Source of support received by farmers

Frequencies shows that highest number of farmers accounting for 4% get their support from Area council 3% gets support from FCT Donor and large number of 96.2% do not receive any support.

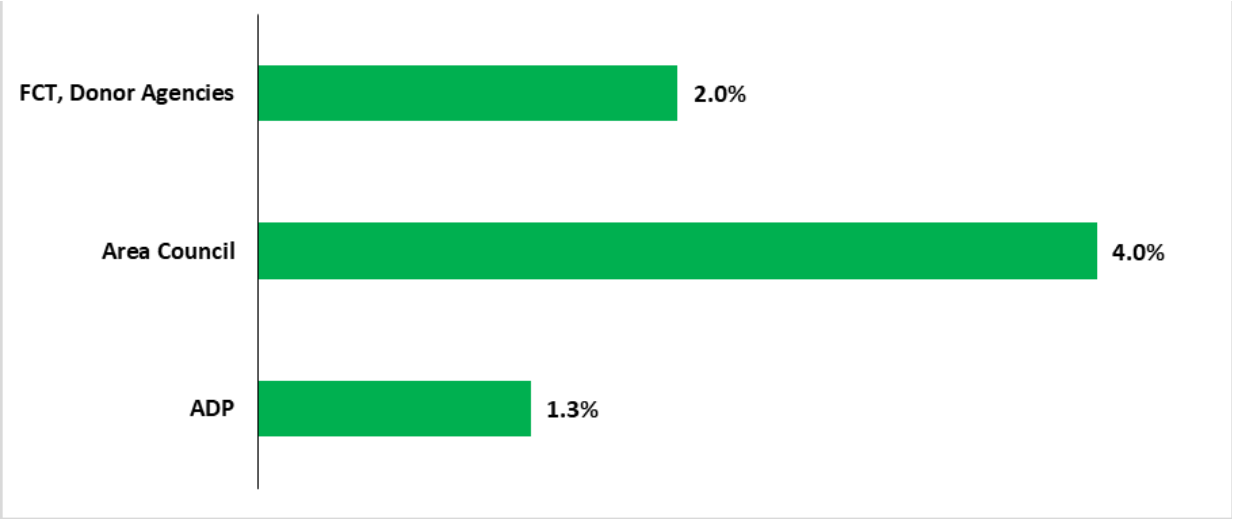

Figure 24: Source of support received by farmers

DISCUSSION

This survey covering three Area Councils of the Federal Capital Territory, Abuja helped highlight climate smart farming systems and methods employed in the adjustments to climate changes over time. the farmers are not aware and have no understanding of climate change, global warming and climate smart cropping but some farmers noticed long term changes in climate such as flooding, short rainfall duration, excessive heat and high temperature, long duration of dry season. This is in the support of IPCC (2014) reports that the earth surface has been warmer in the past three successive decades. The aforementioned climatic elements have been reported to influence crop production (Sowunmi and Akintola, 2010). According to Sowunmi and Akintola, 2010, the overall predictability of these climatic elements is imperative for day-to-day and medium term planning of farmers' operations.

The results of survey revealed that the majority of farmers employ few methods of climate smart farming in response to climate change over time. Some of the climate farming responses observed by the farmers in these Area Councils surveyed includes Early cropping, farming near rivers and in low lands, irrigation, seed replacements, crop rotation, cover cropping, use of resistant varieties, growing trees for shading, mulching etc. Adaptation and awareness of climate smart farming is very poor, this result agrees with **Saliu *et al.* (2018). Large percentage of the farmers use fire wood as fuels which could also contribute to the problem of deforestation observed by the farmers.**

CONCLUSION

The study determined the extent of farmers' adoption of Climate Smart Farming System practices in the FCT. The findings indicated that a large proportion of respondents were not aware of most of the practices and so, adoption of most of the practices was very low. Agronomic practices in term of cultivation of high yielding, drought tolerant, disease and pest resistant seed varieties was the most

adopted practice due to long time of research and extension activities on seed varieties as well as favorable government policy and support prograrmme on seed production and utilization in the country. Adoption of Integrated Pest Management (IPM), water management, integrated soil fertility management and agro-forestry were very low. Effort should be made to encourage farmers in the study area to adopt climate smart agricultural practices.

6.0 RECOMMENDATIONS

i. Sensitization campaign on reality of climate change and the need to adopt climate smart practices towards reduction of adverse effect of climate change should be intensified.
ii. Policy and supportive programmes towards climate change mitigation and adaptation in the study area should focus on adoption of all Climate Smart Agricultural practices especially those climate smart practices that were not highly adopted by farmers.
iii. Efforts should be made by research institution to train extension staff properly about all the components of climate smart agricultural practices.
iv. Extension staff should in turn disseminate extensively accurate information on Climate-Smart Agricultural practices to cover a larger proportion of farmers in the study area. Government should provide incentives and enabling policy environment towards adoption of good CSA practices in general and specifically those ones that were not highly adopted.
v. Credit facilities should be provided in order to enhance the capacity of farmers in procuring the necessary climate smart inputs.

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Performance of Noiler Chickens Fed Graded Levels of Maize Cob and Groundnut Shell Marsh in Abuja, Nigeria.

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Abstracts

A study was conducted for 84 days to evaluate performance of noiler chicken fed maize cob and groundnut shell marsh (1:1) at different inclusion levels. A total of one hundred and fifty unsexed noiler chicks were randomly allotted into five dietary treatments in a completely randomized design. Each treatment was replicated thrice with ten birds per replicate. Birds on treatments1, 2, 3,4 and 5 were fed the basal diet at inclusion level of 0%, 5%, 10%, 15% and 20%, with maize cob and groundnut shell marsh in partial replacement of maize grain, respectively. Feed and water were provided ad libitum. Data were collected on feed intake, weight gain and feed conversion ratio. 5ml of blood sample were collected for haematology and serum biochemistry analysis from 3 birds per replicate via the wing vein. All data generated were subjected to analysis of variance (ANOVA). Result of the growth performance showed no significant ($p>0.05$) difference in all the parameters measured except for the feed intake (FI) feed conversion ratio (FCR) and mortality (%). The result of the hematological parameter shows significant differences ($P<0.05$), in the values of white blood cell (WBC) and lymphocytes (LYM) only. The serum biochemistry shows significant differences in the value of Creatinine. (Mg/dl), Triglycerides (Try Mg/dL), Total bilirubin (Mmol/L) and Alanine aminotransferase (ALTiu/L) ($P<0.05$).The carcass characteristics showed no significant difference. Hence result obtained from this research can be recommended for inclusion of maize cob and groundnut shell marsh up to 20% as partial replacement of maize grain in the diet of Noiler birds.

