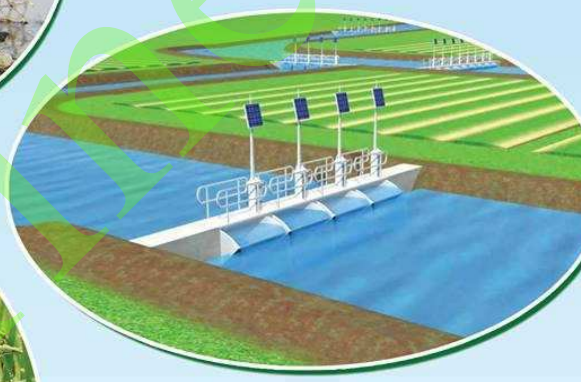
Initiation for Information..

THE AGRINEER 2016

Volume 5



An Annual Publication of

Nepal Agricultural Engineering Students' Society (NAESS)

IOE, Purwanchal Campus

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Editorial...

It is the moment of great pride and happiness to come with the fifth volume of our technical journal entitled "The Agrineer". The idea of publishing a new volume of this journal was a real excitement and courage with small time bound. The Agrineer is not just complilation of page it is the compilation of meaningful pages which carries a knowledge about the different topics of agricultural engineering. It include research articles and informative articles that benefit all of our agricultural engineering student and related professionals.we aim to correct the shortcoming of volume-4 in this new edition.

Agricultural engineering are swiftly evolving fields that integrate the principles of biological and physical sciences and use them to solve agricultural and environmental problems. Engineers in these fields design systems and equipment that increase agricultural productivity and food safety. They also manage and conserve soil, water, air, energy, and other agricultural resources. As an agriculture engineering major, you'll learn the skills of engineering as they relate to agriculture, food production, and resource conservation.

Agricultural engineers apply their knowledge of biological and agricultural systems and engineering to equipment design and assure environmental compatibility of practices used by production agriculture. This includes all activities related to agriculture and horticulture for smooth functioning and efficient increase of food productivity, improvement in agriculture farm machinery, farm structure, rural electrification, biogas, new technology in the design and manufacture of agriculture products, conservation of soil and water are the major jobs handled by agriculture engineers.

We are thankful to all the seniors,purwanchal campus agricultural engineering department,student's union and campus administration who helped us in every steps of our journey for publishing the journal.

नेपाल सरकार

मा. गौरी शंकर चौधरी
कृषि विकास मन्त्री

Message from the Agriculutre Development Minister

I am glad to know that the Nepal Agricultural Engineering Students' Society (NAESS) of Institute of Engineering, Purwanchal Campus is publishing its Fifth Edition of Technical journa "AGRINEER" in 2017.

Agriculture is the backbone of Nepalese economy which contributes about one third of nationa GDP and employs about 66% of total labor force in the country, is still practicing at below subsistence level. Therefore, there is a great need of commercialization of agriculture. Farm mechanization, food processing, soil conservation and water management, rural energy anc farmsted management plays a vital role in agricultural production.

Moreover, outflow of unskilled and semi-skilled rural youth to international market is a majoı challenge. "Making Pride is Agriculture" is necessary for the country is required to make sustainable economy of the country. The double digit GDP and food insecurity can be solved by the application of agricultural engineering technologies.

I would therefore like to congratulate NAESS and its team for the collaborative effort for its publication of technical journal for the sector of agriculture and Nepalese economy as a whole.

Wishing all the best for the success of marking yet another milestone for the Nepalese agriculture and engineering.

.....

Gauri Shankar Chaudhary
Agriculture Development Minister

TRIBHUVAN UNIVERSITY

Kirtipur, Kathmandu, Nepal

OFFICE OF THE VICE CHANCELLOR

November 18, 2016

MESSAGE FROM THE VICE CHANCELLOR

It gives me immense pleasure to observe the successful publication of the magazine 'THE AGRINEER', by Nepal Agricultural Engineering Student's Society, Purwanchal Campus, Institute of Engineering, Tribhuvan University, Dharan.

This magazine is focusing on the modern technologies, research works, innovative ideas, and contemporary issues in the field of Agricultural Engineering. It aims to develop a platform for integration of agricultural students, researchers, scientists, academicians, entrepreneurs, and other scientific societies and academic institutions of the country with international societies for promotion of interaction among research workers across the country and abroad.

I would like to congratulate the Editorial Board for maintaining the quality of the magazine with publishing high standard research articles and maintaining the regularity of the publication. Finally, I would like to express full support of the university to this society in its endeavors to achieve greater heights in the days to come.

Prof. Tirth Raj Khaniya, Ph.D.
Vice-Chancellor

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Date: 21st December 2016

Message from the Dean

I am gratified to know that the 'Nepal Agricultural Engineering Students Society' of Institute of Engineering, Purbanchal Campus, Dharan is bringing out 5th Volume of their technical journal **"Agrineer"**.

The Institute of Engineering (IOE) being the centre of excellence for engineering education in Nepal; it has greater role to achieve its goal and provide excellent manpower to the nation. This can be possible only by setting a mission of quality engineering education in the frontier engineering areas relevant primarily to the nation thereby enhancing national development process. I believe this publication will be one of such steps to achieve the national development goal.

The most important aspect we could derive from this stupendous effort is that it brings out the various technical and analytical skills of the promising engineers. I also applaud the coordination and efforts behind the team to bring out this issue. I congratulate all the contributors and the editorial board for bringing out such a beautiful journal and glad to welcome students with more interest in bringing the article with more bright concepts and innovative ideas in the next issue. I wish them to experience victory in all of their future endeavors.

Prof. Dr. Tri Ratna Bajracharya

Dean

Institute of Engineering
Office of the Dean

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पू.क्या.फा.नं. ( ) च.नं. 651/073-074

मिति : २०७३/११/०३ गते

Message from the Campus Chief

It is my immense pleasure to know that our students of Agricultural Engineering Department are going to publish the "Agrineer Vol-5", a technical magazine through Nepal Agricultural Engineering Students Society (NAESS).

It is my core belief that such magazine helps to disseminate technical knowledge and upgrade the understanding & skills of students in the area agricultural engineering. In the country, such program is run at IOE/Purwanchal Campus only and I hope the articles will assist the innovative and constructive ideas in the concerned.

I would like to thank specially the business organizations, entrepreneurs, industrialists that have helped this magazine with their advertisements and financial helps. I hope such type of co-operation will be in future too.

Finally, I would like to congratulate the members of NAESS for their hard work in publishing the magazine. I wish the success for the magazine and hope the continuation in future too.

Jeetendra Chaudhary

Campus Chief

Campus Chief
Purwanchal Campus
Dharan-8

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मिति : २०७३/११/०१

MESSAGE FROM DEPUTY PROGRAM CO-ORDINATOR

It is indeed a great pleasure to express my word in the fifth edition of Agricultural Engineering Students Society's (NAESS) scholarly publication of AGRINEER.I would like to express mine gratitude to the team and functionaries for the positive effort in bringing out the constructive work in the sector of Agricultural Engineering.

The fact of fragmented small land holding capacity and food insecurity in the country, development of Agricultural Engineering plays a vital role towards the contribution towards GDP of country. Focusing on the goal to achieve double digit GDP, Department of Agricultural Engineering concentrates on high crop productivity, farm mechanization, farm shed management, entrepreneurship and advanced water and soil management. The constructive support and encouragement of the team plays a great role for the development and growth of significant role in the sector of Agricultural Engineering.

Finally, I would like to congratulate all the positive effort of The AGRINEER team for the commendable scholarly efforts for the contribution to the society.

.....

(Sameer Shakya)
Deputy Program Coordinator
Department of Agricultural Engineering.

Regd No. 29/046/047

नेपाल कृषि इन्जिनियर्स सोसाइटी

Nepalese Society of Agricultural Engineers

Message from Chairperson

First academic journal was published in the 17th century, beginning with the Journal des Sçavans in 1665 and followed by the Philosophical Transactions of the Royal Society of London a year later. The importance of a journal as a means of wider disseminating knowledge has grown considerably since then. Journal articles are generally given greater prestige and merit within the scientific community, relative to other forms of disseminating research findings because published journal articles generally have gone through a rigorous screening process known as peer review. Articles published in peer reviewed journals are likely to remain a very important means of distributing research findings for the foreseeable future.

The most advantage of publishing a paper in a journal is an additional point you can provide on your Curriculum Vitae – actually a very important point. The more of these points there are on your CV, the more attractive it will appear to prospective employers, particularly, if those employers are academic institutions who keep their eyes on the ranking in the research arena. Other benefits of publishing article in the journal are that it brings your name out in your professional field, and heightens your academic reputation. Publishing your findings in the journal is particularly important career step but, like all things that are worthwhile, it takes time; it also gets easier with practice. So don't wait any longer. Start writing the journal paper now. This is the message I would like to convey to all my prospective Agricultural Engineers Colleagues.

I am very much pleased to know that Nepal Agricultural Engineering Student's Society of Purwanchal Campus is publishing a journal "Agrineer" covering wide range of topics of technical, social, economical and environmental importance and related to Agricultural Engineering. I wish all the best!

Dr. Laxmi Devkota
Chairperson
Nepalese Society of Agricultural Engineers
January 1, 2017

TRIBHUVAN UNIVERSITY
Institute of Engineering
Nepal Agricultural Engineering Students Society
Purwanchal Campus
Dharan-8,Sunsari

Message from President

It's a matter of immense pleasure and honored to all of us agricultural engineers for bringing new issue of our regular technical journal, Fifth volume of '*The Agrineer*'. Finally, our hard work has come to an end.

"Agricultural Engineering" the branch of engineering that deals with the design of farm machinery, the location and planning of farm structures, farm drainage, soil management and erosion control, water supply and irrigation, rural electrification, and the processing of farm products. Despite having great scope and importance we are deprived from the opportunities for the development of agriculture sector in Nepal. I hope that our journal will work for the change in the mindset of planners, policy makers and stakeholders about necessity of hiring an agricultural engineer for the development of agriculture in Nepal. There is no doubt that this journal will play an effective role in realizing the fact what an agricultural engineer can do.

Finally I am extremely thankful to the Co-coordinator of '*The Agrineer Vol.5*' publication team Mr. Ayush Poudel, and his whole team who had worked hard without considering day or night to bring this journal in an effective way.

I am very indebtful to our Purwanchal Campus, IOE Dharan and our department of agricultural engineering without whose efforts this was not possible. I am so grateful to all organization who had given us advertisements in our journal and assisted us in many manner.Finally I am thankful to everyone who are part of us in our journal '*The Agrineer*'.

President

Bibek Neupane

TRIBHUVAN UNIVERSITY
Institute of Engineering
NEPAL AGRICULTURAL ENGINEERING STUDENTS SOCIETY
Purwanchal Campus
Dharan-08 Sunsari

Message from Co-Ordinator

It feels immense pride and honoured to work as a co-ordinator of entire family of "The Agrineer volume-5" publishing through NAESS Nepal, Purwanchal Campus.

The journal has tried its almost best to share the researches and knowledge of several engineering experts of Nepal. I believe this journal will provide us the benchmark for continued improvement in overall development of agricultural engineering.

As well know about the country's high dependency on agriculture, this type of document will help not only in transferring the new knowledge and development that are being made in a wider context for the betterment and upgrading the existing technologies and skill. As agriculture is one of the most important sector of country's development in which agricultural engineering is a very supporting part so the Agrineer, collection of agriculture related research papers, is helpful for all agricultural related persons as I hope.

At last but not least, I would like to express my sincere gratitude and respect to Er. Jawed Alam, Er. Samir Shakya, Alankar kafle and Er. Sagar Kafle for their advice, suggestions and encouragement. I am heartily thankful to all the advisors, teachers, staffs, professionals, students and everyone who provided their helping hands for this publication. We are indebted by your support and cooperation and expect the same in the future too.

Ayush Poudel
Co-ordinator, Agrineer Vol-05

CONTENTS

USAGE AND PREFERENCE OF EXTENSION COMMUNICATION CHANNELS BY FARMERS OF KAILALI DISTRICT, NEPAL

Milan Subedi, Sandhya Rijaland Manish Subedi
Institute of Agriculture and Animal Science

ABSTRACT

A study was carried out among 120 sample farmers of Kailali district in 2015in western Nepal for assessing usage and preference of communication channels in obtaining agricultural information by the farmers. The different communication channels considered during the study were neighbor, progressive farmers, agro vets, extension workers, radio, television, landline phone, cell phone, newspapers, internet and indigenous channels which were analyzed to find relationship with personal attributes, socio economic and situational characteristics of farmers. The farmers have access, preferences and are using neighbor, radio, television, cell phone and extension worker as the source of technological knowledge respectively. Neighbor as an information source was found independent of personal attributes and socio economic characteristics of farmer. Radio was highly depended on affiliation to organization and depended on gender and education of farmer. Use of extension worker by farmers highly depends on types of farming, monthly income, age group, presence of service center and use of technology. Neighbour was most preferred communication channel which were followed by radio, television and cell phone.

Key words: Access, Communication channels, Preferences, Usage

INTRODUCTION

Technological transformation developed in core countries still matter in developing countries. Mc Quail (1978) explained, communication serves as media for extending public education and promoting innovation in agriculture, health and population control. Understanding of extension sources and channels used by clients to obtain agricultural information is a prime work for efficient educational method because messages that remain at source cannot lead to change in rural areas (Israel and Wilson, 2006). The extension worker is primary source of new information. However, limited farmers are reachable to extension worker (Okwu and Daudu, 2006). Mathur (1994) suggested proper combination of communication channel provide cumulative effect on people through high exposure to an idea results in action thus has great impact. Nepal Agricultural Research Council, Department of Agriculture, Institute of Agriculture and Animal Sciences and other agricultural related International/National Government Organizations are focusing on communication method and channels for the development of agriculture (Mundy and Phuyal, 1999). This study provides the necessary information on the appropriateness or otherwise of the use of communication channels in disseminating information on improved agricultural technologies to farmers in Kailali and similar districts of Nepal. This research further sets up the agenda for selecting suitable channels for the audience: according to availability and accessibility of channels. The study was carries out with objective of finding the use and preference of communication channels in obtaining agricultural information by farmers in Kailali district, Nepal.

MATERIALS AND METHODS

The study was carried in purposively selected four VDCS of Kailali district, viz. Sahajpur, Masuria, Narayanpur and Bhajni VDCs in 2015. 120 respondents were selected randomly, 30 respondents from each VDC. Required information was taken with the help of interview schedule, observation and group discussion. The collected data were coded, tabulated and analyzed using both descriptive tools like mean, standard deviation, percentage and inferential statistical tools. The descriptive statistics was applied to describe the respondents' socio-economic characters such as sex, age, farm size, education etc. To determine the relation between dependent and independent variables chi square test was done. Categorization of age, income, landholding, and livestock holding was made on the basis of mean and standard deviation. The analysis was carried out with the help of statistical software, SPSS version 16.0 and MS -Excel programs.

RESULTS AND DISCUSSION

Demographic characteristics of the respondents

Table 1: Frequency of respondents based on demographic and social characteristics

Characteristics	VDC				Total
	Sahajpur	Masuria	Narayanpur	Bhajni	
Gender					
Male	23 (76.67)	25 (83.33)	22 (73.33)	21 (70.00)	91 (75.83)
Female	7 (5.83)	5 (4.17)	8 (6.67)	9 (7.50)	29 (24.17)
Type of Family					
Nuclear	20 (23.33)	14 (46.67)	14 (46.67)	16 (53.33)	64 (53.33)
Jointed	10 (33.33)	16 (53.33)	16 (53.33)	14 (46.67)	56 (46.67)
Average ± S.E. (No.)	5.10±0.37	6.27±0.31	5.40±0.29	6.87±0.43	5.91±0.18
Standard Deviation (No.)	2.07	1.70	1.59	2.33	2.05
Marital Status					
Married	27 (90.00)	26 (86.67)	30 (100.00)	27 (90.00)	110 (91.67)
Unmarried	3 (10.00)	4 (13.33)	0 (0.00)	3 (10.00)	10 (8.33)
Age					
Average ± S.E. (Yrs)	43.23±2.70	47.53±1.97	39.86±2.93	46.40±2.18	44.25±1.25
Standard Deviation (Yrs)	14.81	10.67	16.05	11.95	13.72

Source: Field Survey, 2015 Figures in parenthesis indicate percentage

One fourth of the respondents of the study were female (24.17 percent) which seems to near with Nepal Living Standards Survey 2010/11 i.e. 26.6 percent (CBS, 2011). Nuclear family (53.33 percent) was higher than Joint family (46.67 percent) in the study area. Average family size was 5.91 can be said as 6 person in a family with standard deviation 2.05. Average age of the respondents was 44.25 years. Young farmers were dominantly distributed in Narayanpur VDC. 91.67 percent of farmers from study area were married.

ECONOMIC CHARACTERISTICS OF FARMER IN SURVEY AREA

From table 2 we can explain that agriculture was the major source of income of the farmers. Nearly half of the total farmers were engaged in other activities along with agriculture for earning their income. Main occupation of the respondents was agriculture and livestock rearing (80.83 percent) followed by business (7.50 percent) and Teacher (5.83 percent).

Table 2: Frequency of respondents based on source of income and occupation

Characteristics	VDC				Total
	Sahajpur	Masuria	Narayanpur	Bhajni	
Source of income					
Agriculture	16 (53.33)	21 (70.00)	14 (46.67)	11 (36.67)	62 (51.70)
Agriculture and Other	14 (46.67)	9 (30.00)	16 (53.33)	19 (63.33)	58 (48.30)
Occupation					
Farmer	21 (70.00)	27 (90.00)	27 (90.00)	22 (73.33)	97 (80.83)
Business	2 (6.67)	1 (3.33)	2 (6.67)	4 (13.33)	9 (7.50)
Service	3 (10.00)	0 (0.00)	0 (0.00)	0 (0.00)	3 (2.50)
Teacher	2 (6.67)	2 (6.67)	1 (3.33)	2 (6.67)	7 (5.83)
Abroad	0 (0.00)	0 (0.00)	0 (0.00)	1 (3.33)	1 (0.83)
Household Chores	2 (6.67)	0 (0.00)	0 (0.00)	1 (3.33)	3 (2.50)

Source: Field Survey, 2015 Figures in parenthesis indicate percentage

Table 3 revealed average monthly income and standard deviation of farmers of Kailali district was Rs. 12033.33 and Rs. 6645.18. Respondents had average land holding size of 1.31 ha, which is higher than national land holding size, 0.2 ha (FAO, 2005). Average livestock holding was 1.30±0.09 LSU which was larger in Masuria and Bhajni and least in Narayanpur VDC.

Table 3: Monthly income, land holding and livestock unit of study area

Characteristics	VDC				Total
	Sahajpur	Masuria	Narayanpur	Bhajni	
Monthly Income					
Average ± S.E. (Rs. '000)	12.17±1.4	10.95±1.11	11.12±1.29	13.90±0.98	12.03±0.60
Standard Deviation (Rs. '00)	76.97	61.10	70.60	53.90	66.45
Land holding					
Average ± S.E. (Ha)	0.35±0.68	1.86±0.18	1.24±0.18	1.80±0.25	1.31±0.11
Standard Deviation (Ha)	0.37	0.99	1.01	1.41	1.17
Livestock holding					
Average ± S.E. (LSU)	1.18±0.16	1.41 ±0.14	1.21 ±0.22	1.41 ±0.20	1.30±0.09
Standard Deviation (LSU)	0.86	0.77	1.23	1.12	1

Source: Field Survey, 2015

USAGE OF DIFFERENT COMMUNICATION CHANNELS

Among Interpersonal communication channel neighbor (82.50 percent) was used daily by of the farmers in study. Radio (85.00 percent) was daily used mass communication channel which was followed by cell phone (78.33 percent) and television (63.33 percent). Neighbour was mentioned as most important channel to get information of improved farm practices (Sinha and Prashad, 1980; Sharma, 1966). Study of Jan *et.al.*(2011) also concluded that neighbor, relative and friends primarily guide rural farmers. According to study of Doordarshan (1994) most of the television viewers in rural area also listen radio. Radio emerged as the most used channel of information input (Singh and Ambastha, 1975). This result is nearly similar to the result of Yadav*et.al* (2011) study, television ranked first in utilization of mass media for agricultural information followed by radio and cell phone. Internet (98.33 percent) was never used by most of the farmer which was followed by Landline phone (90.83 percent). This was because of lack of facility.

Table 4: Frequency of using communication channels

Communication Channels	Frequency				
	Never	Annually	Monthly	Weekly	Daily
Interpersonal					
Neighbour	4 (3.33)	1 (0.83)	3 (2.50)	13 (10.83)	99 (82.50)
Progressive farmer	80 (66.67)	2 (1.67)	7 (5.83)	24 (20.00)	7 (5.83)
Agro vet shop	37 (30.83)	2 (1.67)	62 (51.67)	15 (12.50)	4 (3.33)
Extension Worker	17 (14.17)	13 (10.83)	69 (57.50)	21 (17.50)	0 (0.00)
Mass Media					
Radio	12 (10.00)	0 (0.00)	3 (2.50)	3 (2.50)	102 (85.00)
Landline Phone	109 (90.83)	0 (0.00)	0 (0.00)	5 (4.17)	6 (5.00)
Cell Phone	7 (5.83)	0 (0.00)	2 (1.67)	17 (14.17)	94 (78.33)
Television	18 (15.00)	0 (0.00)	3 (2.50)	23 (19.17)	76 (63.33)
Newspaper	49 (40.83)	6 (5.00)	22 (18.33)	35 (29.17)	8 (6.67)
Internet	118 (98.33)	0 (0.00)	1 (0.83)	1 (0.83)	0 (0.00)
Indigenous					
Indigenous	15 (12.50)	14 (11.67)	91 (75.83)	0 (0.00)	0 (0.00)

Source: Field Survey, 2015 Figures in parenthesis indicate percentage

Preference level of different communication channels in study area

Table 5: Preference level of different communication channels in study area

Communication Channel	Total	
	Index	Rank
Neighbor	0.86	I
Progressive Farmer	0.41	IX
Agro vet shop	0.54	VII
Extension Worker	0.75	V
Radio	0.81	II
Landline Phone	0.25	X
Cell phone	0.78	IV
Television	0.80	III
Newspaper	0.45	VIII
Indigenous	0.63	VI

0.2= not preferable to 1= very highly preferable

Table 5 revealed that farmers of study area prefer neighbor (0.86) most as communication channel to get agricultural information. Radio (0.81) was ranked second followed by television (0.80) and cell phone (0.78) third and fourth respectively.Result of the study was same as finding of Devi and Verma (2011) who stated that neighbor was ranked first interpersonal communication channel and radio was ranked first mass media channels followed by television whereas, Internet was least used and preferred channel.

REASON OF USING AND PREFERRING CHANNELS

Figure 1 shows that most of the farmer used Neighbour as communication channel because they provide suggestion (19.77 percent) to the farmer when they need. It was followed by new information (18.02 percent) provided by neighbour and easiness to ask (17.44 percent) to the neighbour by the farmer. The result is in the line of Sharma (1966) neighbour are used to get information of improved farm practices. Sinha and Prashad (1980) further supported saying neighbour regularly shared with newly acquired knowledge and skill with other farmer.

According to figure 2 radio was mostly used as it provides recent information (39.22 percent) followed by cheapness (26.96 percent) and portability (14.22 percent). Siddaramaiah and Rajana (1984) and Kharel (2005) said that radio is comparatively a cheaper mass media. Melkote and Steeves (2001) also reported advent of radio as cheap and portable which makes discussion of innovation ease.

Television has audio and visual (48.74 percent) which was major reason of using it followed by entertainment (22.11 percent) and recent information (18.09 percent). Adhikary (2005); Balan and Rayadu (1996) point out strong point of television by its feature of audio and visual. This result is also supported by Bhagat and Mathur (1985), televisions are basically used for entertainment and information by the farmers. Farmers of study site used cell phone because of its easiness (37.28 percent) and quick (30.28 percent) to contact. 14.47 percent of respondent used them for privacy.

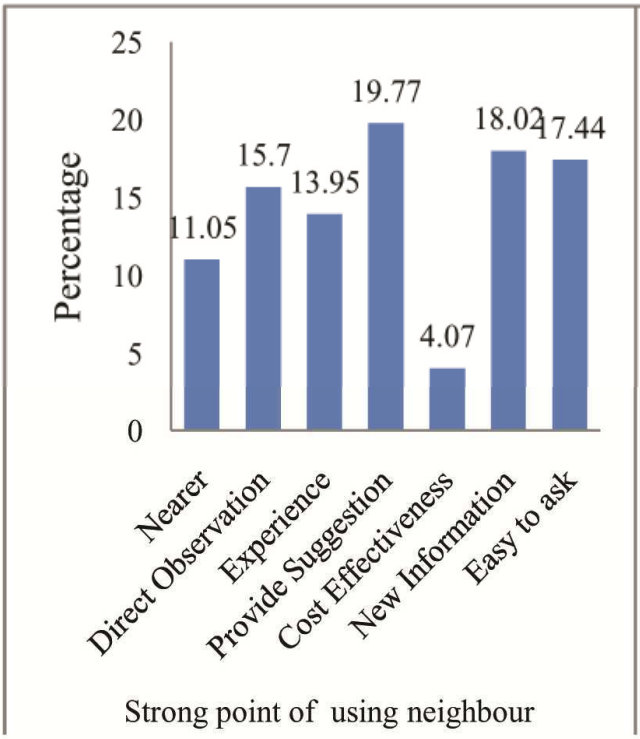

Figure 1: Reason of using neighbour

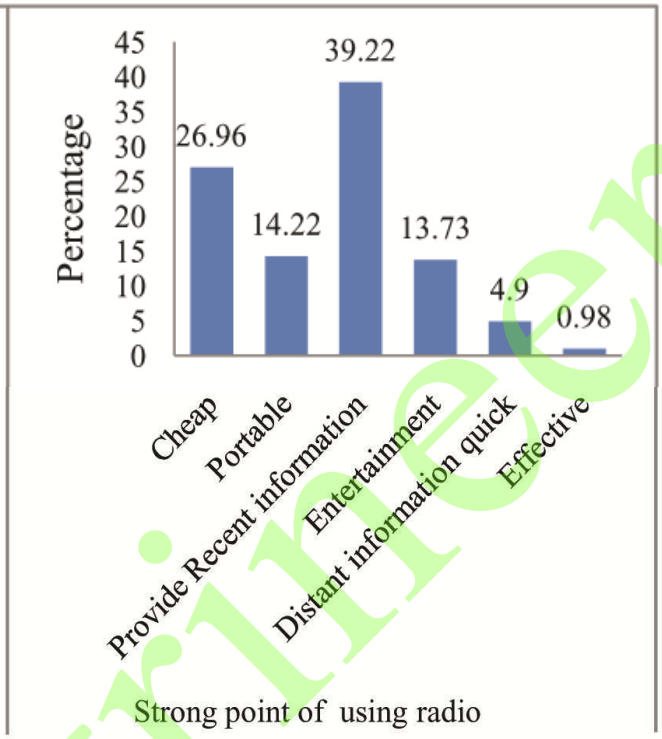

Figure 2: Reason of using radio

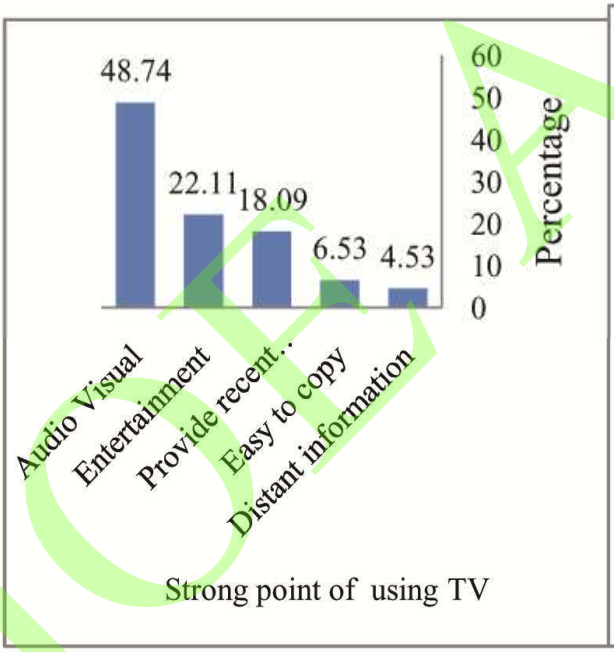

Figure 3: Reason of using TV

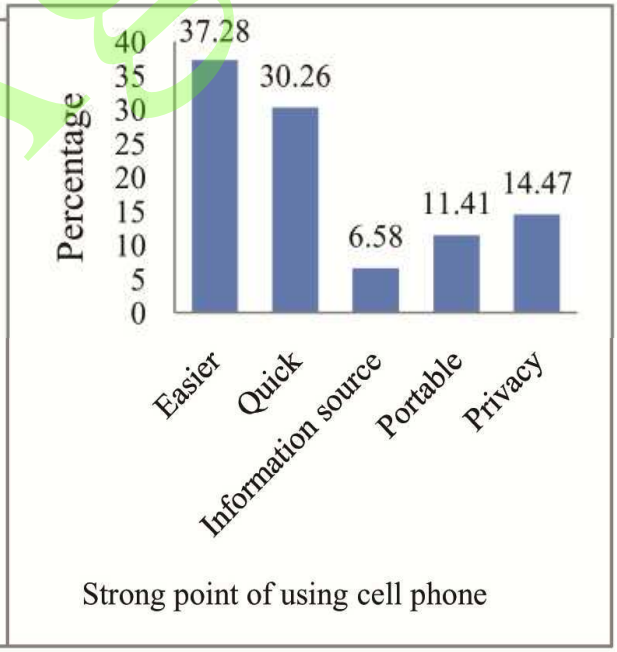

Figure 4: Reason of using cell phone

CONCLUSION

Mostly used and preferred communication channel is neighbor which is independent to any personal attributes and socio economic characteristics of the farmer. Radio, TV and cell phone are most popular media in Kailali district but they were confined to literacy and monthly income. Extension worker does not seem to be regular in most of the VDCs and they were biased by types of farming, monthly income, age group, availability to service center and technology use of the farmers. Radio, TV and cell phone were in similar use as neighbor, so none of single communication channels were important to disseminate agricultural information. Internet, agro vet shop, progressive farmer and newspaper were not suitable in Kailali district and have lot of limitation. Although indigenous channels were not used regularly but used by most of the farmers so, it cannot be separated while disseminating agricultural information.

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METHODS FOR IMPACT ASSESSMENT AND SUITABILITY ANALYSIS: A REVIEW

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ABSTRACT

In order to minimize the environmental impact of development, site identification will come to the forefront as a key consideration. To address this issue, the practice of Geographic Information System (GIS) suitability mapping is now used widely as a tool in planning and development. In this paper, we will discuss the concept of suitability mapping, comprised of Multi-Criteria Decision Making (MCDM), computer assisted overlay mapping – using Boolean and fuzzy logic, as well as artificial intelligence to replicate human decision making. This is followed by a review of the workflow in application to environmental impact assessment. The workflow respectively is selection and classification of evaluation index, weight determination, generation of single layers, overlay, and comparison. Usually, the process is done in a GIS-based environment to fuse decision making methodologies and allows planners to logically locate suitable areas for development, as well as trading off attributes and levels of risk to find optimal solutions to problems. It is expected that environmental impact assessment can result in the minimization of impacts from a project development, and lead to the creation of a smaller ecological footprint.

Keywords: Suitability analysis, environmental impact assessment, GIS

INTRODUCTION

With the rising issue of climate change, the world nowadays is shifting towards withdrawing a larger proportion of renewable energy from the grid. Globally, the amount of installed renewable technologies and their production capacity have increased by a large degree, and new legislation and policies to this effect have spread to many countries in regions around the world (REN21, 2014).

As global growth in renewable energy project accelerates, there will be major developments in the rural sector. This is particularly due to the fact that renewable energy can be harnessed in the most pristine areas. Therefore, the environmental impact of the project development has to be assessed even at a higher stake than before. Environmental Impact Assessment (EIA) is already an important part of any project's planning process. However, in order to minimize the environmental impact of development, site identification will come to the forefront as a key consideration (Watson & Hudson, 2015).

To address the issue of site identification, the practice of Geographic Information System (GIS) suitability mapping is now used widely as a tool in planning and energy development (Griffiths &Dushenko, 2011). Malczweski (2004, p. 4) states that "GIS suitability mapping aids in identifying the most appropriate spatial pattern with regards to specify requirements, preferences, or predictors of some activity."

Historically, suitability analysis was first practiced in the late 19th and early 20th century where American landscape architects use hand-drawn overlay techniques called sun-prints. In 1960s, these hand-drawn techniques were advanced into computer systems. This was based on common technique in English/Scottish landscape planning called 'sieve mapping', which used constraints to determine if the areas are suitable. Sieve mapping involves mapping data to do with the natural and anthropocenic attributes of the environment within a study area. This information is then presented on individual, transparent maps using different shading which indicates the level of suitability. In the end, each individual transparent map is superimposed to construct the overall suitability (McHarg, 1969; Malczweski, 2004). The problem with this method is that it is very strict and results in a very small area of high suitability.

In order to expand the area of suitability Multi Criteria Decision Making has been increasingly used to address issues to do with attribute and objective weighting using various methods and techniques. Within the last two decades, suitability analysis has been further developed in the field of Artificial Intelligence, incorporating geo-computation methods as a way to counter problems of resource allocation and subjective inputs (Collins, Steiner, &Rushman, 2001).

Historically, GIS-based multi criteria decision making has not been used extensively in the quantification of ecological impacts (Griffiths &Dushenko, 2011). As such, this paper will discuss applications of suitability mapping in environmental impact assessment, particularly in renewable energy projects. It will outline the key forms of impact assessment and discuss the methodologies most commonly employed in the area of suitability analysis. Finally, it will conclude with a discussion of the advantages and disadvantages of these methodologies in respect to renewable energy technologies.

ENVIRONMENTAL IMPACT ASSESSMENT

Impact assessment (IA) is a process that is used to evaluate the possible consequences of a project or plan of action (Treweek, 1995). These consequences can be direct, indirect, negative or broad, depending on project or the type of analysis required (Lawrence, 2013). EIA is done prior to the decision to move forward with the proposed project. Lawrence (2013, p. 5) conceives of it as an early part of the process of project development and states that it "precedes decision making, prior to irrevocable commitments." It is processed based and can provide information for project managers, communities, politicians, and scientists to consider in the implementation of projects such as new energy installations, waste processing plants, settlements, or land zoning.

Importantly, impact assessment is broad enough to cover a range of different environments, such as physical, financial, chemical, and biological, and can have a scope that is wide-ranging or highly focused, depending on the requirements (Lawrence, 2013). This flexibility leads naturally to a fragmentation of different types of IA.

As a tool, IA can be distinguished into separate categories based upon the objectives of the assessment, and the definition of the impact. Common types of IA include environmental, ecological, economic, and social (Lawrence, 2013). The oldest and most common is EIA, which seeks to "integrate environmental concerns and values into decision making", giving them higher importance with the ideal end result of minimising possible negative impacts. However, it "tends to assume a passive approach to decision making…and an indirect route to environmental change"(Lawrence, 2013, p. 7). In this case the assessment is typically restricted to specific physical projects and activities (Lawrence, 2013, p. 5). Yet, in relation to project proposals, EIA can cover vast areas, e.g. industrial products, which use Life Cycle Analysis or assessing genetically modified plants, which use INOVA. As such, the importance of EIA is illustrated by European Union laws such as the Environmental Impact Assessment (EIA) directive 85/337/EEC on assessment of certain public and private projects on the environment (as amended by Directive 97/11/EC), as well as the Strategic Environmental Assessment (SEA) Directive 2001/42/EC on the assessment of the effects of certain plans and programs on the environment (Drewit&Langstan, 2006).

In practice, EIAs measure data to estimate the exact magnitude of impacts. Traditional EIA methods are generally successful at identifying and mitigating major impact. Projects with unacceptable scales and magnitudes of impact can be detected and screened out. However, many of environmental impacts cannot be quantified, for example visual and landscape quality. Furthermore, traditional EIA methods do not specifically aim to seek balance between ecological, social, and economic factors (Malczweski, 2004).

While traditional EIAs are very common, one important variant is an ecological impact assessment (EcIA). Treweek (1995, p. 290) describes this as an assessment type "used primarily to predict the consequences of development activities for organisms other than people." Typically, it uses baseline studies, taxonomic classification, and predictive monitoring to aid in the assessment. Like other IA approaches, the ecological approach looks at cause and effect relationships between ecosystem components and defined actions (Treweek, 1995). Some argue that it recognises other environmental aspects, such as the effect of current social, aesthetic, economic, and cultural conditions, as important to understanding ecological impacts. This is due to the fact that these conditions affect both the value, as well as the funds likely to be assigned to counter such impacts and protect ecosystem functions (Treweek, 1995). Others believe that an EcIA needs to focus more on interconnectedness with other areas and types of environmental impact (Lawrence, 2013).