INTRODUCTION

The utilization of non-conventional feed material has become very important as it helps reduces the competition between human and animals when it comes to conventional feed materials thereby reducing cost of feeding and also reduces nuisance caused by the agricultural by-product in the society (Olafadehan *et al.,* 2020). Noiler chicken production is becoming more acceptable due to their resistivity to diseases and ability live on kitchen and agricultural waste and they are dual purpose birds (Animashahun *et al.,*2022). The ability of these birds to convert agricultural, natural and household waste into edible product such as meat and egg of high protein, for human consumption, growth and healthy living makes noiler birds a vital part of poultry production (Livestock, 2020).

Poultry production generally rely on the use of conventional feed ingredients. However, the prices of conventional feeds are becoming unaffordable to most smallholder farmers involved in poultry production. According to (Chandrasekaran, 2014), Poultry plays an important economic, nutritional and socio-cultural role in the livelihood of rural households in developing countries, including Nigeria as the major source of animal protein and income. Poultry sector is in competition with human on the meager feed ingredients leading to an increase in cost of production. WorldoMeter (2020), stated that Nigeria population was about 206,139,589 with an annual growth rate of 2.58%, in the year 2020.Hence, there is a need for low-cost feed input for sustainable and profitable production and breeds with high meat and egg production (Animashahun *et al.,*2022). Groundnut shells contain diverse bioactive and functional components which are important for human and animals (Pham *et al.,* 2019). Basically, it is used as a feedstock, filler in fertilizer and bio-filter carriers. Nutritional level is one of the vital factors which affect the physiology and performance of animals (Ajao, 2013).

The utilization of crop residue in livestock production will minimize cost of production and environmental impacts cause by the indiscriminate disposal of the residues. Without limiting the performance characteristics of the animal if given at the right quantity (Yanti and Yayota, 2017).

Therefore, evaluation of the Noiler chicken performance fed graded level of the maize cob and groundnut shell diets will help to determine the effect of synergistic use of the two ingredients for poultry production and its economic implication**.**

Materials and methods

Experimental site

The experiment was carried out at the Teaching and Research Farm in the University of Abuja, located in Gwagwalada Area Council of the Federal Capital Territory Abuja, Nigeria. The University lies between latitude 08°51° and 09°37°N and longitude of 7° 20° and 7°51° E. The area is characterized by two distinct seasons which are the rainy seasons from May to October and the dry season from November to April

Source of ingredients used for the experiment

100kg bag each of maize cob and groundnut shell were collected around Gwagwalada community at Gwagwalada Area Council, Abuja, was thoroughly dried and grinded into marsh.

Experimental design

The experimental design was completely randomized design (CRD). One hundred and fifty (150) day old Noiler chicks was purchased from reputable hatchery from Ibadan. The animals were grouped into 5 treatments, with thirty (30) birds per treatment (T1, T2, T3, T4 and T5) and three replicate with ten (10) birds per replicate (R1, R2, and R3) respectively. Groundnut shell and maize cob was thoroughly grinded into marsh at proportion of 0%, 5%,10%,15% and 20% respectively.

Experimental birds and management

Amo noiler chicks obtained from Amo Farm Sieberer commercial hatchery in Ibadan was used for this experiment. The birds were reared in a brooding cage with pen dimension of 0.94 square meter for 28days, then transferred into a battery cage and the experiment lasted for 84 days. Heat and light were provided throughout the brooding period using lanterns, electricity and routine vaccination (Gumboro and lasota) were administered as shown below. Feed and fresh water were provided *ad-libitum.*

EXPERIMENTAL DIETS

Table 2.3.1 and 2.3.2 Composition of Experimental Starter and Finisher diet Containing Graded level of Maize cob and Groundnut shell Marsh at different inclusion level.

Table 2.3.1 Composition of experimental Starter diet Containing Graded level of Maize coband Groundnut shell Marsh at different inclusion levels

	Level of MCGS INCLUSION				
INGREDIENTS (KG)	0%	5%	10%	15%	20%
MAIZE	48	45.6	43.2	40.8	38.4
MCGS	0	2.4	4.8	7.2	9.6
SOYA BEAN MEAL	22	22	22	22	22
DEOILRICE	10	10	10	10	10
PKC	4.5	4.5	4.5	4.5	4.5
FISH MEAL	4	4	4	4	4
BLOOD MEAL	3	3	3	3	3
WHEAT OFFAL	4	4	4	4	4
BONE MEAL	2	2	2	2	2
OYSTER SHELL	1.5	1.5	1.5	1.5	1.5
LYSINE	0.25	0.25	0.25	0.25	0.25
METHIONINE	0.25	0.25	0.25	0.25	0.25
VITAMIN PREMIX	0.25	0.25	0.25	0.25	0.25
SALT	0.25	0.25	0.25	0.25	0.25
TOTAL	100	100	100	100	100
CALCULATED ANALYSIS					
M.E (KCAL/KG)	2880	2877	2872	2869	2865
CP %	23.40	23.30	23.20	23.10	22.90
FEED COST/PER KG (#)	347	341	336	331	325

Table 2.3.2 Composition of Experimental Finisher diet Containing Graded level of Maize cob and Groundnut shell Marsh at different inclusion levels.