SUITABILITY ANALYSIS

To address the issue of interconnectedness and balance between ecological, social, and economic factors, suitability analysis can be used as a filler for the gap. Suitability analysis can aid IAs by highlighting graphically the areas that will have the least significant environmental impact. Environmental planners can then use these suitability maps to carefully site project installations which aids in the minimization of adverse ecological effects (Drewit&Langstan, 2006). Such maps are best used to answer questions of "where" or "how much" of an environment will be affected, and can be useful aids for decision making in providing "what if" scenarios for decision makers' consideration (Griffiths &Dushenko, 2011). In a similar vein, Collins et al. (2001, p. 611) put forward that suitability analysis allows environmental planners and managers to make analyses of interactions between three types of factors, "location, development actions, and environmental

elements", where the first focusses on the quantitative extent of an impact, and the latter two on qualitative elements. This combination of factors provides planners with information necessary to create alternate scenarios, which in turn can be displayed graphically. Finally, information about the impacts of the environment on the installation itself can also be displayed. For example, in the case of desalinization plants Lattemann and Höpner (2008) posit that good site selection can mitigate the effects of poor water quality and the risk of oil pollution, thereby making the overall process more effective.

In predicting environmental impact, scenario analysis, overlay methods, GIS, and remote sensing play an important role. Particularly with overlay methods, the cumulative impact can be assessed.

METHODS IN SUITABILITY MAPPING

There are many methods that can be chosen to complete a suitability analysis. Key methods include Multi-Criteria Decision Making (MCDM) – using Analytic Hierarchy Process (AHP) techniques or linear programming, computer assisted overlay mapping – using Boolean and fuzzy logic, or artificial intelligence to replicate human decision making– making use of heuristic and evolutionary programming, or neuro-computing (Collins et al., 2001). Each of these approaches are often combined with a GIS in order to display the results visually, an action that is often preferred by decision makers, and can reveal connections that were not visible previously (Malczweski, 2004). Additionally, each method can be and often is combined with one or more of the others.

MULTI CRITERIA DECISION MAKING (MCDM)

Suitability analysis can generate multiple solutions to a problem and can also rely on multiple variables to approach a certain objective. In order to make sense of the variety of both outputs and inputs, planners often use MCDM methods.Multi-objective methods are types of multi-criteria decision making processes which deal with more than one objective function and are concerned with mathematical optimization using either linear or other programming tools. Malczewski (2004, p. 33) states that MCDM methodologies "define theset of alternatives in terms of a decision model consisting of two or more objective functions and a set of constraints imposed on the decision variables".

One way to solve multi-objective problems is by the use of the Pareto-optimal concept. In a Paretooptimal solution set any point cannot be made better without making the other worse. This means there is a direct relationship between the points and one point cannot dominate another. There is always the loss and gain between Pareto solutions while going from one optimal solution to another optimal solution. The number of Pareto optimal solution sets depends upon the number of objective functions that we have but we prefer to have a single solution to overcome the requirements for trade-offs by the decision maker (Konak, Coit, & Smith, 2006). Ligmann□Zielinska, Church, and Jankowski (2008) have used Pareto-optimal and other methods of optimization for the multi objective land use allocation problems where they have presented a new model for optimization.

Another general approach when faced with multiple objectives is to convert them to single objective problems and then solve them by using the mathematical tools like linear or nonlinear programming. In this approach the objective functions are either maximized or minimized using programming methods. Linear programming for multi-objective problems has been used together with GIS to optimize spatial land patterns by some researchers and also to produce circumstances for land use (Malczewski, 2004).

While GIS has been used as a tool for optimization, due to increases in the number of problems this use has narrowed. One possible solution for this is to use heuristic algorithms, which have been already used by researchers. This algorithm decides the alternative in search algorithm and solves the problem more quickly than conventional methods. It is also used for solving large decision making problems for land use allocation. While this approach doesn't promise an optimal solution, the suggested allocation is close to the optimal solution (Malczewski, 2004). It is therefore ideal for situations where the solution can be more approximate.

To summarize, multi-objective problems are quite challenging to solve and get optimal solutions as they contain many decision variables, many objective functions and even many constraints. There are a variety of ways to solve these problems and still a large amount of research is going towards improvements in the algorithms and for better solutions.

COMPUTER ASSISTED OVERLAY MAPPINGBOOLEAN LOGIC

One of the most common techniques used to conduct a suitability analysis is Overlay Criteria Mapping with Boolean logic. Named after the mathematician George Boole, who in the 1800s first developed set theory, Boolean logic refers to circumstances where criteria are sorted into binary sets of belonging or not belonging (Eastman, 1999). Each attribute, be it proximity to a road, or angle of a slope, is defined as ideal or not based upon whether the criteria for the objective are satisfied.

Thus, if a wind turbine cannot be built upon topography that has a slope of more than five degrees, the map would be displayed as two distinct colours, one for x≤5, and one for x>5. Multiple criteria layers can be combined together using logic functions, of which the most common are AND, OR, or NOT, to identify areas of suitability that fulfill all requirements. This form of suitability mapping is more widely used for vectors, however it can also be used with raster displays (Eastman, 1999). Also, while the simplicity of this approach is a real boon for decision makers in that it maps can be easily generated and understood, it is problematic in its display of suitability (Eastman, 1999). The real world is never so clear cut as these types of maps present, and often there are gradients of suitability which cannot be displayed using Boolean logic.

WEIGHTED LINEAR COMBINATION

Where Boolean logic proves lacking is when not all attributes contribute equally to an objective or decision. In this situation, one must consider how much weight or impact each attribute has on the end result. The process of determining this, however, can be problematic, as these weights are often the subjective opinions of experts or local consultants, and can be arbitrarily applied without a solid logical basis (Eastman, 1999; Malczewski, 2000).The most widely used decision tool to combine attributes of varied importance is weighted linear combination (WLC; Eastman, 1999; Malczewski, 2000; Demensouka et al, 2014). It is a relatively simple method and this simplicity makes it appealing for decision makers (Malczewski, 2000). Key to the method of WLC is the concept of suitability trade-offs, where a high score in one attribute is balanced out by a low score in another (Eastman, 1999). In order to achieve suitable levels of comparability, the values of each attribute are standardised, typically to between 0 and 1, or 0 and 255 in order to make the digital visibility clearer (Drobne&Lisec, 2009). It is an important step as different attributes may use divergent scales, which will impact upon the spatial variability of suitability in the final result. This is due to the fact that the comparative size and scope of criteria play a key role in their relevance to the overall objective (Malczewski, 2000). Following this standardisation, attributes are either ranked, rated, compared, or traded off between each other by experts, then normalised so that the sum of all add up to 1 (Drobne&Lisec, 2009). In this way, the weighting can be applied to values for each attribute, with GIS software being used to combine the attribute layers and calculate the overall contribution of each to the final produce. This is displayed visually in the form of suitability maps.

ANALYTIC HIERARCHY PROCESS

While there are a variety of methods for determining weights, the most commonly used is termed Analytic Hierarchy Process (AHP; Watson & Hudson, 2015). This method uses pairwise comparison as a means of collecting and evaluating judgments on different criteria or attributes. It is the process whereby attributes are ranked in relative value on a pair by pair basis, eventually filling out a matrix which can be used to generate weights in further steps. The benefit of this approach is that single elements can be compared without having to consider the effects of large amounts of others. Also, it provides logical robustness for the weighting process. Saaty (1990) provides a verbal ranking list to evaluate criteria (reproduced in table 1), which range from 1, equal importance to the other, to 9, extremely more important. Between every odd number there is an intermediate value, which allows decision makers to make compromises between absolute values (Saaty, 1990). While the process can be time consuming and the comparisons subject to human error, the method themselves is relatively simple. Values based upon Saaty's ranking list are inputted into a matrix. Since the matrix is symmetric, only half needs to be filled out, as the other side consists of reciprocals of the first. Following this, the principal eigenvector of the matrix needs to be calculated to produce the weights of best fit. A good way to achieve a solid estimate of these weights is via the approximation method outlined below (Drobne&Lisec, 2009):

a) The columns for each variable are summed up.
b) The value for each variable pair is divided by the sum of the column.
c) These values are averaged by row to find the weight of best fit for each value.

As a final step for the AHP process it is also possible to complete a consistency analysis, in order to account for the multiple layers of paths and levels of ranking (Drobne&Lisec, 2009). This process generates a consistency ratio (CR) for each variable that essentially assesses the probability of that value being randomly generated. If the CR is above 0.1, then it is advised to reassess the attribute value.

Table 1: Saaty's fundamental scale for pairwise comparison (Saaty, 1990)

Definition	Index	Definition	Index
1	Equally important	1/1	Equally important
3	Moderately more important	1/3	Moderately less important
5	Much more important	1/5	Much less important
7	Far more important	1/7	Far less important
9	Extremely more important	1/9	Extremely less important
2, 4, 6, 8	Immediate values between two adjacent values		

FUZZY LOGIC

Strict boundaries can place unrealistic restrictions on spatial suitability, as in reality gradients of change are much more common. As such, target locations may partially belong to a category, but not completely. Fuzzy logic is a kind of logic used to deal with this concept of partial truth. Unlike Boolean logic, which uses only 0 and 1, Fuzzy logic contains any real number between 0and 1. Membership function is the principal concept of fuzzy set theory and that represents the amount of belonging of a given element to the set (Malczewski, 2004). Fuzzy logic allows the user to classify not only good or bad, but the different ranges between the best and the worst. Therefore, this can provide more a realistic gradient of options for decision makers, which is advantageous compared with traditional logic like Boolean logic that only shows the best and the worst scenarios.

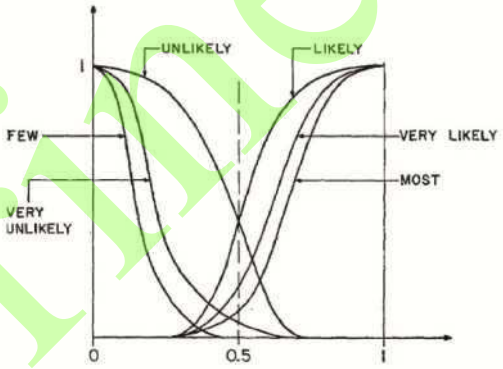

Figure 1: Functional representation of different levels of truth values with their symmetry along the line 0.5

While fuzzy logic is undoubtedly useful, it can prove difficult to grasp at first. In this case, it is perhaps beneficial to look at an example to make the concept clear. Suppose for a moment there is a dam that is going to be constructed in the Isar river of Munich, Germany. Planners need to look at site suitability, along with the environmental impacts of various sites upstream of the river. Using the conventional logic one can get only the true or false result which means the result can be either 1) it is suitable to build and has no impact or 2) it is unsuitable to build and has more impacts. However, using the fuzzy logic the result ends up with various ranges. We will have the result showing the various levels of impact and suitability i.e. more impact and less suitable, less impact and suitable, no impact and more suitable, less impact and more suitable. This result will allow decision makers to choose the best available option and make tradeoffs that perhaps were not clear earlier.

Zadeh (1975), who introduced the concept of fuzzy logic, has explained about the various level of truth-values and use of approximate reasoning in this logic. The different ranges of the truth values can be better understood with the function representation which is shown in figure (1).

Fuzzy logic can be applied in various fields including that of suitability analysis and site selection. It is also incorporated in visualizing software like GIS. In case of suitability mapping, using fuzzy logic we can get the many classes between 0 and 1 where 0 indicates an unsuitable or poorly located site, while 1 indicates a suitable or best available site. According to Malczewski (2004, p. 37), fuzzy logic can be a good tool to address issues like “vagueness, imprecision and ambiguity”. In ARC GIS fuzzy logic can be used for suitability mapping and site selection. The overlay tool can be used in ARCGIS after using fuzzy membership. The overlay types that can used are AND, OR, PRODUCT, SUM and GAMMA, which will result in a map with different classes ("Fuzzy OverlayHelp | ArcGIS for Desktop", 2016). Many researchers have described the use of this logic for land evaluation and land-use analysis and some of them have also used it with MCDA (Malczewski, 2004).

ARTIFICIAL INTELLIGENCE

Artificial Intelligence, also termed as AI, are the computer programs or algorithms which work similarly to how the nervous system of human brain works and can be seen as an attempt to replicate how humans think (Turing, 1950; Bourquin, Schmidli, van Hoogevest, &Leuenberger, 1998). This concept was developed by British mathematician Alan Turing but the word was termed as AI later in a conference. It was the difficulty of dealing with problems which are nonlinear in nature and also with complicated models that resulted in the concept of AI (Bourquin et al., 1998). Currently, many AI techniques have been developed and there are a wide range of applications in various field. The following section will discuss some of the AI techniques which are often used in suitability analysis and impact assessment.

CELLULAR AUTOMATA

Cellular Automata is a system where the set of cells are arranged in a one-or multidimensional frame which can be used to simulate complex systems. The state of each cell in the frame depends on its previous state and that of the cells next to it. Furthermore, each cell is updated in a parallel manner (Malczewski, 2004)

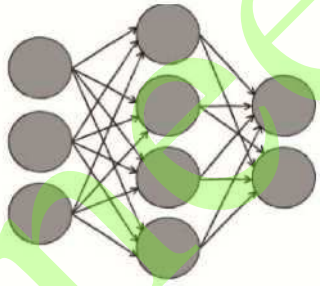

Fig2: Structure showing the networks in neural network (adopted from Shiffman, 2012)

The use of cellular automata in the field of land-use and land-cover analysis and simulation has intensively increased in recent years. They are often used in quantitative analyses using neighborhood rules (Liao et al., 2015). Barredo, Kasanko, McCormick, and Lavalle (2003) have shown the potential of using CA in the simulation of urban growth and urban design at different level along with the influencing factors. They also have validated the result of simulations which showed that CA is relevant to for urban planning and designing. Cellular automata has also been used in GIS for generating maps for land use and suitability analysis. The problems which are solved merging GIS and artificial intelligence like cellular automata can provide us new automated knowledge for decision making process but it has been questioned whether artificial intelligence techniques can be effective for complex spatial decision making problems (Malczewski, 2004).

NEURAL NETWORK

Neural networks are systems in which processing elements are interconnected and the structure of the interconnected network look like the human brain. Since they are designed to work as the nervous system of a human brain, they have the ability to solve much more complex problems than with conventional computer algorithms. Their ability to recognize trends in data has resulted in an increase in their application. Input, model and output are the three steps for neutral networks (Malczewski, 2004). In his book "The Nature of Code", Shiffman (2012) discusses how neural networks function. He states that the structure can be changeable and the paths of workflow do not follow the linear path. This can be seen on the figure below (figure 2).

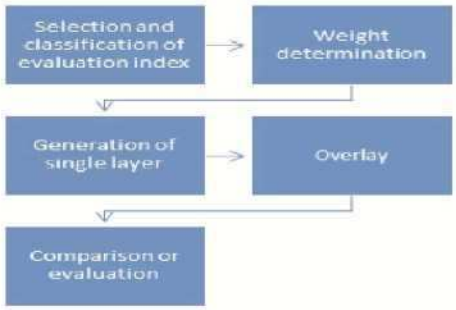

Figure 3: Application of Suitability Analysis for EIA

When using a neural network all the input data initially interacts with the networks and during that time the network is commanded to make the correction for output (Malczewski, 2004). Neural networks have been applied for land suitability and also in combination with GIS. Araújo, Pearson, Thuiller, and Erhard (2005) have used the artificial neural network for validating the model for climate change and also reduce the uncertainty in the data. Some experiments show that neural networks can be a good tool for replication of the traditional combination of GIS methods of overlay and multi-criteria combination (Malczewski, 2004). Another advantage over other algorithms is that one can focus purely on problems and not worry about technical details. Neutral networks can be used for planning in

such a place where users have a very little idea about the structure of the problem. It is difficult to distinguish the optimal structure of network which is the drawback of this approach (Malczewski, 2004).

APPLICATION / DISCUSSION

From a review of several papers (see for example: Jie, Jing, Wang, & Shu-xia, 2010; Watson & Hudson, 2015; Griffith &Dushenko, 2011; Caniani, Labella, Lioi, Mancini, &Masi, 2016) we can identify common methods for creating a suitability analysis for an EIA. A specific workflow is usually followed (see figure 3).

Selection and classification of evaluation index can be done by expert elicitation, for example with the Delphi method (Jie et al., 2010). In other cases, an evaluation index is created by reviewing peer reviewed literature (Watson & Hudson, 2015) and using a principal component analysis (PCA). Caniani et al. (2016) used PCA to reduce their number of variables, as the method identifies correlations between indices so that any duplication of effort is limited. Griffith and Dushenko (2011) used expert elicitation as well as regulation measures to define the index. For instance, with regard to ecosystem variables, they determined suitability to build around rivers and lakes using buffer distances related to the local regulation. However, it is possible that the scoring process may not be straightforward, subjective, and involve value judgment.n terms of, weight determination, Pohekar and Ramachandran (2004) concluded that the AHP method outlined earlier was the most widely used technique in sustainable energy studies. Griffith and Dushenko (2011) used WLC to assess ecological impact on wind farm development. This method was chosen due to explicit underlying assumptions such as the simplicity of use and transparency of the calculation.

Generation of single layers and overlays is usually done in the GIS environment. As previously discussed, the most popular methods are Boolean constraint and fuzzy logic overlay. Overlays can be done in numerous orders for a suitability map.

In the end, impacts are assessed by comparing results of suitability mapping with the target. In the study by Griffiths and Dushenko (2011), the ecological impacts of wind power plant were estimated using GIS in vector format. It measured the spatial intersection between the layout wind farm and polygons of an ecological base map, so that the total number of impacted polygons were known. However, the study did not include the ranges of risk for each impact category, choosing instead to evaluate all at a uniform level.

A summary of commonly used methods in suitability mapping for impact assessment can be seen in table (2).