	% LEVEL OF MCGS INCLUSION				
INGREDIENTS(KG)	**0%**	**5%**	**10%**	**15%**	**20%**
MAIZE	60	57	54	51	48
MCGS	0	3	6	9	12
SOYA BEAN MEAL	20	20	20	20	20
DEOILRICE	5	5	5	5	5
PKC	4	4	4	4	4
FISH MEAL	4	4	4	4	4
WHEAT OFFAL	2.5	2.5	2.5	2.5	2.5
BONE MEAL	2.5	2.5	2.5	2.5	2.5
OYSTER SHELL	1	1	1	1	1
LYSINE	0.25	0.25	0.25	0.25	0.25
METHIONINE	0.25	0.25	0.25	0.25	0.25
VITAMIN PREMIX	0.25	0.25	0.25	0.25	0.25
SALT	0.25	0.25	0.25	0.25	0.25
TOTAL	100	100	100	100	100
CALCULATED ANALYSIS					
M.E (KCAL/KG)	3000.98	2996.40	2991.89	2987.35	2982.40
CP %	18.72	18.87	19.03	19.18	19.33
FEED COST/PER KG (#)	167	161	156	151	150

MCGS: Maize cob and Groundnut shell Marsh; PKC: Palm kernel cake; M.E: Metabolizable energy; CP: Crude Protein

Vitamin Premix: 2.5kg of premix contains: *Retinol acetate (10000000iu), Vit. D3 (2000000iu), Vit. E (15000iu), Vit. B (3000mg), Niacin (15000mg), Vit. B6 (3000mg), Vit. B12 (10mg), Vit. K3 (2000mg), Biotin (20mg), Folic Acid (500mg), Calcium pantothenate (800mg), Chlorine Chloride (250000mg), Manganese (75000mg), Iron (25000mg), Copper (5000mg), Zinc (70000mg), Selenium (150mg), Iodine (1300mg), Magnesium (100mg), Ethoxyquin (500g), BHT (700g)*

Table 2.3.3 Cost of feed per kilogram of ingredient used

Ingredients	Cost (#/kg)	Cost (USD/) #640/$1
MAIZE	230	147,200
MCGS	5	3,200
SOYA BEAN MEAL	340	217,600
DEOILRICE	210	134,400
PKC	140	89,600
FISH MEAL	2200	1,408,000
WHEAT OFFAL	200	128,000
BONE MEAL	130	83,200
OYSTER SHELL	40	25,600
LYSINE	2500	1,600,000
METHIONINE	2500	1,600,000
Vitamin premix	1660	1,062,400
Salt	650	416,000

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2.4 DATA COLLECTION

Parameters measured

The following parameters were measured; Initial weight (IW), Final weight (FW), Weight gain (WG); (FW - IW) ……. Figure 1

Average Daily Weight Gain (ADWG); (WG÷84) …….. Figure 2

Daily feed intake; (left over feed - feed given) ……Figure 3

Average Daily Feed Intake (ADFI); (Feed intake ÷ 84). ….Figure 4

Feed intake (FI): Sum of (ADFI) for 84 days. …….Figure 5

Feed conversion ratio; (FI) ÷ WG……Figure 6

Economy of production: The feed cost was calculated per treatment diet. Other expenses on drugs, vaccines and litter were common for all the treatments. Cost per kg gain was calculated by multiplying cost per kg by the Feed conversion ratio.

2.4.1 HEMATOLOGICAL AND SERUM BIOCHEMICAL PARAMETERS

2.4.2. Hematological parameters

Blood sample were collected from the wing vein of three birds per replicate into a 2ml sterile syringe and transferred onto an ethylene diamine tetra-acetic (EDTA) bottle to determine the packed cell volume (PCV), red blood cell (RBC) count, hemoglobin (Hb) concentration, white blood cell (WBC) counts and differential counts. The packed cell volume (PCV), erythrocyte concentration (RBC), hemoglobin (Hb), and leucocytes concentration (WBC) counts were calculated using an automated cell counter. While mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) Were calculated using the formula below as described by (Jain, 1986).

$$\text{MCHC (g/dL)} = \frac{HB}{PCv} \times 100 \quad \text{……..figure 7}$$

$$\text{MCV (fL)} = \frac{PCV}{RBC} \times 100 \text{……..figure 8}$$

$$\text{MCH (pg)} = \frac{HB}{RBC} \times 100 \text{…….figure 9}$$

The mean corpuscular volume (MCV) is used to calculate the erythrocyte size, the mean corpuscular hemoglobin (MCH) to measure hemoglobin amount per blood cell and the mean corpuscular hemoglobin concentration (MCHC) to know the amount of hemoglobin relative to size of the cell per red blood cell.

2.4.3. Biochemical parameters

Blood samples of 2ml were collected from 3 birds per replicate and transferred into a vacuum test bottle without ethylene diamine tetra-acetic acid. The blood samples were used to analyses the Albumin (Ab), Total protein (TP), Uric Acid (U), Glucose (G), Blood cholesterol, Globulin (GL), alanine transaminase, alanine phosphate as described by (Reitman and Frankel 1957; Tietz *et al.,* 1983)

2.4.4 Carcass characteristics

A bird per replicate was used for the purpose of evaluating the carcass characteristics. The feet were separated from each carcass in the tibio-tarsal joint. Weights of the carcass parts, abdominal fat, internal organs (liver, thymus, heart, lungs, kidneys, pancreas, testes), and gastrointestinal tract characteristics (crop, proventriculus, gizzard, right and left cecum) were all measured as described by Ahmadi *et al.,* (2018). The width, length, wall thickness of left and right cecum was also recorded respectively. Total weight of all dissected parts and the weights of various segments of the digestive tract were expressed as a percentage of carcass, as described by Ahmadi *et al*., (2018).

2.5 Data analysis

2.5 .1 Proximate analysis

Proximate analysis of the test ingredient and each treatment diet was carried out at faculty of agriculture, Animal Science laboratory using standard method as described by (AOAC, 2002).

2.5.2 Statistical Analysis

All data were subjected to one-way analysis of variance (ANOVA) using SPSS (25) and significant means was separated using Duncan Multiple Range tests (Duncan, 1955).

3.0. Result and discussion

3.1 Proximate analysis of test ingredient

The proximate composition, mineral and anti-nutritive value of groundnut shell marsh and maize cob are presented in Table 3.1. The two samples contain moisture content, crude protein, dry matter, crude fibre, ether extract, total ash and metabolizable energy at 14.85%, 14.11%, 85.15%, 20.71%, 1.86% ,4.22% and 3280.6 kcal/kg respectively.

Table 3.1 Proximate Composition of Groundnut shell marsh

PARAMETER	% COMPOSITION
MOISTURE CONTENT	10.72
DRY MATTER	89.28
CRUDE PROTEIN	11.65
CRUDE FIBRE	7.22
ETHER EXTRACT	1.20
M.ENERGY (Kcal/Kg)	1892.8

Table 3.1.3 Anti-nutritive value of groundnut shell marsh

Anti-nutritive factors (Mg/100g)	% Composition
Phytate	204.6
Oxalate	371.2
Saponin	156.9
Tannin	100.3
Cyanide	10.6
Trypsin	73.4

3.1. 4 Proximate analysis of maize cob marsh

The proximate composition, and anti-nutritive value of maize cob marsh are presented below.