Table 2: Commonly used methods in suitability mapping for impact assessment

Method / Study	EIA Landscape Planning (Jie et al., 2010)	SA for WindEnergy (Watson & Hudson, 2015)	SA for EIA wind farm (Griffith & Dushenko,2011)	EIA habitat ecology (Caniani et al.,2016)
Identification of Evaluation Index	Delphi Method	Review of peer review literature, binary scale	Expert elicitation	PCA and fuzzy logic
Weighting	AHP (judgment matrix, calculate eigen-value, eigenvector,normalization, andconsistency check)	AHP, pair wisecomparison	Weighted Linear Combination	-
Overlay	-	-	Boolean Overlay Method	Fuzzy Overlay
Compare	Master Plan	-	Valued ecosystem component and disturbance target	Landscape metric

With regards to application of artificial intelligence methods, it can be concluded that the use of cellular automata and neural network is less popular for environmental impact assessment. Cellular Automata is used more for modeling and simulation of land use change, urban development (urban sprawl and urban expansion). This being said, some have argued that there is real potential for research in this area (Malczewski, 2004).

ADVANTAGES AND LIMITATIONS

Multi-objective methods allow us to deal with those problems which contain many variables and constraints. They are concerned with models and are more mathematical, while multi-attribute decision making methods are concerned on the information that we have (Malczewski, 2004). Since this method deals with many objective functions, there is complexity in solving which limits the use of multi-objective optimization in visualizing software like GIS. They are solved by linear and nonlinear programming and also by different algorithms so a good knowledge in mathematical programming algorithms or models and optimization techniques are required for solving these kinds of problems (Malczewski, 2004).

As previously discussed, fuzzy logic is able to manage the uncertainty and imprecision of data values. It can perform what mathematical mode cannot handle, which is to analyze multiple input expressed in the form of linguistic variables. Moreover, it is easy to use. As is the case with other suitability analysis tool, it can act in a decision support function during the planning and help in the management of interventions aimed at the protection habitat. (Caniani et al., 2016).

In terms of weighting attribute layers, there are some key advantages to using AHP (Watson & Hudson, 2015):

a. Flexible and the possibility to check inconsistencies
b. Clear importance of each criterion
c. Support decision makers through generation of the geometric means of the pairwise comparisons

Overall, the advantages of using suitability analysis for environmental impact assessment are varied (Jie et al., 2010):

a. It takes advantages of GIS and RS
b. Produce objective and rational result with help of AHP and multi factor index overlay
c. Possibility to select and classify indicator which are related with the specific plan

However, a key drawback is that it is hard to evaluate the actual impact, due to a lack of processing. For example, Griffith and Dushenko (2011) stated that GIS suitability maps in their study do not reflect the interaction between identified locations and the frequent flight paths of avifauna, despite the important impact that wind power can have.

Public participation also plays a critical role in impact assessment and suitability analysis, however the integration can be challenging. Despite its superiority in formalizing spatial information, real value of social elements is more difficult to be manifested in mathematical form (Griffith &Dushenko, 2011). Therefore, Malczewski (2004) argues that the lost value in the process can be resolved via public participation and appropriate deliberation on ethical issues. One leading approach is concept of Public Participation in GIS (PPGIS). In their study, Griffith and Dushenko (2011) assessed severity of impacts of wind power plant in Canada by comparing wind farm results from suitability analysis with the Valued Ecosystem Component (VEC). VEC is a product of Canadian Environmental Assessment Agency, where it states environment area with high importance according to stakeholder. This is one example where public can be involved in the assessment. By this, it is possible that the results of the assessment are improved and more evocative for the stakeholder.

CONCLUSION

As this paper has discussed, the application of suitability mapping for environmental impact assessment can result in the minimization of impacts from a project development, and lead to the creation of a smaller ecological footprint. The most used methods in suitability mapping for environmental impact assessment of renewable energy project have been examined and are comprised of decision making methods, computer overlay techniques, and artificial intelligence. Some of the advantages and disadvantages were also summarised and discussed further.

Suitability analysis for renewable energy is a complex process that has evolved from overlay mapping to incorporate a variety of approaches from different disciplines. It uses GIS to fuse decision making methodologies and allows planners to logically locate suitable areas for development, as well as trading off attributes and levels of risk to find optimal solutions to problems. Impact assessment has become increasingly important to project planning, and is greatly helped by this multi-disciplinary approach, as it reduces environmental, social, and economic costs.

The use of computer algorithms has been highlighted as a key growth area in the field of suitability analysis. In particular, it can be helpful in reducing the time it takes to survey an area as, when combined with remote sensing data, it has the potential to highlight locations associated with higher risks of environmental degradation. As the demand for renewable energy increases, so will the demand for installation space for such as wind turbines and solar farms. Increasingly elegant and reliable algorithms will allow planners to locate spaces in more remote regions, without needing to spend as much time on the ground examining the surroundings. However, while this may be an ideal situation, it is still far off being a dependable element for impact assessment and suitability analysis. This is due to the fact that expert opinion is so crucial in determining key attributes to be considered in the mapping process.

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Soil Type and Acidity in the Chatara Canal Irrigated and Ground Water and Local Stream Irrigated Farmlands of Khanar, Itahari Sub Metropolitan City

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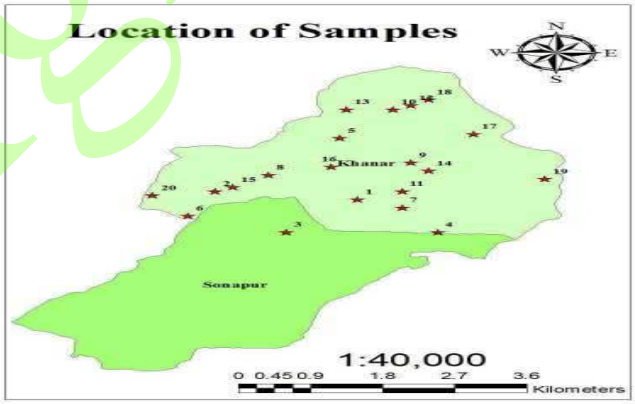
ABSTRACT

Soil Quality is greatly responsible for crop production. The quality of soil is not sustainable, it is dynamic. The quality of soil is greatly influenced by human and industrial activities. Hence, frequent assessment of soil quality is obligatory. The quality of soil was assessed by analyzing the pH and Soil Textural Class of the soil. This study truly focuses on the study of status of soil of Khanar, Nepal. A comparative study of soil of was carried two clusters divided by Chatara Canal in which the south to the flow of canal which is a cluster irrigated by canal itself while north to the flow of canal is a cluster irrigated by groundwater sources and natural streams. Based on the fact of data gained through lab analysis of soil, the overall texture is either loam, sandy loam or silt loam and the average value of soil pH is for the cluster of canal irrigated is 5.9 while that of another cluster irrigated by local resources is 7.1.

Key words: *Soil Quality, Soil pH, Soil Texture*

1. INTRODUCTION

Nepal is an agricultural country having diversified type of climatic and soil condition. From apple to watermelon, tomato to potato etc every types of food crops to cash crops can be grown here because of its diversified type of climatic and soil condition. The agriculture contributes to about 34.7% to national GDP and provides part and full time employment opportunities to 73.9% of its population. The average land holding per family across Nepal is found to be less than 0.8 hectare (NARC Annual Report 2012/2013). Because of small land size, unavailability of the other Small land holdings, low investment capacity of the farmer, lack of farm mechanization and proper study of soil quality there is no charming in agriculture production.



Practically soil quality of agricultural soils is defined as the soil's fitness to support crop growth without resulting in soil degradation or otherwise harming the environment.

Day by day, the quality of soil is degrading due to the environmental effects as well as human activities. Excessive uses of fertilizers, industrial activities are human activities while decomposition of flood mass, erosion etc. are environmental factors for the degradation of soil quality. As a result production is decreasing due to lack of proper study of soil and its appropriate information to the farmers. Soil texture is an important soil characteristic that influences numerous soil properties like Drainage, Water holding capacity, Aeration, Susceptibility to erosion, Organic matter content, Cation exchange capacity (CEC), pH buffering capacity etc.(Brady and Weil,2002). Similarly both macronutrient and micronutrient availability are affected by soil pH. it is necessary to analyze physical properties including soil texture, pH of soil. This study describes the soil type and soil pH of farmlands of Khanar.

2. MATERIALS AND METHODS

2.1 Study Area

Khanar is located in the Sunsari Morang Industrial Corridor which lies in Itahari Sub-Metropolitan City. Most of the land of it is utilized for agricultural activities and is irrigated by one of the largest irrigation project, Sunsari-Morang Irrigation Project.

A comparative study was carried out by dividing Khanar into two cluster, cluster A which is north to the flow of canal and cluster B which was south to the flow of the canal. Cluster A is irrigated by local resources i.e. by Tyangrakhola and groundwater sources while Cluster B by Chatara canal.

Figure1: Location map of sampling sites

2.2 Data Collection

Soil sampling and Analysis was performed with the help of approved study protocol. Soil was taken from the field and brought to the laboratory then sample was prepared for analysis by the systematic method as stated by FAO. Soil pH was determined by pH meter and soil Texture was determined by Hydrometer Method (Anderson et al. 1982).

3. RESULT AND DI SCUSSION

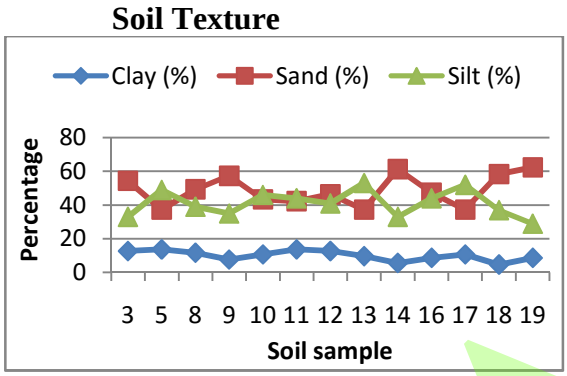


Figure 2: Textural values of Soil Samples of the field irrigated by local resources

The textural class of soil of both the cluster is determined on the basis of particle size distribution. Most of the soil samples contain highest percentage of sand followed by silt and clay. The overall textural class is Sandy Loam, Loam or Silt Loam. This class of soil is suitable for farming.

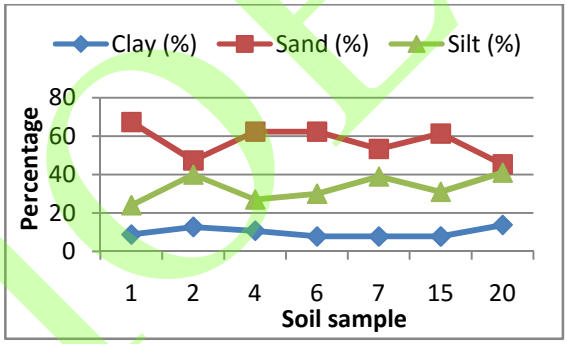


Figure 3: Graphical Representation of Textural values of Soil Samples of the field irrigated by Chatara Canal

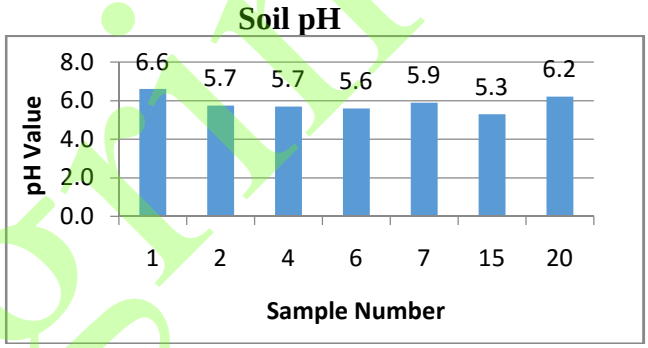


Figure 4: pH of Soil Samples of the field irrigated by Chatara Canal

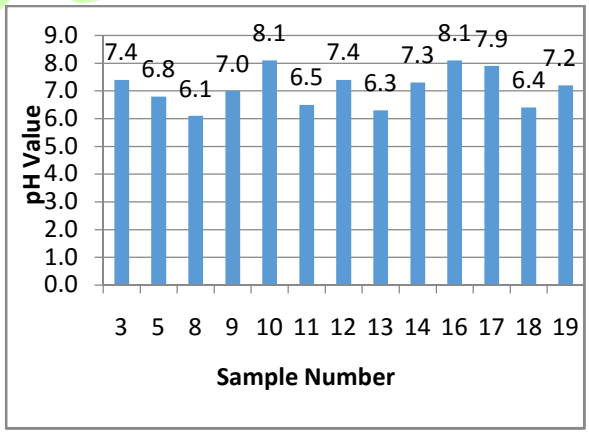


Figure 5: pH of Soil Samples of the field irrigated by local resources

The pH value for the cluster of land irrigated by Chatra canal is lower than to that of the cluster irrigated by other system. The average value of pH for the cluster of canal irrigated is 5.9 while that of another cluster irrigated by other system is 7.1 According to the research on fertility status of soils on LARC command area (Tuladhar,1995),the pH value suitable for the paddy farming must be within the range of 5.5-6.5.

CONCLUSIONS

The physical properties including soil texture, pH of soil was analyzed. Analyzing pH what we find is that the soil of cluster B is acidic than cluster A. Overall soil texture of Khanar is good for cultivation, it is either loam, sandy loam or silt loam.

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OPENING UP RIVER BASIN CLOSURES: INTEGRATED WATER RESOURCES MANAGEMENT AS A RELEVANT INSTRUMENT

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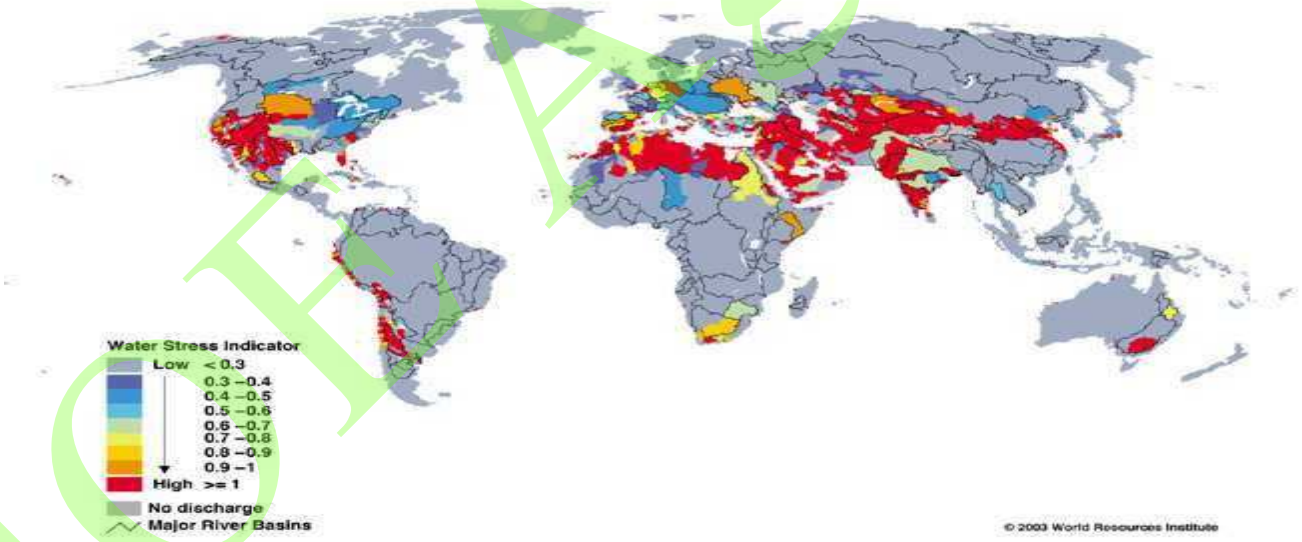
ABSTRACT

The theme of the literature study is to analyse river basin closures and the role of integrated water resources management (IWRM) in the present scenario of increasing water stress in river basins with reference to the literatures review. IWRM at the basin scale, its contribution to improved water management, and methods for management will be discussed. The study examines the links between the present challenges of basins arising from river basin closure and the possibilities to reopen the closures. This study attempts to argue on how the concepts of IWRM fit in the basin issues, and discusses the constraints and prospects of IWRM for the development and management of river basins.

1. GLOBAL WATER CRISIS: AN ASSESMENT

The world's supply of fresh water is running out. Gregersen *et al.* (2007) discusses how water scarcity continues to be a global issue that grows more serious with ever-expanding human populations. River basin closures are some of the major factors for the global water crisis. The list of rapidly closing and closed basins includes the Jordan River, the Krishna River, Lerma-Chapala, and many others, including the Murray-Darling River in Australia and the Indus river in India and Pakistan (Falkenmark and Molden, 2008).



Map-1: A map of a water stress indicator (WSI): Red areas show 'closed' basins. Source: water for food, water for life issue brief-4 (World Resource Institute, 2003).

Map-1 clearly shows that many regions (i.e. red colored) of the world are seriously stressing limited freshwater resources. River basin closures affect 1.4 billion people worldwide (Id21, 2008). Based on this fact, it can be agreed that supply of freshwater will be a more critical issue in future. At the same time, we must produce more food and agricultural products with less water, as agriculture is the major sector suffering from reduced water availability. The poor are often the people hurt the most by water scarcity because poverty and access to water are closely linked. Despite these facts, according to Falkenmark and Molden (2008), limited attention has been given today to this urgent water situation.

1.1 Why is River Basin Management a Global Water Issue?

International rivers account for 60% of all the water that flows into the world's rivers (Varis *et.al*, 2008), and they supply fresh water to the vast majority of populations for different uses such as domestic, fishery, agriculture, recreation, hydropower, transport, industrial use, and nature and environment, etc. It should be noted that all forms of basin water use and the effects produced by such use are hydraulically connected at the scale of the river basin. The nature of hydrological linkages implies that river basins form a natural unit of management for river conservation and other purposes. Those facts lead to a conclusion that the river basins are logical units for water resources management.

2. AN INTRODUCTION TO BASIN CLOSURE

A designation of closing or closed indicates the water stress condition of a river basin. A closure progresses successively through different development phases, from the undeveloped state to the fully developed or closed state, when the rapid process of development of its rare water resources continues to increase. According to Carriger and Williams (2006), many of the world's river basins are either 'closed' or are 'closing', as water use within them exceeds or is approaching the amount of renewable water available. A water resource system is said to be 'closed' when there is no usable water leaving the system other than that necessary to meet minimum instream and outflow requirements" (Keller *et al*., 1998). In this case, no water resources are left to be mobilized and used.

2.1 Driving Forces of Basin Closure: Are They Avoidable?

Venot *et al.* (2006) mentioned that the process of basin closure has been very rapid worldwide and is mainly driven by three processes that put ever-increasing pressure on the rare available water resources of the basins. These processes are: 1) increasing water diversions in the upstream, 2) high population growth and the growing needs of cities, and 3) the large share of water used in agriculture. Besides this, poor management, climatic change, and vagaries of weather are being cited as being the roots of water scarcity, as these drivers lead to a decline in river flows.

Kirchhoff and Bulkley (2008) projected that climate change is expected to cause increased water stress in these areas as rainfall continues to decrease and evaporation rates increase with rising temperatures. The combined impacts of climate change and population growth dramatically reduce availability of fresh water. It is logical to suppose that climate change is unavoidable to some degree, and will be influencing streamflow even in future. However, many driving forces (discussed above) are avoidable in some ways that are briefly discussed in section five.

3. OPENING THE BLACK BOX OF PROBLEMS IN A CLOSED/CLOSING BASIN

3.1 Conflict

The overuse of water leads to water shortages, especially during droughts, and upstream and downstream activities are often in conflict, leading to serious consequences such as groundwater overdraft, sediment buildup in rivers, seawater intrusion and wetlands degradation. In such a case, water pollution and competition for water is high, leading to conflicts. If a water basin approaches closure, massive "head ender and tail ender" problems will develop, with the tail ender at the bottom of the water basin receiving progressively less water of worse quality (Seckler, 1996). This set of problem badly affect the water and agriculture sectors, and a complex set of social, technical and economic problems emerge. Furthermore, the salinity in the aquifer increases with depth, and this salinity is compounded by the use of fertilizers and pesticides; this implies that costlier alternative sources will have to be tapped in the near future (Venot *et al.*, 2006: P.12). In a nutshell, serious management problems, such as upstream and downstream conflicts, water quantity and quality, surface and groundwater, and land and water resources, are seen in a water-stressed basin.

3.2 THREATS AND UNCERTAINTY

Carriger and Williams (2006) bring forward a grave concern that withdrawing additional water for human use within closing basins can cause the greatest threat to biodiversity: losses of habitat, species, ecosystems and unexpected

environmental problems. It is clearly a threat to nature and generates an uncertain future. This statement is also confirmed by Falkenmark and Molden (2008) who state, "if a basin goes past the point of closure, the basin is in a danger zone". In this case, environmental degradation and unsustainable management practices continue to be serious and ever increasing threats to river basins.

In conclusion, everyone should be aware of these risks that may seriously affect the people in and around the baisn, even globally. Those vast problems underscore a need of more integrated and holistic approaches in basin water management that would acknowledge and address those sorts of problems at large regarding the basin water management (refer detail discussion in section 5).

4. RIVER BASIN MANAGEMENT & IW RM: KEY ISSUES

Integrated river baisn management (IRBM) is widely being used as an approach to river basin management and is another name for IWRM in a basin-wide context**.** IWRM has emerged during the last decade as a response to the water crises (IRC, 2014).

"IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystem" (GWP TAC, 2000,Clausen and Fugal, 2001). "Integrated" clearly implies that water resources management should be approached from a broad prospective. This means that IWRM takes into account the social, environmental and technical aspects and considers each trade-off. In a more practical sense, IWRM is the management of water resources in qualitative, quantitative and ecological senses from a multidisciplinary perspective.

The fundamental concern of IWRM is to develop democratic governance and to promote the balanced development of water resources for the reduction of poverty, social equity, economic growth and environmental sustainability (Varis *et.al*, 2008). Implementation of IWRM in basin management is a long-term process and may take decades of incremental improvements to achieve complete results. This becomes possible from a regular commitment and support from all concerned stakeholders.

5. DEALING WITH BASIN CLOSURE: OPENING UP OPTIONS IN CLOSING/CLOSED RIVER BASINS

We discussed problems and drivers of basin closure in the previous sections. However, it should not be forgotten that basins can be reopened with suitable measures. In the past, the emphasis on basin management to increase fresh water supply was considered to be a relatively straight forward engineering solution. Some of the well advocated concerns for managing of water stress in the basins are presented below:

- Recognizing the interconnectedness in closed basins is vital, as mentioned by Carriger and William (2006), a unique property of river basins is that, as basins close, water management becomes more complex because the aquatic ecosystems, water cycle and water users become more interconnected.

- The closure of a basin will have an impact on water quality, especially in the downstream, and some basins are entering into the phase where recycling and treatment of water may be required. Besides this, Molle (2004) stressed the need to develop additional storage, conservation, or augmentation to reopen a basin approaching closure.

- As a basin nears closure, sectoral allocation becomes a point of stress, and allocating water to the poor and the environment should be a priority. Therefore, efforts should be directed at allocating water towards the most economically valuable uses, and new institutions must evolve to address inter-sectoral competition and manage river-basin resources in an integrated manner (Seckler, 1996).

- Managing basin closure will require systems analysis, seeing the basin as a complex sociocultural-political-natural resource system, understanding how a change in water and land use in one part of the basin impacts other natural processes in the basin, and involving diverse groups of users in informed decision-making processes (Falkenmark and Molden, 2008).

- Keller *et.al* (1998) suggest that water management in closing systems requires increasingly efficient, effective management of both surface and groundwater.

It is widely perceived that basin closure can be managed by transferring water from neighboring basins and reduce the water stress in a basin. However, according to Carriger and Williams (2006), in closing basins, such efforts actually intensify the pressure on water and speed up the closing process.

These are the most discussed options when it comes to managing a water stress basin. However, if the options are implemented separately, they will not be sufficient to reopen the closed/ closing basin. Rather, these approaches must be implemented as a part of IWRM. This leads to a conclusion that IWRM is to the most effective approach to closely look at these problems and deal with basin closures from a broader perspective.

6. CONCLUSION

IWRM has been recognized as a conceptually sound and powerful concept that deals with the global water crisis and acknowledges a complex human-technology-environment system for action. Water resources in a closing/ closed baisn can be managed in a more coordinated and comprehensive way with a continued and deliberate effort through the multidisciplinary approach of IWRM. The success of IWRM largely depends on the implementers' ability and skill and the active participation of river basin stakeholders in planning and decision making. Local actions and ownership are considered necessary cornerstones for achieving IWRM in river basin management. However, the integration of different sectors, actors and approaches and implementing them in a coordinated way is a challenge. This challenge is still standing for future water professionals to refine and make it more practical for implementation that works well in different socio-economic and geographical settings.

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DEVELOPMENT AND APPLICATION OF WEB EROSIVITYMODULE (WERM) FOR ESTIMATION OF ANNUAL AND MONTHLY R FACTOR

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ABSTRACT

Universal Soil loss equation (USLE) is one of the popular model which is being used in many countries around the world to estimate soil erosion and assess erosion control practice. Erosivity (R-factor) is one of the USLE input parameters to reflect impacts of rainfall in computing soil loss. Value of R factor depends upon maximum rainfall intensity of specific period and kinetic energy of that rainfall event. It is usually calculated from rainfall data having higher temporal resolution but the process of calculation is very tedious and also the higher temporal resolution data are not readily available in many parts of the world. Various regression equations have been developed to estimate monthly R factor as well as annual R factor using monthly/yearly rainfall amount. However, we cannot estimate R factor with higher accuracy using these equations since they are based on old dataset and also only the rainfall amount have been used as an input parameter without rainfall intensity considered. In this study, a web based Erosivity estimation system (Web ERosivity Module-WERM) was developed to calculate the value of R-factor using the 10 minute interval rainfall data. The model was then tested for 75 different cities of Korea using the rainfall data of 15 to 18 years from 1997 to 2014 obtained from Korea Meteorological Administration (KMA).Using the monthly rainfall data and R factor values obtained from the model, regression equation for 25cities were developed to estimate monthly R factor from the monthly rainfall with amount and intensity of rainfall considered. The coefficient of determination (R^2) of the regression equation obtained for Hongcheon city was found to have the greatest value of 0.92 while the Boeun city was found to have the lowest R^2 value of 0.75. These regression equations can be used to estimate the value of R-factor from the monthly rainfall data with more than 75% accuracy .The WERM is very simple to use and it can be very effective tool to calculate parameter R-factor using higher temporal resolution rainfall data. Along with this, it is possible to calculate R factor using local daily rainfall with the help of regression equations which is available for 25 cities in Korea till now.

Keywords: Soil erosion; USLE R; erosivity; rainfall; model; regression equation

1. INTRODUCTION

The world community has recognized soil erosion as a major problem and is giving more and more importance on protection and restoration of soil resources [1]. Some effective best management practice should be implemented for the sustainable management of soil erosion. For this purpose, three different group of models viz. empirical, conceptual and physically-based models have been developed during the last few decades[2].Empirical model like Universal Soil loss Equation (USLE), conceptual models like Soil and Water Assessment Tool (SWAT) and physically based models like Water Erosion Prediction Project (WEPP) have been developed and are being used in order to assess current erosion condition and control practice implemented. Empirical equations such as USLE are still being used in many countries around the world to estimate soil erosion and assess erosion control practice because of their simple structure and ease of application [3] with reasonable accuracy. In Korea, the USLE model has been extensively used to predict soil erosion. The reason behind this is that the USLE parameters have already been well established over the years [4, 5].

Among these six USLE input parameters, the Erosivity or USLE R-factor is one of the input parameters to explain rainfall impacts on soil loss. It is an erosive power of rainfall to cause soil loss. The factors that affect the rainfall erosivity are amount, intensity, terminal velocity, drop size, and drop size distribution of rain [6]. The value of R factor depends upon maximum rainfall intensity of specific period and kinetic energy of that rainfall event. It is calculated as sum of product of Kinetic Energy and maximum 30 minute intensity of each rainfall storm in a year [7-9]. It is usually calculated from rainfall

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data having higher temporal resolution but the process of calculation is very tedious .Thus, a web based platform could be a very effective tool in this case in order to save time and energy and get the accurate R factor value using these data within a couple of minutes. Moreover, measured higher temporal resolution data are not always readily available in many regions of the world. Various regression equations have been developed to estimate monthly R factor as well as annual R factor using monthly/yearly rainfall amount. However, we cannot estimate R factor with higher accuracy using these equations since they are based on old dataset and also only the rainfall amount have been used as an input parameter without rainfall intensity considered. The objectives of this study are to develop and test a Web ERosivity Module (WERM), evaluate annual R factors for 75 weather stations of Korea from recent rainfall data using WERM, create annual R factor map for Korea and determine specific three dimensional regression equation for monthly R factor having monthly rainfall amount and order of month as two parameters.

2. MATERIALS AND METHODS

The R factor was calculated from the rainfall data of the 75 weather stations in Korea. The values of average annual R factor were computed for these stations along with determination of maximum 30 minute intensity ($I30_{max}$) and the R factor value for each month. Based on monthly R factor value and monthly rainfall data, regression model were developed for each weather station. Among these 75 stations, 25 stations having the greater R^2 values were selected for the further study. Rainfall data for all the weather stations in this study were obtained from the Korea Meteorological Administration [10]. The first task for calculation of the R factor from existing ten minute interval rainfall data is to separate rainfall event [11] from long-term rainfall dataset.

Web ERosivity Module (WERM) was developed based on equations from Agricultural Handbook number 537 [7] to calculate the R factor. The program uses ten minute interval rainfall data accumulated for one day of entire time period as a text file. The input data has to be in the specified format in the increasing order. The module was developed using HTML, PHP, JavaScript, JQuery and HighChart. It provides yearly, monthly and event wise R-factor values instantly in the

Figure 1: WERM input Interface

Website and the output can be downloaded as a separate ASCII files for further analysis. Based on the R factor values calculated by the WERM, nationwide R factor map was constructed using the inverse distance weighted (IDW) method in ArcGIS 10.1.

The specific regression equation for 25 different cities were developed to calculate monthly R factor from monthly rainfall data and the order of months ranging from 1 to 12. The coefficient of equation was derived using the CurveExpert Professional (v.2.2.0) which offers more than 60 different models providing curve fitting result with various linear as well as nonlinear models. Out of different models provided, suitable model was selected for each equation based on their given performance and rank.

3. RESULTS AND DISCUSSIONS:

Web ERosivity Module (WERM) was developed which is very useful to calculate the value of R factor easily within a minute from the 10 minute interval rainfall data. Anyone can access this module WERM from anywhere using following web address :(*http://www.envsys.co.kr/~werm/*). User can upload the input text file in the web interface. User can view the value of average annual R factor computed by this WERM module from the input rainfall data of specified time period. Moreover, yearly, monthly and event wise values of R factor can be downloaded from the WERM website as separate text files. Likewise, we can see the relationship among monthly rainfall amount, monthly R factor and order of month in the form of three dimensional scatter plot.

Average annual R factor for the 75 weather station were calculated from recent rainfall data of 15 to 19 years using the WERM and the values were compared with existing R factor suggested by Korean Ministry of Environment based on the data from Park, et al. [12] and [13] which were calculated from the rainfall data of 24 years from 1973 to 1996. Table 1 shows the list of base period for calculation, new R factors and existing R factors along with their differences on their values for 12 representative stations.

Table 1: List of New R factors, Existing R factors and their difference for 12 representative stations:

Station number	Station name	Starting year	Ending year	Base period	New R factor	Existing R factor	Difference %
294	Sancheong	1997	2015	19	11,328	7,076	38
102	Baengnyeongdo	2000	2015	16	2,942	-	-
90	Sokcho	2000	2015	16	4,086	3,784	7
106	Donghae	1997	2015	19	3,553	3,975	-12
130	Uljin	1999	2015	17	3,377	3,027	10
216	Taebaek	1997	2015	19	4,229	3,662	13
152	Ulsan	1999	2015	17	4,844	4,276	12
184	Jeju	1999	2015	17	8,034	4,348	46
202	Yangpyeong	1997	2015	19	8,651	4,956	43
294	Sancheong	1997	2015	19	11,328	7,076	38
256	Suncheon	1997	2012	16	9,420	5,067	46
189	Seogwipo	1999	2015	17	10,766	6,035	44

The maximum and minimum values of R factor calculated were 11,328 MJ mm ha^{-1} $hr^{-1}yr^{-1}$ for Sancheong and 2,942 MJ mm ha^{-1} $hr^{-1}yr^{-1}$ for Baengnyeongdo respectively. The average R factor in Korea based on these stations was found to be 6,189 MJ mm ha^{-1} $hr^{-1}yr^{-1}$ which is seen to have increased from the previous value of 4,210 MJ mm ha^{-1} $hr^{-1}yr^{-1}$[14]. The R factor values are seen to have increased for all the stations except for Donghae where the value of R factor has decreased by 12%. The maximum increase seen in new R factors from the existing R factor is 4,731 MJ mm ha^{-1} $hr^{-1}yr^{-1}$ for Seogwipo which is 44% increase from previous value while the minimum increase is 302 MJ mm ha^{-1} $hr^{-1}yr^{-1}$ for Sokcho which is 7% higher than previous value. The greater R factor value is due to increasing trend of rainfall intensity.

The iso-erodent map shows that value of average annual R factor varies spatially. Eastern part of Korea is seen to have lower R factor values in comparison to that of western part. Using this Map, we can calculate R factor of any location in Korea easily and calculate the soil loss using USLE. The

R factor from this nationwide map gives better result than previous R factor maps which are based on old dataset 60 minute interval rainfall data.

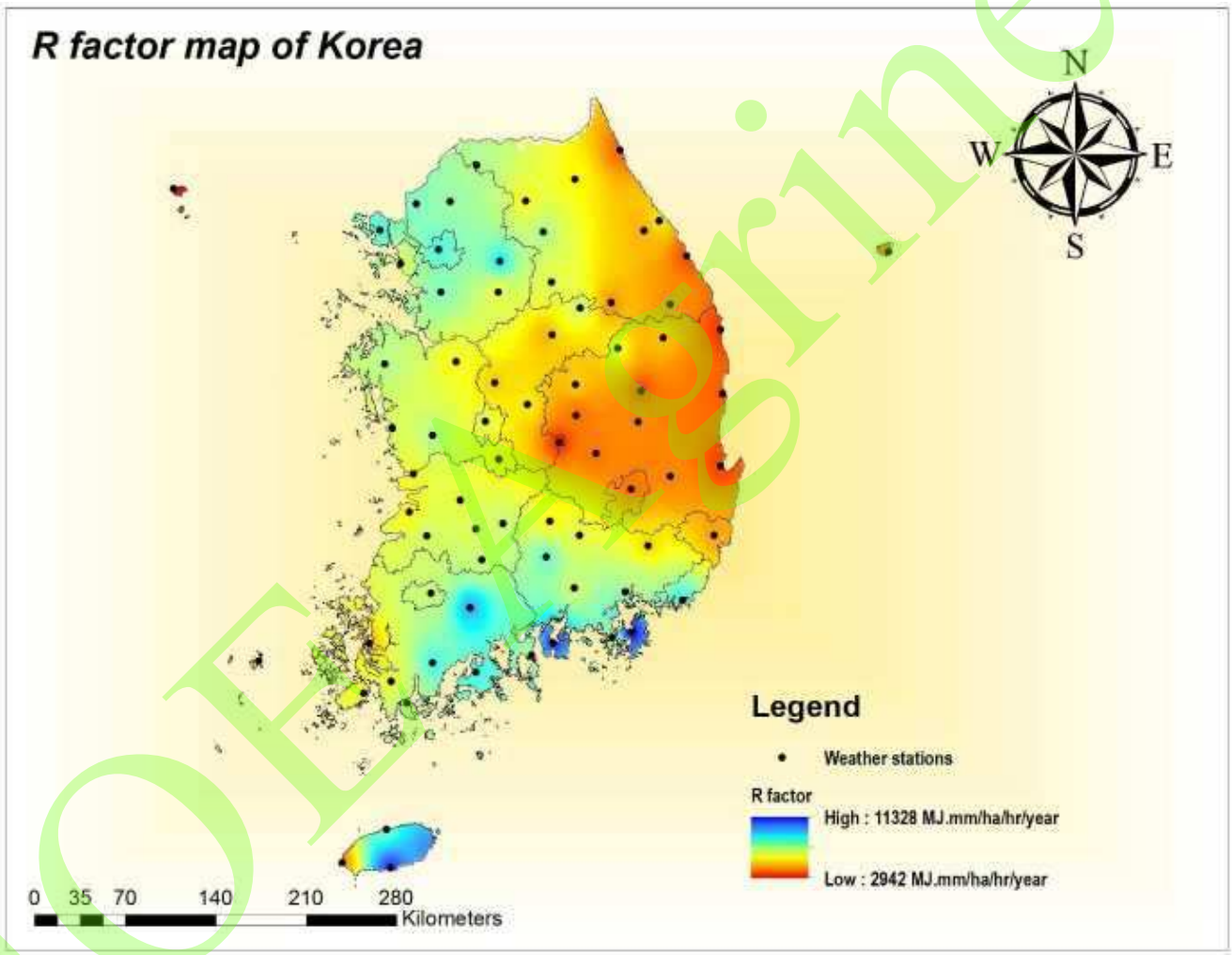

Figure 2: R factor map of South Korea

The specific regression model for 25 different locations that were developed for the determination of monthly R factor was based on monthly rainfall amount and order of month. The order of the month has values from 1 to 12. The correlation graph was plotted between the R factor from Regression model and the R factor from WERM .The coefficient of determination (R^2) of the correlation graph obtained for Hongcheon was found to have the greatest R^2 value of 0.92, whereas Boeun was found to have lowest R^2 value of 0.75 among our 25 weather stations.