3.1.5. Proximate Composition of Maize cob marsh

PARAMETER	% COMPOSITION
MOISTURE CONTENT	7.11
DRY MATTER	92.89
CRUDE PROTEIN	5.08
CRUDE FIBRE	31.56
ETHER EXTRACT	2.18
M.ENERGY (Kcal/Kg)	2008.7

Table 3.1.6 Anti-nutritive value of Maize cob marsh

Anti-nutritive factors (Mg/100g)	% Composition
Phytate	403.1
Oxalate	300.2
Saponin	120.9
Tannin	205.7
Cyanide	75.71
Trypsin	21.80

Table 3.1.7 Proximate analysis of the mixture of Maize cob and Groundnut shell marsh

PARAMETER	% COMPOSITION
MOISTURE CONTENT	14.85
DRY MATTER	85.15
CRUDE PROTEIN	14.11
CRUDE FIBRE	20.71
ETHER EXTRACT	1.86
TOTAL ASH	4.22
M.ENERGY (Kcal/Kg)	3280.6

3.2 Growth performance of Noiler chicken fed graded level of maize cob and groundnut shell marsh

The result of Noiler chicken fed graded levels of maize cob and groundnut shell marsh at different proportion presented on Table 3.2, shows no significant effect (P>0.05) on the initial body weight (IBW) final body weight (FBW) and weight gain (WG). However, there was significant (P<0.05) difference in the value of feed intake (FI), average daily feed intake (ADFI), feed conversion ratio (FCR) and mortality (%) respectively. P>0.05) on the initial body weight (IBW) final body weight (FBW) and weight gain (WG). However, there was significant (P<0.05) difference in the value of feed intake (FI), average daily feed intake (ADFI), feed conversion ratio (FCR) and mortality (%) respectively.

Table 3.2

	% LEVEL OF MCGS INCLUSION						
Parameters	**0**	**5**	**10**	**15**	**20**	**SEM**	**SIG**
IBW (g)	46.53	47.20	47.00	46.66	46.43	0.20	NS
FBW (g)	1,250.66	1,313.16	1,242.60	1,176.66	1,150.33	45.50	NS
WG (g)	1,204.13	1,265.96	1,195.66	1,130.00	1,103.90	45.55	NS
ADWG (g)	14.33	15.07	14.23	13.45	13.14	0.54	NS
FI (g)	6,703.04^{ab}	5,749.23^{b}	6,631.57^{ab}	7,148.28^{a}	7,174.42^{a}	179.85	*
ADFI (g)	79.79^{ab}	68.44^{b}	78.94^{ab}	85.09^{a}	85.40^{a}	2.14	*
FCR	5.57^{ab}	4.58^{b}	5.58^{ab}	6.32^{a}	6.77^{a}	0.11	*
Mortality (%)	0.23^{ab}	0.40^{a}	0.33^{a}	0.10^{b}	0.23^{ab}	0.335	*

$^{a-c}$Means in the same row with different superscript differ significantly (P<0.5); IBW: initial body weight; FBW: final body weight; WG: weight gain; ADWG: average daily weight gain; FI: feed intake; ADFI: average daily feed intake; SEM: standard error of means; SIGN: significant (P<0.5) difference; FCR: feed conversion ratio.

3.3 Haematological parameters of Noiler Chicken fed graded level of maize cob and groundnut shell marsh.

Table 3.3 present haematological parameters of Noiler chicken fed graded level of groundnut shell and maize cob marsh. The haematolohogical values ranged of Pack cell volume (PCV) (29.06-30.63%,), Haemoglobin (Hb) (6.78- 9.52g/dl), Red blood cell (RBC) (2.83-3.37×10^6/uL), Mean corpuscular haemoglobin (MCH) (70.01-75.83pg), Mean corpuscular volume (MCV) (39.28-42.55fL,) and mean corpuscular haemoglobin concentration (MCHC) (80.21-84.80%).

Hb (g/dl) and MCH concentration were significantly (P <0.05) different in treatment 1 with treatments 2, 3, 4 and 5. The white blood cell (WBC), lymphocyte (LYM), Monocyte (MON) Hematocrit (HET) and Eosinophil (EOS) values ranges between 5.41-7.56 (×10^6/uL), 7.34-8.86(×10^6/uL), 0.64-1.48(×10^6/uL) ,2.18-2.54(×10^6/uL) and 0.59-0.84(×10^6/uL) respectively**.** Likely the values of LYM and WBC were significantly (P <0.05) different with WBC treatment 1 having a value of (5.14×10^3uL) that is lower than (6.11×10^3uL) value in treatment 2, whereas, treatment 3,4 and 5 were statistically similar (p>0.05).

Table 3.3.

	% LEVEL OF MCGS INCLUSION							
Parameters	0	5	10	15	20	MEAN	SEM	SIG.
PCV (%)	29.84	29.06	30.07	30.01	30.63	29.92	0.32	NS
Hb(g/dL)	6.78 ^{b}	8.76^a	9.24^a	9.52^a	9.24^a	8.71	0.28	*
RBC(×10^6uL)	3.22	2.83	2.95	3.37	3.31	3.13	0.11	NS
MCV (fl)	42.09	39.28	40.03	42.31	42.55	41.25	0.67	NS
MCH (pg)	70.11^b	70.01^b	73.03^{ab}	75.83^a	72.74^{ab}	72.84	0.76	NS
MCHC (%)	84.10	81.86	80.21	81.78	84.80	82.55	1.04	NS
WBC(×10^3uL)	5.41^c	6.11^b	7.42^a	7.08^a	7.56 ^{a}	6.71	0.23	*
LYM(×10^3uL)	7.34^b	8.02^{ab}	8.19^{ab}	8.37^a	8.86^a	8.15	0.16	*
MON(×10^3uL)	0.82	0.64	1.34	1.48	1.35	1.12	0.12	NS
HET (×10^3uL)	2.18	2.26	2.23	2.36	2.54	2.31	0.05	NS
EOS (×10^3uL)	0.62	0.78	0.66	0.84	0.59	0.70	0.05	NS

3.4. Serum biochemical indices of Noiler chicken fed graded level of Maize cob and Groundnut shell marsh.

Table 3.4 presented Serum biochemical indices of Noiler chicken fed graded level of Maize cob and Groundnut shell marsh. The values ranged between Albumin (ALB) 1.68-2.13 g/dl, Globulin (GLO) 1.81-2.02g/dl, Try (Mg/dL)38.81-42.96mg/dl, T.bil (Mmol/L)0.98-1.76Mmol/dl, Urea (URE) 31.66-34.25mg/dl, Creatinine (Creat) 1.14 -1.55mg/dl, Alkaline phosphate (ALP) 36.39-44.52iu/L, Asparte aminotransferase (AST) 92.90-99.21iu/L and Alanine aminotransferase (ALT) 63.62-76.11 iu/L, respectively. There were no significant difference in the value of Alb (g/dL), Glo (g/dL), Ure (Mg/dL), AST (iu/L) and ALP (iu/L) (P>0.05). But there were significant differences in the value of Creat. (Mg/dl), Try (Mg/dL),T.bil (Mmol/L) and ALT (iu/L) (P<0.05) .

Table 3.4

	% LEVEL OF MCGS INCLUSION							
Parameters	**0**	**5**	**10**	**15**	**20**	**MEAN**	**SEM**	**SIG.**
Alb (g/dL)	1.68^{b}	1.95^{ab}	1.99^{ab}	1.90^{ab}	2.13^{a}	1.93	0.06	NS
Glo (g/dL)	1.81	1.86	1.93	1.98	2.02	1.92	0.03	NS
Creat. (Mg/dl)	1.14^{c}	1.37^{bc}	1.82^{a}	1.61^{ab}	1.55^{b}	1.49	0.06	*
Try (Mg/dL)	38.81^{b}	39.98^{ab}	41.80^{ab}	42.96^{a}	42.75^{a}	41.26	0.56	*
T.bil(Mmol/L)	0.98^{b}	1.44^{a}	1.40^{a}	1.56^{a}	1.76^{a}	1.43	0.08	*
Ure (Mg/dL)	31.66	34.32	32.79	32.80	34.25	33.16	0.40	NS
ALT (iu/L)	63.62^{b}	64.21^{b}	75.51^{a}	74.98^{a}	76.11^{a}	70.88	1.89	*
AST (iu/L)	92.90	94.65	96.89	97.04	99.21	96.14	1.20	NS
ALP (iu/L)	36.39^{d}	41.04^{c}	42.16^{bc}	43.32^{ab}	44.52^{a}	41.48	0.78	NS

3.5 Carcass Characteristics and Relative Organ Weights Noiler chicken fed graded level of Maize cob and Groundnut shell marsh

The carcass characteristics of Noiler chicken fed graded level of Maize cob and Groundnut shell marsh is presented in Table 3.5. The live weight (757.00 - 815.00g), Dressed weight (685.00 - 722.66g), Dressing percentage (65.16 -74.32g) and Eviscerated weight (495.16 - 617.33 g) while, weight of Head (32.33-52.66 g), , Wing (73.66-79.33 g) ,Leg (53.66 - 60.00 g),Drumstick (68.66 - 76.66),Neck (g)(36.00-46.66), Breast (g) (101.00 -131.00) Back (g) (91.33 - 105.33) Thigh (g)(75.33 - 89.66), Liver(g) (16.00 -16.66),Heart (g) (0.83 -0.79), Intestine length(cm) (127.33 - 149.33),Gizzard (g)(32.66-44.00) respectively

Table 3.5

	% LEVEL OF MCGS INCLUSION					
Parameters	**0**	**5**	**10**	**15**	**20**	**SEM**
Live weight(g)	757.00	824.00	681.00	889.00	815.00	71.11
Dressed weight(g)	685.00	758.66	632.00	716.00	722.66	60.75
Eviscerated weight (g)	495.16	673.00	510.50	638.66	617.33	56.57
Dressing percentage (%)	65.16^{b}	82.16^{a}	75.07^{ab}	71.76a^{b}	74.32^{ab}	1.88
Head (g)	32.33	34.00	36.00	38.00	52.66	3.32
Wing (g)	73.66	79.00	67.50	75.66	79.33	6.90
Legs (g)	53.66	56.00	43.50	48.00	60.00	4.33
Drumstick (g)	68.66	89.33	58.00	81.33	76.66	8.08
Neck (g)	36.00	47.66	40.00	58.16	46.66	5.08
Breast (g)	101.00	51.33	105.50	137.50	131.00	14.24
Back (g)	91.33	128.33	92.00	102.66	105.33	9.22
Thigh (g)	75.33	83.66	70.00	79.66	89.66	7.82
Liver(g)	16.00	19.00	22.00	16.66	16.66	1.67
Heart (g)	0.83	0.72	0.79	0.80	0.79	0.02
Intestine length(cm)	127.33	127.33	151.50	138.66	149.33	6.09
Gizzard (g)	32.66	49.66	44.00	50.66	44.00	4.43

3.6.0 Economy of production

The cost per #/kg of feed reduces across the treatment due to the lesser cost of the test ingredient maize cob and groundnut shell marsh. Treatment 4 and 5 has higher cost per kg gain due to it high feed conversion ratio.

Table 3.8

	% LEVEL OF MCGS INCLUSION				
Parameters	**0%**	**5%**	**10%**	**15%**	**20%**
Initial weight (g)	46.53	47.20	47.00	46.66	46.43
Final weight(kg)	1.25	1.31	1.242	1.17	1.15
Cost per kg feed(#/kg)	167	161	156	151	150
Total feed intake(g)	6.70^{ab}	5.74^{b}	6.63^{ab}	7.14^{a}	7.17^{a}
Daily feed intake(g)	79.79^{ab}	68.44^{b}	78.94^{ab}	85.09^{a}	85.40^{a}
Feed conversion ratio	5.57^{ab}	4.58^{b}	5.58^{ab}	6.32^{a}	6.77^{a}
Total feed cost (#)	13,326.29	11,019.37	12,315.77	12,849.89	12,811.47
Total Weight gain(kg)	1.20	1.26	1.19	1.13	1.10
Cost per kg gain (#)	930.18	738.04	871.24	955.07	1,016.73

4.0. Discussion

The maize cob and groudnut shell marsh contain crude protein (14.11%), dry matter(85.15%), crude fibre(20.71%), ether extract(1.86%), total ash (4.22%)and metabolizable energy of 3280.6 kcal/kg. According numerous studies crude fibre was considered as an anti-nutritional factor due to it adverse effect on feed intake and nutrient digestibility also it was noted to have vital effect on the gastro intestinal tract development, digestive physiology and nutrient absorption in poultry birds nutrition. Noiler chicken are known to be efficient converted of feed into meat and egg, due to their ability to utilize low quality feed ingredient. Hence high crude fibre content didn't hinder their performance. According to Mokolopi, 2022 groundnut shell contains 0.50% crude protein, 59.0% crude fiber, 2.50% ash While, Irabor *et al.,* 2022 reported crude protein (5.29%) crude fibre (34.77%). The results obtained for the performance were in agreement with Donkoh *et al.,* 2003, whose, inclusion of maize cob marsh in the diets of broiler has no significant effect on the weight gained Animasahun *et al*., 2021 reported no significant (P>0.05) differences in the growth performance of noiler chicken fed *Parkia biglobosa* leave meal (PBLM).According to Attia *et al*., (2018) haematological analysis is important in assessing the suitability and quality of the non-conventional feed ingredients for the animal. These parameters are influenced by age, sex, toxic compounds and feed content.