4. CONCLUSIONS:

The Web ERosivity Module (WERM) is very simple to use and it can be very effective tool to estimate the USLE R-factor from the ten minute interval rainfall data within a minute without tedious calculation. In addition, user can obtain the value of yearly, monthly and event wise R factor of entire period of which the rainfall data has been used. It is not required to process or manipulate for the missing rainfall data as the module is adjusted for those kind of data and correct value can be achieved even if the data for some short period is absent. If we have the higher temporal resolution rainfall data, it is a very convenient way of determination of erosivity factor. For the estimation of soil loss using USLE in Korea, the value of average annual R factor that is calculated and published for 75 different cities in this research gives the better value than previous R factor suggested by Ministry of Korea [14]. The R factor values published in this research are based on rainfall data of recent 15 to 19 years, whereas the values of previous R factors [12, 13]were based on very old rainfall data set from 1973 to 1996. The R factor Map prepared in this study gives better result than previous R factor map developed based on old dataset. Moreover the previous research had used 60 minute interval rainfall data from which they derived the maximum 30 minute intensity whereas ten minute interval data is used in this study which obviously can give more accurate value of maximum 30 minute intensity and R factor. In absence of higher temporal resolution rainfall data, we can estimate the monthly R factor from local daily rainfall data using regression model developed in this study. The regression model can be used to estimate R factor with more than 75 % accuracy. In addition to this, these regression equations can be used for the prediction of future R factor from predicted monthly rainfall amount using different climate change scenarios and thus erosion forecasting can be done[15].

Since the R factor from this research is reliable and is based on recent rainfall data , the updated R factor is suggested to be used in future instead of the one suggested by Ministry of Environment [16] which is based on the old data from the research of Jung, et al. [13] and Park, et al. [12]. The law enforced by the public notice by the Ministry of Environment [16] regarding survey of topsoil erosion should be changed and this research result should be incorporated in the guideline. Moreover, the monthly R factor is suggested to be used as far as possible instead of average annual R factor for the estimation of soil loss since more than 80% of rainfall occurs in the rainy season and the erosion potential then is very high compared to dry season. In such case, using the average annual R factor value can give misleading amount of soil loss especially when we are considering a smaller watershed or field based studies. The monthly R factor values from the WERM can be very effective in such case.

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IRRIGATION SCHEDULING IN WHEAT USING TENSIOMETER

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ABSTRACT

A field experiment on 'irrigation scheduling in wheat using tensiometer'' was conducted at National Wheat Research Program, Bhairahawa, Rupandehi during 2013/2014 and 2014/015. Trial was laid out in randomized complete block design with 3 levels of irrigation threshold (20, 35 and 50 kPa) and depth of soil water tension monitoring (20, 35, 50 cm). i.e. a total of 9 treatments with three replications. The main objective of the experiments to evaluate the effects of irrigation threshold and measurement depth on wheat yield, irrigation water use and water productivity. Wheat variety Gautam was used in the experiment. Fertilizer was applied at the rate of 100: 50: 50 $N:P_2O_5:K_2O$ kg ha^{-1} and other agronomical operations were followed as per recommendation. Tensiometer reading was recorded every day and irrigation was applied when tensiometer reading reached at threshold. Data on yield and yield attributes collected and analyzed using Genstat statistical package and combine result showed that emergence count m^{-2}, days to heading & maturity, plant height, spikes m^{-2}, grains per spikes, grain yield straw yield and total biomass variables were not significant and 1000 grain weight and harvest index variable were significantly difference in irrigation scheduling based on tensiometer reading at different layer of soil moisture tension. Based on two years result it could be concluded that two time irrigation was found optimum in wheat crop at Bhairahawa condition if winter seasonal rainfall occurred.

INTRODUCTION

Wheat (*Triticum aestivum* L) is the third important cereal after rice and maize in Nepal. It plays an important role in national food security. It is grown in the Terai, mid hill and high hills during the winter season. Wheat covers nearly 0.75 million hectare in Nepal (MoAD, 2014). Total production of wheat in Nepal is 1.88 million tones with 2.495 ton/ha average productivity. Low productivity of the wheat is associated with late planting, inappropriate wheat genotypes, declining soil fertility, formation of hardpan close to plough layer, weeds, disease and insect and unavailability of water as well as water logging during early growth stage of the crop. Irrigation water is used to maximize crop yield by minimizing water stress in the root zone. However, this is not often done in a proper manner. Indiscriminate use of irrigation water has led to problems of rising water tables causing widespread land degradation (Schofield et al., 1989; Anderson et al., 1993). The irrigation scheduling is the process of determining when to irrigate and how much water to apply per irrigation. Proper irrigation scheduling is essential for the efficient use of water, energy and other production inputs. Three major considerations influencing irrigation schedule such as water needs of crop, availability of water for irrigation; and capacity of the root zone to store water. Water needs of crop are of paramount importance in determining the time of irrigation during the crop-growing season. Scheduling irrigation of wheat based on soil water tension can help increase irrigation water productivity through avoiding water deficit stress and over-irrigation. However, there are no rigorously determined guidelines on what depth to place the tensiometers, nor the optimum irrigation threshold. Therefore, a series of experiments is being implemented in a range of agro-ecological situations such as climate, soil type, variety to evaluate the effects of irrigation threshold and measurement depth on wheat yield, irrigation water use and water productivity. To address water deficit stress and over irrigation a study on irrigation scheduling in wheat an experiment was conducted at National Wheat Research Program, Bhairahawa, Rupandehi.

MATERIALS AND METHODS

An experiment on irrigation scheduling in wheat was carried out at National wheat research program, Bhairahawa, Rupandehi during 2013/2014 and 2014/2015. Trial was laid down in randomized complete block design with 3 levels of irrigation threshold (20, 35 and 50 kPa) and depth of soil water tension monitoring (20, 35, 50 cm). i.e. a total of 9 treatments with three replications. Wheat variety Gautam was used in the experiment and planted on 8th December, 2013 &

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19th December, 2014 during 2013/014 and 2014/015 respectively. Fertilizer was applied at the rate of 100: 50: 50 $N:P_2O_5:K_2O$ kg ha^{-1} and other agronomical operations were followed as per recommendation. Common irrigation at crown root initiation was applied in all plots. The experimental soil texture was silt loam with 8.0 pH, low organic matter (1.35 %), low N% (0.08%), medium available phosphorus (53.21 kg ha^{-1}), and medium potash (119.42 kg ha^{-1}) . Tensiometer were installed in each individual plots as per treatment. Reading of tensiometer was recorded every day and crop was irrigated when reached at threshold. Genstat statistical package was used to analyzed data.

RESULTS AND DISCUSSIONS

During 2013/2014 result showed that days to heading, days to maturity, plant height, spike/m^2, grains/ spike, spike length, yield and total biomass were not significant to different depth and soil moisture tensions. Whereas, 1000 grain weight and harvest index were significantly different. (table -1). Similarly, during 2014/2015 emergence count , days to heading, days to maturity, plant height, spike/m^2, grains/ spike, spike length, 1000 grain weight, grain yield, straw yield and total biomass variables were not significant and harvest index was significant in different soil moisture tension and depth (table -2). Combine result also showed similar trend as found during 2013/2014 (Table 3). Year was significantly difference except in spike length. Whereas, interaction of year and treatment was not significant (table-3). 1000 grain weight and harvest index were significantly low in maximum number if irrigation frequencies might be lodging and lower grain yield. Treatment with installed tensiometer at 20cm depth and 20 kpa got 7-8 times irrigation whereas treatment tensiometer installed at 50 cm depth and 50 kpa tension got two time irrigation. Yield increased with decreasing levels of irrigation but yield difference was not significant. Crop lodging was noticed when applied more than three time irrigation.

Table-1. Effect of irrigation scheduling on yield and yield components in wheat at NWRP/Bhairahaawa-2013/014

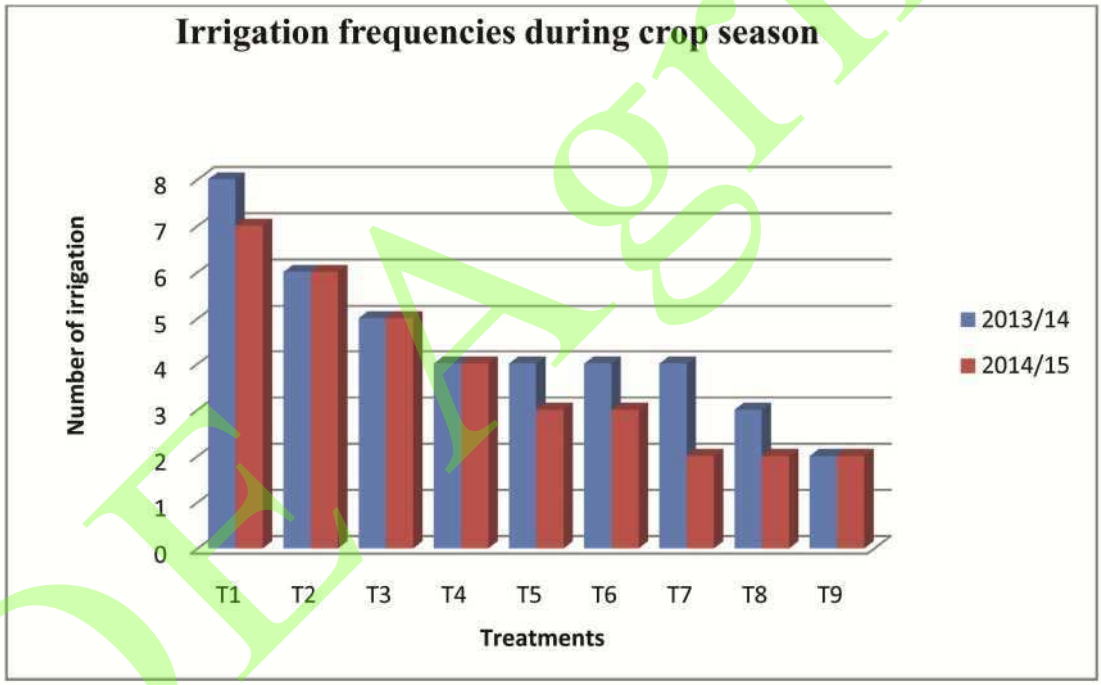
Treatment	Depth (cm)	Kpa	Emergence (M^2)	DH	DM	Plant height (cm)	Spike/m^2	Grains/spike	Spike length (cm)	1000 grains wt (gm)	Yield (kg ha^{-1})	Total biomass (kg ha^{-1})	HI (%)	No. of irrigation
20, 20	20	20	143	81	120	90	240	45	11	35	2509	6900	36	8
20 ,35	20	35	144	82	119	93	186	44	11	40	2552	6600	39	6
20, 50	20	50	137	81	118	92	217	43	12	38	2281	6000	38	5
35, 20	35	20	135	82	120	90	220	40	11	36	2711	6900	39	4
35, 35	35	35	143	80	118	90	193	43	11	41	2681	6633	41	4
35, 50	35	50	136	82	119	93	221	46	11	37	2776	6800	41	4
50, 20	50	20	127	81	118	90	202	50	12	38	2631	6800	39	4
50, 35	50	35	138	82	119	91	216	47	12	39	2789	6933	40	3
50, 50	50	50	131	81	118	94	215	46	11	40	3053	6933	44	2
F-test			NS	NS	NS	NS	NS	NS	NS	*	NS	NS	*	Rainfall (mm)
LSD (P=0.05)			32.00	1.90	0.60	8.06	48.57	9.42	1.65	3.68	617.20	1516.20	3.49	
CV%			17.70	1.40	1.30	5.10	13.20	12.10	8.40	5.60	13.40	13.00	5.10	44.6
GM			137.00	81.00	119.00	91.26	212.00	45.00	11.41	38.26	2665.00	6722.00	39.63	

Table-2. Effect of irrigation scheduling on yield and yield components in wheat at NWRP/Bhairahawa-2014/015

Treatment	Depth (cm)	Kpa	Emergence (M^2)	DH	DM	Plant height (cm)	Spike/m^2	Grains/spike	Spike length (cm)	1000 grains wt (gm)	Yield (kg ha^{-1})	Straw yield (kg ha-1)	Total biomass (kg ha^{-1})	HI (%)	No. of irrigation
20, 20	20	20	160	83	115	82	180	44	11	30	1574	2341	3917	39	7
20 ,35	20	35	187	83	116	82	195	34	11	30	1559	2486	4056	39	6
20, 50	20	50	177	82	116	82	188	35	11	30	1555	2498	4056	38	5
35, 20	35	20	184	82	115	85	183	40	12	32	1788	2517	4305	41	4
35, 35	35	35	182	83	115	80	170	39	10	32	1652	2262	3916	42	3
35, 50	35	50	177	82	115	80	174	38	11	31	1897	2451	4361	44	3
50, 20	50	20	180	82	115	84	176	36	13	34	1773	2299	4083	43	2
50, 35	50	35	179	82	115	81	186	41	11	32	1743	2308	4056	44	2
50, 50	50	50	172	81	115	81	189	41	12	32	2062	2544	4611	45	2
F-test			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	Rainfall (mm)
LSD (P=0.05)			23.34	1.61	0.78	6.66	42.23	11.73	1.77	3.38	476.2	742.8	1198.2	3.46	
CV%			7.6	1.1	0.4	4.7	13.4	17.6	9.2	6.2	15.9	17.8	16.7	4.8	173.1

Table-3. Combine result of irrigation scheduling on yield and yield components in wheat at NWRP/Bhairahawa

Treatment	Depth (cm)	Soil moisture tension (Kpa)	Emergence count (M^2)	Days to heading	Days to maturity	Plant height (cm)	Spike /m^2	Grains /spike	Spike length (cm)	1000 grains wt (gm)	Yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Total biomass (kg ha^{-1})	Harvest index (%)	No. of irrigation (1st year)	No. of irrigation (2nd year)
20, 20	20	20	152	82	117	86	210	45	11	33	2042	3366	5408	38	8	7
20 ,35	20	35	166	82	117	87	190	39	11	35	2055	3267	5328	39	6	6
20, 50	20	50	157	81	117	87	202	39	12	34	1918	3108	5028	38	5	5
35, 20	35	20	160	82	118	87	202	40	12	34	2249	3353	5603	40	4	4
35, 35	35	35	163	81	117	85	182	41	11	37	2167	3107	5275	41	4	3
35, 50	35	50	157	82	117	86	197	42	11	34	2336	3238	5581	42	4	3
50, 20	50	20	154	82	117	89	189	43	12	36	2202	3234	5442	41	4	2
50, 35	50	35	159	82	117	83	201	44	11	36	2266	3226	5495	42	3	2
50, 50	50	50	152	81	117	87	202	44	12	36	2557	3213	5772	44	2	2
F-test			NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	**		
LSD (P=0.05)			19.1	1.28	1.07	5.48	33.5	7.17	1.18	2.32	462.4	739.1	1175	2.34	Rainfall (mm)	Rainfall (mm)
CV%			10.3	1.3	0.8	5.4	14.5	14.7	9	5.7	17.9	19.5	18.4	4.9		
Year			**	**	**	**	**	**	NS	**	**	**	**	**		
Treatment*Year			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	44.6	173.1



Note= T1= Tensiometer installed at 20 cm depth and 20 Kpa soil moisture tension, T2= 20 cm& 35 Kpa, T3= 20 cm& 50 Kpa, T4= 35 cm & 20 Kpa, T5 = 35 cm & 35 Kpa, T6= 35 cm & 50 Kpa, T7= 50 cm & 20 Kpa, T8= 50 cm & 35 Kpa and T9= 50 cm & 50 Kpa

CONCLUSION

Based on two years result it could be concluded that two time irrigation is optimum when winter seasonal rainfall occurred for wheat at Bhairahawa condition.

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EFFECT OF IRRIGATION ON MAIZE PRODUCTION

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ABSTRACT

An experiment was conducted at the experimental farm of Bangladesh Agricultural University, Mymensingh, with a view to evaluate the effect of irrigation on maize (cv. Bornali) production. The experiment included five irrigation regimes with IW/CPE (irrigation water applied divided by cumulative pan evaporation) ratio 1.0 which are I_0 (control), I_1 (35 and 70 DAS), I_2 (35 and 90 DAS), I_3 (70 and 100 DAS), I_4 (35, 55, 70, 90 and 100 DAS). The experiment was laid out in a split plot design with 3 replications, assigning 5 irrigation treatments to main plots. Texturally, the soil of the experimental plot was silt loam. Yield and yield contributing characters were significantly affected due to the application of irrigation. The influence of irrigation on grain yield was statistically significant. The highest grain yield (5.78 t/ha) was obtained with the irrigation treatment I_1 (35 and 70 DAS) and the lowest one (4.28 t/ha) in the control. The grain yields were strongly supported by the yield contributing characters.

Keywords: maize yield, irrigation.

INTRODUCTION

Bangladesh is an agricultural country, occupying an area of 1,47,570 sq. km. and lies in the tropic of cancer between the latitudes 20.25° to 26.64° N and longitudes 88.10° to 92.40° E. Maize grains have high nutritive value containing 66.20% starch, 11.10% protein, 7.12% oil and 1.5% minerals. Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.80 mg thiamin and 0.10 mg riboflavin per 100 gm grains (Chowdhury and Islam, 1993). Maize can be consumed directly as green cob, roasted cob or puffed grain and flour satu. It is also used for manufacturing starch, corn flacks, alcohol, salad oil, soap varnishes, pains, printing and similar products (Thakur, 1980; Ahmed, 1994). In Bangladesh, maize is the third most important cereal crops and covers 2,834 ha of land with an annual production of 3000 tons during the year 1997 and 1998 (BBS, 1999). Maize is grown as fodder and its grains are used for both human consumption and as dairy, poultry and fish feed in many areas.

Limited water supply during the growing season results in soil and plant water deficits and reduces maize yields (Gordon et al., 1995). In relation to crop yield, proper time and supplemental irrigation should be realized in irrigation scheduling for the most effective use of available water in optimizing maize production. Two irrigations give maximum yield at tasselling and three irrigations might be required in sandy soil (Leonard et al., 1940). Application of irrigation water at the rate of 6.4 mm/day can give the highest yield with maximum irrigation and fertilizer applications (Talukder, 1985).

Heading to milking stage is the most sensitive period of water stress and has ultimate impact on grain yield (Shaozhong and Minggang, 1992). Water deficit has little effect on timing of emergence, number of leaves per plant but delayed tasselling initiation and silking, reduced plant height and vegetative growth of maize (Abrecht and Carberry, 1993). The grain yield is the highest at the row spacing of 60 cm and with irrigation at the CPE of 40 mm (Lambe et al., 1998). The optimum amount of water made available to the crop to dissolve the fertilizers is essential for proper growth and development. Therefore, an attempt has been made to evaluate the effect of irrigation on yield and yield contributing characters of maize.

METHODOLOGY

The experiment was conducted at the farm of Bangladesh Agricultural Univeristy, Mymensing, during 29th Novemeber 2000 to 23 April 2001 to study the effect of nitrogen and irrigation on maize production. The experimental site was located approximately between the latitude of 24° 55´ to 25° 50´ N and longitude of 90° 10´ to 90° 30´ E. Texturally, the soil of the experimental plot was silt loam with P^H varying from 6.42 to 7.60 the reaction of the soil was slightly acidic to neutral. The experimental area was under the subtropical climate and the average rainfall is greater than the average rainfall of

Bangladesh. The temperature varies from moderately low in winter to moderately high in summer. The seeds were collected from seed sale center of Bangladesh Agricultural Development Corporation (BADC), Mymensingh.

The experiment was laid out following a split plot design with three replications giving irrigation in the main plots. Each plot was divided into 5 main plots and each main plot was again divided into 4 sub-plots. The application of irrigation water were estimated by IW/CPE ratios, where, IW is irrigation water and CPE is cumulative pan evaporation. The irrigation treatments were as follows: I_0=No irrigation (control); I_1=IW/CPE=1.0 [irrigation at 35 and 70 days after sowing (DAS)]; I_2= IW/CPE=1.0 (irrigation at 55 and 90 DAS); I_3= IW/CPE=1.0 (irrigation at 70 and 100 DAS); I_4= IW/CPE=1.0 (irrigation at 35, 55, 70, 90 and 100 DAS).

Seeds of maize were sown on 29th November 2000 at the depth of 5 to 6 cm by dropping seeds by hand. Seed to seed distance within the row was 25 cm and row to row distance was 70 cm. Before sowing the seeds were soaked in fresh water for 24 hours. First weeding was conducted after 15 days after sowing and also the thinning was done on the same day. Only one healthy plant per hill was kept and rest plants were thinned out. Intercultural operations were made as and when necessary to keep the crop free from weeds and to protect from diseases. There was no major incidence of insects and diseases. So, no pest control measure was adopted. Some of the plants were affected by caterpillar. At booting and young cob stages, jackals and parrots were the big problem in this area. The whole experimental plot was protected by bamboo fence to protect the plant from damage by animals.

Twenty plants were randomly selected from each unit plot and were tagged about a month before harvesting. The full matured crop was finally harvested plot wise on 23rd April 2001. The tagged plants were harvested with root separately. The cobs were then cleaned, dried, shelled with hands and finally dried plot by plot separately to obtain the required data.

The collected data were analyzed using analysis of variance technique and mean differences were adjusted by Duncan's Multiple Range Test (DMRT) according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of different levels of irrigation on the yield and yield contributing characters of maize are discussed in this section. The highest plant height (197.40 cm) was observed with the irrigation treatment I_1 (35 and 70 DAS) and the lowest (183.26 cm) was observed in I_4 (35, 55, 70, 90 and 100 DAS) (Fig. 1). Root lengths were significantly increased with the application of irrigation water. The highest root length (29.69 cm) was observed in the irrigation treatment I_3 (70 and 100 DAS), which is significantly different from the other irrigation treatments. Similar results were obtained by Dai et al., (1990).

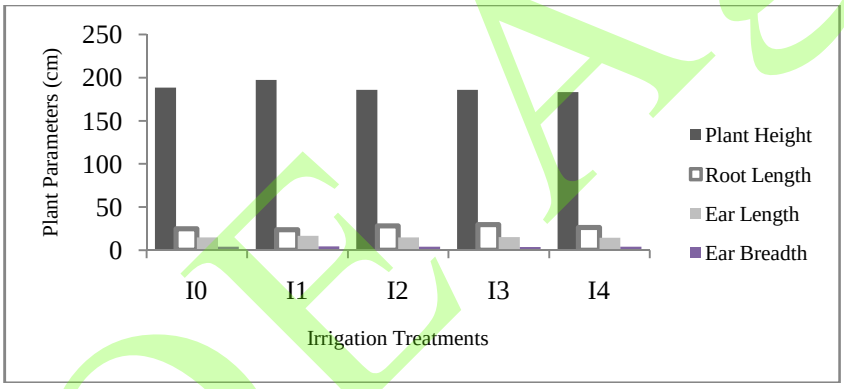

Fig. 1. Effect of irrigation treatments on plant height, root length, ear length and ear breadth.

The ear length was found to be significantly increased due to the application of irrigation water. The highest ear length (16.65 cm) was found in the irrigation treatment I_1 (35 and 70 DAS). The lowest ear length (14.60 cm) was found in the irrigation treatment of I_4 (35, 55, 70, 90 and 100 DAS) (Fig. 1). The highest ear breadth (4.48 cm) was observed in the irrigation treatment I_1 (35 and 70 DAS) and the lowest one (3.38 cm) in the irrigation treatment I_3 (70 and 100 DAS).

Ears per plant was also significantly affected by various irrigation regimes. The highest number of ears per plant (1.08) was observed with the irrigation treatment I_1 (35 and 70 DAS). On the other hand, the lowest one (1.0) was found in the irrigation treatment I_2 (55 and 90 DAS). The irrigation treatment I_1 (35 and 70 DAS) produced the highest number of

kernels per ear (320.34), which was statistically similar to the control treatment. The lowest number of kernels per ear (266.35) was observed in the irrigation treatment I_3 (70 and 100 DAS).

A significant variation was recorded for 100-kernel weight owing to differences in irrigation treatment. The highest 100-kernel weight (29.04 gm) was found in the irrigation treatment I_1 (35 and 70 DAS). The lowest 100-kernel weight was observed in the controlled one (Fig.2).

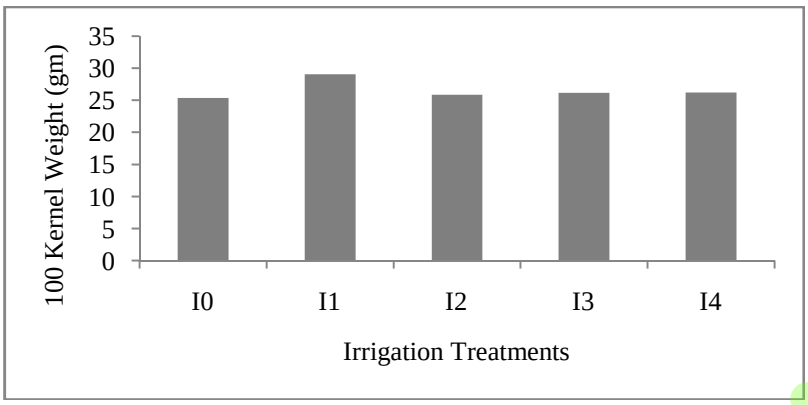

Fig. 2. Effect of irrigation treatments on 100 kernel weight.

The influence of irrigation on grain yield was statistically significant. The highest grain yield (5.78 t/ha) was obtained with the irrigation treatment I_1 (35 and 70 DAS) and the lowest one (4.28 t/ha) in the control (Fig. 3). The grain yields were strongly supported by the yield contributing characters. The results are in conformity with the findings of Talukder (1985), Chowdhury and Islam (1993) and Zhirkov (1995).

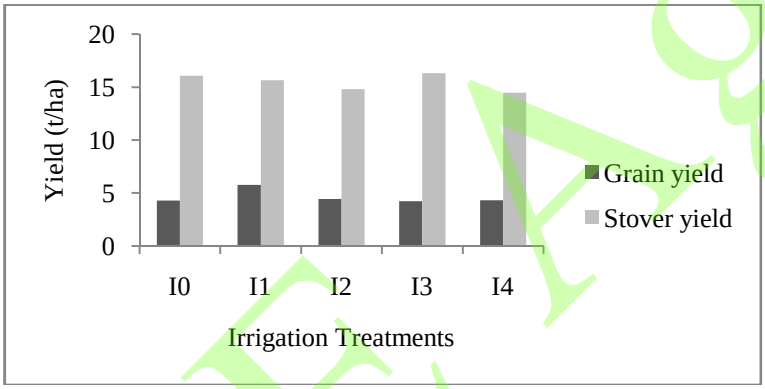

Fig. 3. Effect of irrigation treatments on yield.

Different irrigation regimes were found to have significant effects on stover yields. Stover yields were significantly increased by the irrigation treatment I_3 (70 and 100 DAS) and was statistically identical to the controlled one. The lowest stover yield was observed in irrigation treatment I_4 (35, 55, 70, 90 and 100 DAS) (Fig. 3). Chowdhury and Macksoud (1997) also found similar results.

CONCLUSIONS

The following conclusions were drawn from the study:

1. The yield and yield contributing characters were significantly affected due to the application of double cycle irrigation water based on IW/CPE ratio at different growth stages of maize.
2. The highest grain yield of 5.78 t/ha was obtained with the application I_1 (35 and 70 DAS) irrigation treatment and the lowest 4.22 t/ha was obtained with the irrigation treatment I_3 (70 and 100 DAS).

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COMPARATIVE STUDY OF PRODUCTION COST FOR PADDY USING TRADITIONAL AND SEMI MECHANIZED METHODS OF FARMING; A CASE STUDY OF AURAHI VDC, SIRAHA DISTRICT, NEPAL

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ABSTRACT

This study attempted to calculate the cost incurred in the production of paddy by both the methods i.e., traditional and semi mechanized and have compared them for conclusive remarks. A survey was conducted in the Aurahi VDC, of Siraha district, Nepal with pre tested and thorough questionnaire in all 9 wards of the VDC from 85 households to calculate the cost incurred in both the methods of paddy production and was cross checked it with the old expertise of the VDC. The results depicted that production per hectare is almost equal in both the methods i.e., 36 qt/ha with the cost incurred per hectare for farming operations in semi mechanized method amounting lesser than traditional methods i.e., Rs. 56,193/ha<Rs.66,443/ha. Also the cost incurred per kg of the paddy in semi mechanized method was found to be lesser than that in traditional method i.e.,Rs.15.9<Rs.19.04 per kg.The productivity in case of traditional method is far lesser than that in Semi-mechanized method i.e.,0.053kg/Rs<0.066kg/Rs. By benefit cost analysis we got higher benefit cost ratio in semi mechanized methods than in traditional methods i.e., 1.68>1.35, which tells us that the benefit of the farmers increases shifting our practices to mechanization in the field.\

Keywords: Production cost, Semi-Mechanized methods, Traditional method

INTRODUCTION

Rice is by far the most important crop in Nepal and accounts for about 50 percent of the total agricultural area and production in the country. It is grown on about 1.45 million ha, and total production since 1988/89 has hovered between 3.2 million and 3.5 million tones. Rice contributes approximately one-fourth of GDP and more than 75 percent of the working population is engaged in rice farming for at least six months of the year. Furthermore, rice in Nepal provides nearly 50 percent of the calorie requirements supp lied by cereals. **Rice, as the staple food of Nepalese provides calories, protein and other nutrient requirements of people Upadhayaya and Ojha (1992).**

Traditional method of cultivation refers to the method that has been followed and use as a basic procedure for cultivation by farmer. It includes the use of traditional equipments and tool for farming operation. Traditional farmers are those farmers who have no improved farm implements but are having less than 25 percent of the cropped area under high yielding varieties **Singh et al. (1971**).

Farm mechanization refers to the use of mechanical, upgraded and modernizes techniques as base for cultivation by farmers. It includes the use of mechanical means i. e., machines, tools, equipments e.t.c., for farming operation and upgraded techniques for fertilizers applications and irrigation. By farm mechanization we mean introducing the use of mechanical procedures into farm operation in an area where these procedures have not previously been used.

Average yield of various countries from the datas analysis were found to be 6.38,6.51,3.14,3.69,2.57 t/ha for China,Japan,India,Bangladesh,Nepal respectively.similarly from data analysis taken from CBS,2013 average yield of various agro ecological regions of nepal were found to be 2.02,2.74,2.95 t/ha for mountains,hills,terai respectively.

Only under certain conditions, where production increases achieved through the use of other improved inputs has come to its limits, can improved tools and equipment by themselves lead to production increases, cost reductions or improvements in the environmental sustainability of farming. In situations where land is not a constraint, increased farm power can lead to direct increases in production by simply increasing the land area or animal numbers that one man can handle. In the past, misunderstood concepts and inappropriate selection and use of certain mechanization inputs (mainly tractors and heavy machinery) have, in many parts of the world, led to heavy financial losses and lowered agricultural production as well as contributed to environmental degradation.

In many cases farm mechanization has also been seen as constraints whereas many cases traditional methods have limited outcome but till now it has not yet been concluded specifically that using traditional method is costly than farm mechanization method or not. This question has varying answers with varying places and also varies with the crop that is to be produced. So, it is great need for these questions to have site specific answers so that farmers will taste the sweet buds of their hardships and thereby serving for socio-economic uplift of farmers.

The objective of this study was to determine the production cost of paddy using traditional and semi-mechanized methods of farming and compare them for conclusive remarks.

METHODOLOGY

This study was carried out at **Aurahi, Siraha** which is a village development committee in Siraha District in the Sagarmatha Zone of south-eastern Nepal.

The primary data were collected from 85 paddy farmers in all 9 wards by interviewing the farmers using a specially designed and pre-tested questionnaire. For secondary data comprehensive literature review was undertaken to understand the existing policy scenarios, production trends and cost of factor of paddy cultivation. The data were then inquired and taken from the NARC, Ranighat, Birgunj which in turn were recorded from the package farming contractors and practical observations by the NARC itself. For the calculation of average yield of various agro-ecological regions of Nepal data of area and production were analyzed from CBS, 2013.

A descriptive statistical analysis was done to analyze the cost of production, yield, cost incurred per kg, productivity and for benefit cost analysis. These values were thus calculated by simple mean and unitary method. Productivity and Cost Benefit analysis was calculated by the formulas from literature review. Manual calculation was also done for the analysis.

The gross value of production and benefit to cost ratio were calculated using the following equations **Mohammad et al. (2008):**

Gross value of production (Rs/ha) =Yield (kg/ha)* Sale price (Rs./kg)

Productivity (kg/Rs)=Yield(kg/ha)/Total cost of production(Rs/ha)

Benefit to cost ratio=Gross value of production (Rs/ha)/Total cost of production (Rs/ha)

RESULTS AND DISCUSSIONS

Traditional farming methods

The results shows that the average yield by this method in this VDC was found to be 36.1~**36 qt/ha** and total cost incurred was found to be **Rs.66, 443 per ha.** The cost per Kg production was found to be **Rs.19.04** also the productivity was found as **0.053Kg/Rs** and by benefit cost analysis B/C Ratio of that VDC for this method was found to be **1.35.** The power sources used in this method on that VDC was bullocks, manual and implements used were animal plough, sickle, spade, wooden leveler.The average land holdings of the farmers in that VDC was found as 1.065 ha.

Semi-Mechanized farming methods

The results shows that the average yield by this method in this VDC was found to be **36 qt/ha** and total cost incurred was found to be **Rs.56, 193 per ha**. The cost per Kg production was found to be **Rs.15.9** also the productivity was found as **0.066Kg/Rs** and by benefit cost analysis B/C Ratio of that VDC for this method was found to be **1.68**. The power sources used in this method on that VDC was bullocks, manual, tractors and implements used were animal plough, sickle, spade, wooden leveler, thresher, and cultivator.

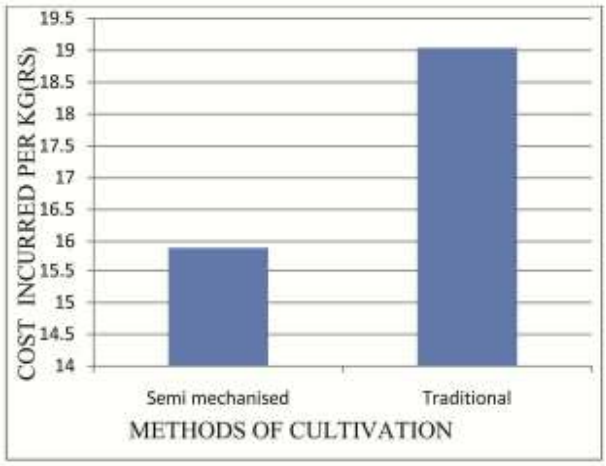

Fig.1 Variation of cost incurred per kg (Rs.) production of paddy by both methods.

By comparisons, it can be found that production per hectare is almost equal in both the methods i.e.,36qt /ha with the cost incurred per hectare for farming operations in semi mechanized method amounting lesser than traditional methods i.e.Rs.56,193/ha<Rs.66,443/ha(Fig. 4). This tells us that the production per hectare increases if we shift towards mechanization in same farming field. Also the cost incurred per kg of the paddy in semi mechanized method was found to be lesser than that in traditional method i.e.,Rs.15.9<Rs.19.04 per kg(Fig. 1), which tells us that introducing mechanization makes the cost incurred lesser, saving the problem of capitalization of poor farmers.