Polat *et al.* (2011) reported values of 1.12-1.22mg/dl creatinine in Arbor acre. Which is in agreement with the creatine values obtained across the treatment for serum biochemistry. Furthermore, Yakubu *et al.* (2009) reported that Albumin value of Arbor acre and Titan Anak were 2.77g/dl and 2.48g/dl respectively which also is similar with the result obtained. Donkoh *et al.,* (2003) reported that were no effect on the carcass characteristics of broiler chickens fed maize cob at various inclusion level in their diet which is also in agreement with the result obtained. The cost of feed was also minimal across the treatment.

5.0 Conclusion

The experiment investigated the effect of feeding graded level of maize cob and groundnut shell marsh in partial replacement of maize on the performance characteristics of Noiler chicken. The utilization of non-conventional feed material has become very important as it helps reduces the competition between human and animals, thereby reducing cost of production. Based on the result obtained and physical examination of the experiment for a period of 12 weeks, it is recommended to include maize cob and groundnut shell marsh up to 20% as partial replacement of maize grain in the diet of Noiler birds. Since it doesn't have negative effect on the performance, blood profile and carcass quality of the chicken.

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On Collocation Methods for Solving First-Order Volterra Type Linear Integro-Differential Equations

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Abstract

The numerical solutions of linear Volterra-type integro-differential equations (VIDEs) have been considered in this paper. We propose using the third kind of Chebyshev polynomial as the basis function to approximate the solution of the problems using **MAPLE 2018** software. Standard collocation points were chosen to collocate the approximate solution, and numerical experiments were performed on some sample problems already solved by the finite difference method and the method of power series as a basis polynomial, utilizing both the standard and Chebyshev-Gauss-Lobbatto collocation points. Furthermore, we compared our results to some previously published findings. Our proposed method yields superior approximate solutions and exhibits significantly lower absolute errors compared to the existing method. Furthermore, the absolute errors obtained are exceptionally minimal, indicating both convergence and computational efficiency.

Keywords: Chebyshev polynomial, Collocation, Approximate solution and Volterra Integro-differential equation

INTRODUCTION

This paper considers the collocation method for VIDEs, there has been extended research in recent years on integral and integro-differential equations for physical systems with memory effects in which stability and asymptotic stability have been the main interest. These numerical analyst aims to produce an efficient and effective method for obtaining a numerical solution to problems that prove difficult in getting their solution in a closed-form. There exist numerous numerical techniques to solve Integro-differential equation such as Wavelet-Galerkin Method (WGM) by (Avudainayan & Vani 2000), Homotopy Analysis Method (HAM) by (Kunjan Shah & Twinkle Singh, 2015).

Furthermore, the application of the Taylor, Chebyshev, Hermite, Legendre, and Laguerre polynomials and their numerical merits in solving integral and integro- differential equations (IDEs) numerically have been discussed in (Akyuz & Sezer, 2003), (Maleknejad & Mahmoudi, 2003), (Taiwo, O. A., Alim, A. T. & Akanmu, M. A., 2014), and (Richard & Roderick, 2010). Furthermore, many techniques such as a new algorithm for calculating Adomian polynomials, (Hashim, 2006), Chebyshev polynomials by (Eslahchi, M. R., Mehdi, D., Ayinde et al., 2021 & Sanaz, A., 2012), Chebyshev and Legendre by (Abubakar & Taiwo, 2014), Homotopy Perturbation Method (HPM), (Wazwaz, 2011) and, Variation Iteration Decomposition Method (VIDM) by (Ignatius & Mamadu, 2016). Application of Adomian's decomposition method on Integro- differential equation also examined by (Wazwaz, 2001) and others have been used to derive solutions of some classes of integro- differential equations. The great work did by the researchers aforementioned motivated us to develop a numerical approximation method that is efficient and accurate with less computational work to obtain an approximate solution for LVIDEs.

2. Basic Definitions

Definiion 2.1

An integro-differential equation is an equation in which the unknown function $g(x)$ appears under the integral sign and contains an ordinary derivative $g^{(s)}$ as well. A standard integro-differential equation is of the form;

$$g^{(m)}(x) = f(x) + \lambda \int_{\alpha(x)}^{\beta(x)} K(x,s)\, g(s)ds \qquad (1)$$

where $\alpha(x)$ and $\beta(x)$ are the limits of integration which may be constants, variables, or combined. λ is a constant parameter, $f(x)$ is a given function and $K(x, s)$ is a known function of two variables x and s called the kernel.

Definition 2.2

Volterra integro-differential equations (Wazwaz 2015)

Volterra integro-differential equations of the form:

$$g^{(m)}(x) = f(x) + \lambda \int_0^x K(x, s)\, g(s)ds \qquad (2)$$

where $g^{(m)}$ indicate the m^{th} derivative of $g(x)$, $K(x.s,)$, and function f(x) are given real-valued functions and λ is a constant parameter.

Definition 2.3

Chebyshev Polynomials:

The Chebyshev polynomial denoted by $T_n(x)$ and valid in the interval $a \leq x \leq b$ is defined as

$$T_n(x) = \cos n \left[n \cos^{-1} \left(\frac{2x - (a+b)}{b-a} \right) \right], n = 0, 1, 2, \ldots \quad (3)$$

and the recurrence relation is given as

$$T_{n+1}(x) = 2 \left[\frac{2x - (a+b)}{b-a} \right] T_n(x) - T_{n-1}(x), \quad a \leq x \leq b \quad (4)$$

Definition 2.4

Chebyshev polynomials of third kind (*Ayinde et al., 2022*)

The Chebyshev polynomial of the third kind in [-1, 1] of degree m is represented by $T_n(x)$ where:

$$T_n(x) = \cos \frac{\left(n+\frac{1}{2}\right)\vartheta}{\cos\left(\frac{\vartheta}{2}\right)}, \text{ where } x = \cos\vartheta \quad (5)$$

This elegance of Chebyshev polynomials satisfied the subsequent recurrence relation given by

$$T_0(x) = 1, \quad T_1(x) = 2x - 1, T_n(x) = 2xT_{n-1}(x) - T_{n-2}(x), \qquad n = 2, 3, \cdots \quad (6)$$

The Chebyshev polynomial of the third kind in [a, b] of degree, m is represented by $T_n(x)$

$$T_n^*(x) = \cos \frac{\left(n+\frac{1}{2}\right)\vartheta}{\cos\left(\frac{\vartheta}{2}\right)}, \cos\vartheta = \frac{2x-(a+b)}{a-b}, \quad \vartheta \in [0, \pi] \quad (7)$$

Definition 2.5

Approximate solution: *(Ayinde et al. 2021)*

Approximate solution is an inexact representation of the exact solution that is still close enough to be used instead of exact and it is denoted by ζ(x), where is the degree of the approximant used in the calculation. Methods of the approximate solution are usually adopted because complete information needed to arrive at the exact solution may not be given. In this work, the approximate solution used is given as

$$\zeta(x) = \sum_{i=0}^{N} c_i \varphi_i(x) \quad (8)$$

where C$i = 0, 1, 2, \ldots, M$ are unknown constants to be determined, $\varphi_i(x)$ $(i \geq 0)$ are the third kind of Chebyshev polynomials described in equations (5-7) and is the degree of approximating polynomials.

Definition 2.6

Exact Solution (*Ayinde et al., 2022*)

A solution is called an exact solution if it can be expressed in a closed form, such as a polynomial, exponential function, trigonometric function, or the combination of two or more of these elementary functions.

3. Methodology

The general problem considered is of the form

$$a_{01}y^n + a_{11}y^{n-1} + a_{21}y^{n-2} + \ldots + a_{n1}y(x) + \lambda \int_{h(x)}^{i(x)} K(x, s)\, y(s)\, ds = f(x) \tag{9}$$

subject to boundary conditions.

$$y(b) = \text{A},\ y(a) = \text{B} \tag{10}$$

where *h(x)* and *i(x)* are the limits of integration which may be constants, variables or combined, λ is a constants parameter, *f(x)* is a given function, and K (*x, s*) is called kernel.

In order to solve equations (9) and (10) using the standard method, we assumed an approximate solution of the form

$$y_n(x) = \sum_{i=0}^{N} a_i T_i^*(x) \quad i \geq 0 \tag{11}$$

where N is the degree of our approximant, *ai,* are the unknown constants to be determined and Ti, (*X*) are the third kind Chebyshev polynomials defined in equation above

Thus, differentiating equation (11) n times, we obtain

$$\left.\begin{aligned} y' &= \sum_{i=0}^{N} a_i T_i^{*\prime}(x) \\ y'' &= \sum_{i=0}^{N} a_i T_i^{*\prime\prime}(x) \\ &\vdots \\ y^n &= \sum_{i=0}^{N} a_i T_i^{*n}(x) \end{aligned}\right\} \tag{12}$$

Hence substituting (12) into equation (9) to obtain

$$a_{01}\sum_{i=0}^{N} a_i T_i^{*n}(x) + a_{11}\sum_{i=0}^{N} a_i T_i^{*(n-1)}(x) + \ldots + a_{n1}\sum_{i=0}^{N} a_i T_i^{*n}(x) + \lambda \int_0^x k(x,t)\left(\sum_{i=0}^{N} a_i T_i^{*n}(t)\right) dt = f(x) \tag{13}$$

Evaluating the integrals, we obtain

$$a_{01}\sum_{i=0}^{N} a_i T_i^{*n}(x) + a_{11}\sum_{i=0}^{N} a_i T_i^{*(n-1)}(x) + \ldots + a_{01}\sum_{i=0}^{N} a_i T_i^{*n}(x) + \lambda G(x) = f(x) \qquad (14)$$

where $G(x) = \int_0^x K(x,t)\left(\sum_{i=0}^{N} a_i T_i^{*n}(t)\right)dt$

Thus, collocation at point $X = Xk$, we obtain

$$a_{01}\sum_{i=0}^{N} a_i T_i^{*n}(x_k) + a_{11}\sum_{i=0}^{N} a_i T_i^{*(n-1)}(x_k) + \ldots + a_{n1}\sum_{i=0}^{N} a_i T_i^{*n}(x_k) + \lambda G(x_k) = f(x_k) \qquad (15)$$

where $x_k = a + \frac{(b-a)k}{N}$; k = 1, 2, . . ., N – 1.

Equation (15) gives rise to (N - 1) algebraic linear equation in (N + 1) unknown constants. Two extra equations are obtained from the conditions in equation (10). Altogether, we now have (N + 1) algebraic equations in (N + 1) unknown constants. These equations are then solved using Maple 2018 software to obtain the (N + 1) unknown constants $a_i (i \geq 0)$ which are then substituted back into the approximate solution given by equation (11).

4. Results

In this section, standard points have been employed to solve sample problems. The numerical solutions obtained using the present method had been compared with the exact solutions of the sample problems. Similarly, absolute errors of results from this present method have been compared with those obtained in Behrouz (2010) by finite difference method (FDM) and the use of power series as basis polynomial utilizing both the standard and Chebyshev-Gauss-Lobbatto collocation points for the same problems by Agbolade and Anake (2017). In the tables the following notations were used.

SCM_1: Solution via standard collocation using Power series as basis polynomial.
SCM_2: Solution via standard collocation using third kind Chebyshev polynomial as basis polynomial, which is the proposed method in this paper.

CGLCM: Solution via Chebyshev-Gauss-Lobatto collocation Method using third kind Power series basis polynomial.

Numerical Example 1

Consider the Linear Volterra linear integro-differential equation (Agbolade and Anake, 2017)

$$y'(x) = -y(x) - (x^2 - 2x + 1)e^{-x} + 5x^2 + 8 - \int_0^x t\, y(t)dt \qquad (12)$$

subject to initial condition

$$y(0) = 10 \tag{13}$$

The exact solution is given as $y(x) = 10 - xe^x$ (14)

Table 1.1 Comparison of exact solutions with approximate solutions for Numerical Example 1

x_i	Exact	SCM_2
0.0000	10.00000000	10.000000000
0.0714	9.933520218	9.933520218
0.1429	9.876128457	9.876128457
0.2143	9.827037138	9.827037139
0.2857	9.785299870	9.785299871
0.3571	9.750136229	9.750136229
0.4286	9.720801197	9.720801197
0.5000	9.696734670	9.696734670
0.5714	9.677310846	9.677310846
0.6429	9.661985366	9.661985366
0.7143	9.650325388	9.650325389
0.7857	9.641877524	9.641877522
0.8571	9.636254445	9.636254445
0.9286	9.633104130	9.633104128
1.0000	9.632120559	9.632120559

Table 1.2 Absolute Errors for Numerical Example 1

x_i	**Error in SCM$_1$**	**Error in CGLCM** (Agbolade & Anake (2017))	**Error in FDM** (Behrouz (2010))	**Error in SCM$_2$**
0.0000	0.0000000000	0.0000000000	0.0000000000	0.0000000000
0.0714	1.72431 E – 06	5.91262 E– 06	2.85397 E – 04	0.0000000000
0.1429	1.92637 E – 06	2.31105 E– 05	2.98284 E – 04	0.0000000000
0.2143	1.77825 E – 06	4.91013 E– 05	5.43393 E – 04	1.0E-09
0.2857	1.63695 E – 06	7.92123 E– 05	5.11413 E – 04	1.0E-09
0.3571	1.51288 E – 06	1.06967 E– 04	7.15638 E – 04	0.0000000000
0.4286	1.34028 E – 06	1.24865 E– 04	6.54200 E – 04	0.0000000000
0.5000	1.09939 E – 06	1.25617 E– 04	8.18261 E – 04	0.0000000000
0.5714	8.36590 E – 07	1.03879 E– 04	7.38321 E – 04	0.0000000000
0.6429	6.24770 E – 07	5.85256 E– 05	8.64022 E – 04	0.0000000000
0.7143	5.03018 E – 07	4.48751 E– 06	7.73248 E – 04	1.0E-09
0.7857	4.31615 E – 07	6.86526 E– 05	8.63249 E – 04	2.0E-09
0.8571	2.95402 E – 07	1.02783 E– 04	7.66939 E – 04	0.0000000000
0.9286	1.39661 E – 08	5.62088 E– 05	8.24573 E – 04	2.0E-09
1.0000	4.08829 E – 07	1.46741 E– 04	7.26353 E – 04	0.0000000000

Numerical Example 2

Consider the Linear Volterra linear integro-differential equation (Agbolade and Anake, 2017)

$$y'(x) = -y(x) + \int_0^x e^{t-x}\, y(t)dt \tag{15}$$

subject to initial condition

$$y(0) = 1 \quad (16)$$

The exact solution is given as $y(x) = e^{-x}coshx$ (17)

Table 1.3 Comparison of exact solutions with approximate solutions for Numerical Example 2

x_i	Exact	S SCM_2
0.0000	1.0000000000	0.9999862060
0.0833	0.9232690798	0.9232552092
0.1667	0.8582417719	0.8582278950
0.2500	0.8032653300	0.8032515254
0.3333	0.7567256737	0.7567120165
0.4167	0.7172846180	0.7172711789
0.5000	0.6839397204	0.6839265676
0.5833	0.6557119923	0.6556991912
0.6667	0.6317897828	0.6317773951
0.7500	0.6115650802	0.6115531624
0.8333	0.5944440975	0.5944326997
0.9167	0.5799345438	0.5799237081
1.0000	0.5676676417	0.5676573973

Table 1.4. Absolute Errors for Numerical Example 2

x_i	**Error in SCM_1 (Agbolade & Anake, 2017)**	**Error in CGLCM**	**Error in FDM**	**Error in SCM_2**
0.0000	0.0000	0.0000	0.0000	$1.37940E-05$
0.0833	$9.76008E-06$	$4.61438E-05$	$1.77203E-02$	$1.38706E-05$
0.1667	$9.82124E-06$	$7.55931E-05$	$2.16887E-03$	$1.38769E-05$
0.2500	$8.43856E-06$	$7.54254E-05$	$1.89273E-03$	$1.38046E-05$
0.3333	$7.74622E-06$	$4.08918E-05$	$4.52374E-03$	$1.36572E-05$
0.4167	$7.56304E-06$	$2.06182E-05$	$2.06181E-02$	$1.34391E-05$
0.5000	$7.32270E-06$	$8.83487E-05$	$7.13624E-03$	$1.31528E-05$
0.5833	$6.79994E-06$	$1.31400E-05$	$1.10585E-02$	$1.28011E-05$
0.6667	$6.15006E-06$	$1.18269E-05$	$8.20866E-03$	$1.23877E-05$
0.7500	$5.64809E-06$	$3.47095E-05$	$3.41335E-03$	$1.19178E-05$
0.8333	$5.40361E-06$	$8.79889E-05$	$8.16328E-03$	$1.13978E-05$
0.9167	$5.23390E-06$	$1.32084E-05$	$2.89396E-03$	$1.08357E-05$
1.0000	$4.79838E-06$	$1.62442E-05$	$3.27168E-03$	$1.02444E-05$

Discussion and Conclusion

Tables 1.1 and 1.3 display the numerical solutions obtained using the Volterra Integro-Differential Equations (VIDEs) solved with the basis function of third-kind Chebyshev polynomials. Comparing the absolute errors of the results obtained by the present method (SCM_2) with those obtained by the finite difference method for the same problems, it is evident that the method is both efficient and cost-effective for obtaining numerical solutions of first-order Volterra-type integro-differential equations. These findings are illustrated in Tables 1.2 and 1.4. Furthermore, the third-kind Chebyshev basis polynomial serves as an excellent approximation for these problems, producing results that compete favorably with existing methods.

Authors Contribution:

1. William D. (dunamakadiri@gmail.com)- Development of Scheme and Results
2. James A.A. - Implementation of schemes
3. Ayinde A. M. (ayinde.abdullahi@uniabija.edu.ng.) – Grammar & Plagiarism Checking
4. Oyedepo T. (oyedepotaiye@yahoo.com)- Editing & Typing of manuscript

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