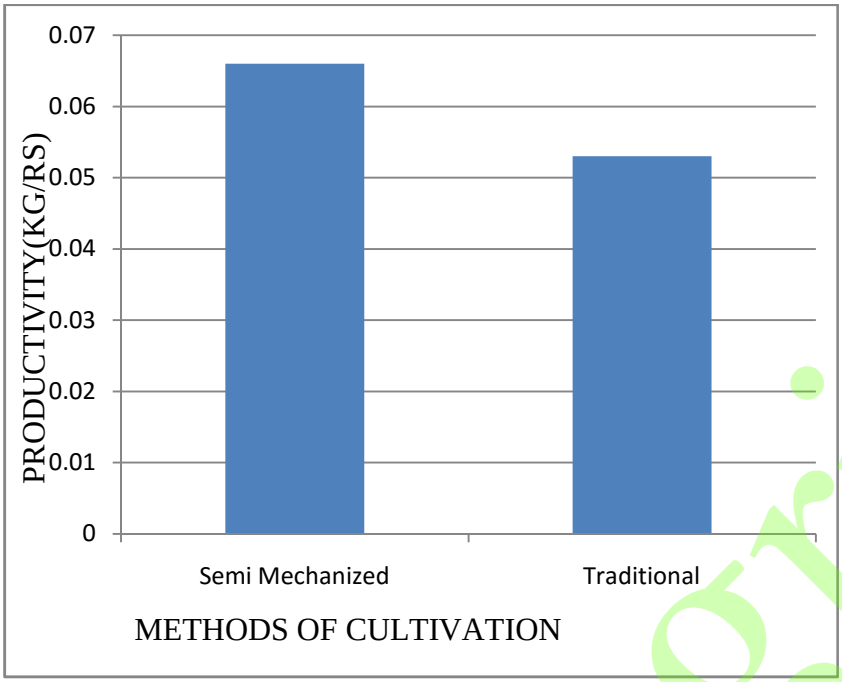

Fig.2 Variation of productivity (kg/Rs) by both methods of farming.

The productivity in case of traditional method is far lesser than that in Semi-mechanized method i.e., 0.053kg/Rs<0.066kg/Rs (Fig. 2), which tells us that the mechanization creates the condition to increase production to the potential of the land. By benefit cost analysis we got higher benefit cost ratio in semi mechanized methods than in traditional methods i.e., 1.68>1.35 (Fig. 3), which tells us that the benefit of the farmers increases shifting our practices to mechanization in the field

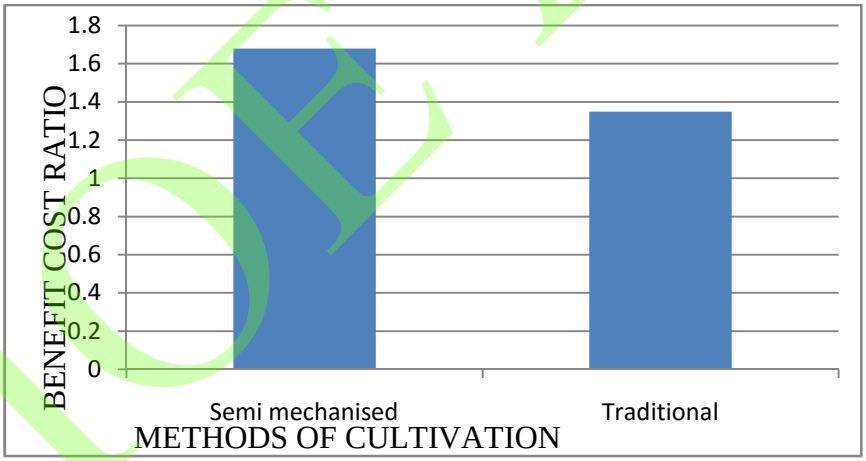

Fig.3 Variation of benefit cost ratio by both mentioned methods of farming.

This particularly occurred due to the use of farm machineries which created such situation to increase productivity at minimum input i.e., increase in production per unit land at minimum implication of cost per unit land. This situation may have been such created by optimum churning of soil by the machineries. Also the harvesting and threshing which is done separately in traditional methods leads to higher losses leading to less return and increasing costs incurred. But in semi mechanized methods both these operations are performed sequentially by machines reducing the massive losses and increasing the return thereby decreasing the costs incurred.

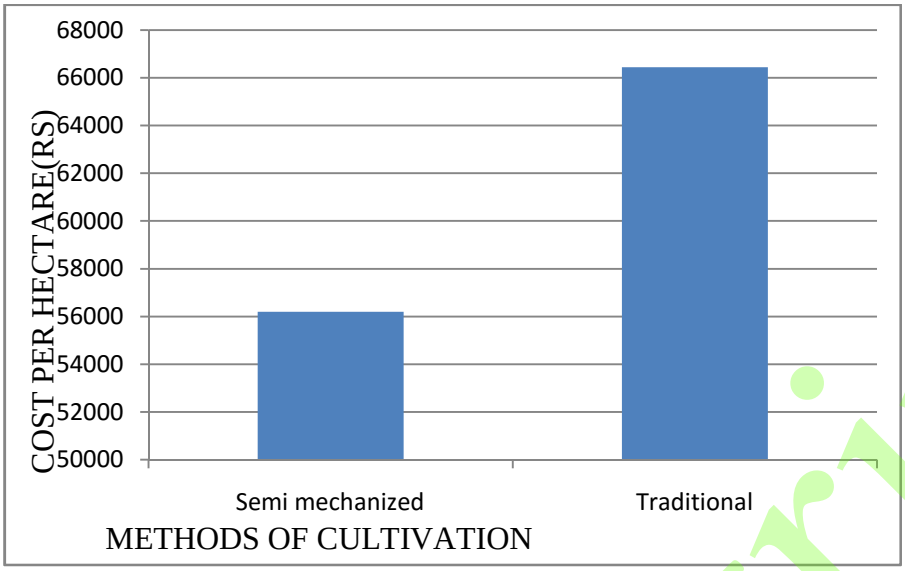

Fig.4 Variation of total cost incurred per hectare (Rs/ha) by both methods.

It is also seen that the inputs in traditional methods is higher in comparison with semi mechanized method which may be one of many reasons for high cost incurred in traditional methods. All these operation reduces losses, labors, time thereby reducing the costs incurred. So, these may be discussed as the probable reasons for reduction of costs incurred and increase in productivity in case of semi mechanized methods.

CONCLUSIONS

It was also concluded that shifting towards mechanization in farms boosts up the agricultural potential of the farm land to its full potential. The conclusion was also drawn on average land holding of the farmers of that particular VDC which we found as 1.065ha, so there were farmers of small land holdings. The costly method in all our analysis was traditional methods of farming and also concluded that the preferable method of farming should be fully mechanized methods as seen from literature review.

We can be self sustained and to some extent may export paddy by adopting farm mechanization methods in farming as we see the productivity increases with mechanization and will have positive effects on GDP if we shift our practices to mechanization. Since it was seen that the output from semi-mechanized methods was not that remarkably cheaper than traditional methods. So fully mechanized methods was concluded to be used as farming methods to get fruitful results as seen from the analysis made from the data provided by the NARC.

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HYDROPOWER AS RENEWABLE ENERGY, ITS SCENARIO IN NEPAL AND EARTHQUAKE IMPACTS

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ABSTRACT

As far as sustainability is concerned hydropower has a huge potential to improve economic viabilities, to preserve ecosystem and to enhance social justices. Skillfully planned, built and operated hydropower scheme can make significant contributions for a nation economy. The role of hydropower as one of the renewable and clean energy sources and its potential should be realized in an environmentally sustainable and socially acceptable manner (WWC and IHA 2003), however it has to be acknowledged that the recognition of hydropower as a legitimate renewable energy resources has been questioned by a number of influential interest groups. Political declaration made at the conclusion of international conference for renewable energy 2004 in Bonn gave recognition to hydropower as a renewable energy resource. More than 154 countries representatives signed in Bonn identify hydropower as one of the renewable technologies. Hydropower, one of the most reliable and common renewable sources of energy is abundantly available in the hilly regions like Nepal and 714 MW is the gross installed capacity ofhydropower plant at present. The massive earthquake of April 25, 2015 and series of aftershocks that followed the main shock of 7.8 scale Richard and still occurring has affected public houses, schools roads and infrastructures of the country and different sector of economy including agriculture, tourism, remittance and Hydropower projects directly. It has been estimated around 9.3to 18% of national output is reduced in agricultural sector due to this earthquake. Tourism and remittances are severely affected. Around 9000 life is lost and 22000 people are injured. The hydropower stations which are main source of economy are badly affected. 14 hydropower stations are damaged across the country resulting a loss of 150 MW of electricity from countries power grid. As a result Nepal electricity Authority (NEA) is distributing only 564 MW including 210 MW imported from India.

Keywords: Renewable energy, Hydropower, Earthquake Impact.

INTRODUCTION

Sustainable development requires integration of three components- economic development, social development, and environmental protection as independent and mutually reinforcing pillars(Antinbelic,2005).The sound development policy and proper application of financial , technical, social and environmental management are the key factors for the success of the projects. As far as sustainability is concerned hydropower has a huge potential to improve economic viabilities to preserve ecosystem and to enhance social justices. Skillfully planned, built and operated hydropower scheme can make significant contributions to achieving these three pillars of sustainable development as mentioned above.

HYDROPOWER AS RENEWABLE ENERGY RESOURCES

Hydropower has been officially declared a renewable energy source in the UN submit on sustainable development in Johannesburg 2002 (IHA, 2004 a). Third world water forum in Kyoto in March 2003 acknowledged “the role of hydropower as one of the renewable and clean energy sources and its potential should be realized in an environmentally sustainable and socially acceptable manner “(WWC and IHA 2003) however it has to be acknowledged that the recognition of hydropower as a legitimate renewable energy resources has been questioned by a number of influential interest groups. In the lead up to international conferences for Renewable energy 2004 Bonn. There had been a concerned that hydropower would not be recognized as renewable energy resources on the ground that new hydropower projects would be unlike tomeet pre- requisites WCD guidelines(pater rae,2005).

However political declaration made at the conclusion of international conference for renewable energy 2004 in Bonn gave recognition to hydropower as a renewable energy resources and further went on to estimate that up to 1 billion people could be given access to energy services from renewable resources including hydropower. .More than 154 countries representatives signed in Bonn identifies hydropower as one of the renewable technologies (hydroworld.com).

SCENARIO OF HYDROPOWER PROJECTS IN NEPAL

Nepal has huge hydropower potential. It has so many numbers of rivers with the significant head from which hydropower can be generated easily. In the developing country, like Nepal, the main problem of growth of population and scarcity of food for their nourishment so we need energy for the efficient production of food to cope with such challenging scenario. The scenario of energy consumption is at the increasing rate. This causes depletion in non-renewable and exhaustive sources of energy, which may invite energy in future. Also, it is essential to meet the concept of sustainable development which means that our children should get at least this much resource that we are consuming at present. So, energy consumers should keen on using of non-exhaustive and renewable sources of energy. Hydropower, one of the most reliable and common renewable sources of energy is abundantly available in the hilly regions like Nepal. Again, hydraulic conveyance circuit can be beneficial for multipurpose use (irrigation, water supply etc.). Hydropower production does not consume water, so it is considered as renewable source of energy. Consumption of this energy is environmental friendly because it uses water as fuel and no harmful by products are produced. It does not emit greenhouse gases that cause ozone layer depletion and global warming. Because of abundant water resources and potential hydropower sites available, there is huge possibility of hydropower power production. Large projects involve huge amount of funds and the gestation period is large hence activities regarding development of Small Hydropower Projects are accelerating in these days which is technically, financially and socially sustainable at the present scenario.

HYDROPOWER DEVELOPMENT IN NEPAL

Nepal, being a developing country, is facing a lot of challenges to raise its economic status. To achieve the sustainable and remarkable development of any country, it is necessary to use its available natural resources. Nepal is endowed with rich hydropower resources which is the major potential source of renewable energy. Hence the major achievements in the socio-economic development of Nepal could be possible through power harnessing of the water resources potentials. First approach in hydropower development in Nepal was the power generation from the construction of Pharping Hydropower station (500 KW) in 1911. But the progressive development was gradual only after the Sundarijal (600 KW) and Panauti (2400 KW) Hydropower Stations came into operation after long interval of 23 and 29 years. The completion of Dhankuta Hydropower station (240 KW) in 1971 was regarded as the bench mark of small hydel development of Nepal. The establishment of small hydel development board in 1975 was another milestone under which several small hydro schemes such as Jhupra (345 KW), Doti (200 KW), Jumla (200 KW) etc. were made during 1975 to 1985. Nepal Electricity Authority (NEA), established 1985, responsible for generation, transmission and distribution of electric power brought the revolution in hydropower development. Many potential sites for hydropower generation had identified by private consultancies and companies in collaboration with NEA. Prior to 1960, all the hydropower stations were constructed through grant aid from friendly countries like the USSR(Panauti), India (Trishuli, Devighat, Gandak, Surajpura- Koshi) and China (Sunkoshi). Since 1970, hydropower development took a new turn with the availability of bilateral and multilateral funding sources. The major donor countries in the period were Japan, Germany, Norway, South Korea, Canada, Finland, Denmark, Sweden and USA. The financial lending agencies were the World Bank, Asian Development Bank (ADB), Japanese Bank for International Cooperation (JBIC), Saudi Fund for Development Kuwait Fund and others. From 1990s, subsequent to the adoption of the policy of economic liberalization, hydropower development took yet another turn with the private sector entering the arena. After formulating Hydropower Development Policy – 1992 by government of Nepal, many private sectors are involving towards power development. In order to encompass projects of various scales intended for domestic consumption as well as to export hydropower, the former policy was replaced by the **Hydropower Development Policy 2001** to provide further impetus to active participation of private sectors. Development of hydropower in Nepal is a very complex task as it faces numerous challenges and obstacles. Some of the factors attributed to the low level of hydropower development are lack of capital, high cost of technology, political instability, and lower load factors due to lower level of productive end-use of electricity and high technical and non-technical losses.

Table 1. Power Development of Nepal

LEGEND FOR POWER DEVELOPMENT OF NEPAL

MAJOR HYDRO POWER

Existing:

1. Trisuli	24.000 kW
2. Sunkosi	10.050 kW
3. Gandak	15.000 kW
4. Kulekhani No. 1	60.000 kW
5. Devighat	14.100 kW
6. Kulekhani No. 2	32.000 kW
7. Marsyangdi	69.000 kW
8. Puwa Khola	6.200 kW
9. Modi Khola	14.800 kW
10. Kali Gandaki "A"	144.000 kW
Total 399.150 kW	
Under Construction:	
1. Middle Marsyangdi	70.000 kW
Planned and Proposed:	
1. Seti (West)	750.000 kW
2. Arun 3	402.000 kW
3. Budhi Gandaki	600.000 kW
4 Kali Gandaki No. 2	660.000 kW
5. Lower Arun	308.000 kW
6. Upper Arun	335.000 kW
7. Karnali (Chisapani)	10,800.000 kW
8. Upper Karnali	300.000 kW
9. Dhaulagiri	300.000 kW
10. Pancheswor	6480.000 kW
11. Thulo Dhunga	25.000 kW
12. Tamur/Mewa	101.000 kW
13. Budh Kha (Storage)	300.000 kW
14. Budhi Ganga	90.000 kW
15. Rahughat Khola	27.000 kW
16. Likhu-4	40.000 kW
17. Kabeli "A"	30.000 kW
18. Upper Marsyangdi "A"	121.000 kW
19. Kulekhani No. 3	14.000 kW
20. Andhi Khola (Storage)	180.000 kW
21. Khimti II	27.000 kW
22. Upper Modi	14.000 kW
23. Langtang Khola (Storage)	218.000 kW
24. Madi Ishaneswor (Storage)	88.000 kW
25. Upper Seti (Storage)	122.000 kW
26. Kanikai (Storage)	60.000 kW
27. Upper Tamur Kosi	309.000 kW
28. Upper Modi 'A'	42.000 kW
29. Hewa Khola	10.000 kW
Total	22,430.000 kW

THERMAL POWER STATIONS

Existing:

1. Mahendra	1,728 kW
2. Birgnagar	1,028 kW
3. Hetauda	12,750 kW
4. Marsyangdi	2,250 kW
5. Duhabi Multifuel-1	25,000 kW
6. Duhabi Multifuel-2	13,000 kW
Total	55,756 kW

SMALL HYDRO POWER

Existing (Grid Connected)

1. Pharping**	500 kW
2. Panauti	2400 kW
3. Sunderijal	640 kW
4. Phewa (Pokhara)	1,088 kW
5. Seti (Pokhara)	1,500 kW
6. Tinau (Butwal)	1,024 kW
7. Hagiwag	200 kW
8. Tatopani/Myagdi (HH)	2,000 kW
9. Jomsom**	240 kW
10. Chatara	3,200 kW
Total	12,792 kW

Existing (Isolated):

1. Dhankuta	240 kW
2. JHupra (Surkhet)	346 kW
3. Doti	200 kW
4. Phidim**	240 kW
5. Gaviche (Ilam)***	64 kW
6. Jumla**	200 kW
7. Dhading	32 kW
8. Syangja***	80 kW
9. Helambu	50 kW
10. Salleri (Solu)	400 kW
11. Darchula (i) & (ii) **	300 kW
12. Chame	45 kW
13. Taplejung**	125 kW
14. Manang	80 kW
15. Chaurjhari** (Rukum)	150 kW
16. Syanpudaha** (Rukum)	200 kW
17. Khandbari**	250 kW
18. Terhathum**	100 kW
19. Bhojpur**	250 kW
20. Rameshhap	150 kW
21. Bajura	200 kW
22. Bajhang**	200 kW
23. Arughar Gorkha	150 kW
24. Okhaldhunga**	125 kW
25. Ramechap (Underconstruction)	100 kW
26. Sumnalyagad (Salyad)	200 kW
27. Namche	500 kW
28. Achham	400 kW
29. Dolpa	200 kW
30. Kalikot	500 kW
Total	6,170 kW

Under Construction:

1. Gamgad	400 kW
2. Heidang	500 kW
Total	900 kW

PRIVATE SECTOR PLANTS

Existing:

1. Andhi Khola (BPC)	5,100 kW
2. Jiltrul (BPC)	12,300 kW
3. Khimtikola (HPL)	60,000 kW
4. Bhotekosi (BKPC)	36,000 kW
5. Sange Khola (SHP)	183 kW
6. Indrawati (NHPC)	7,500 kW
7. Chilime (CPC)	20,000 kW
8. Piluwa Khola (AVHP)	3,000 kW
9. Chaukhola (APCo)	1,500 kW
10. Sunkosi Small (SHP)	2,600 kW
11. Kairang (KHHP)	500 kW
Total	14,8683 kW

Under Construction:

1. Khudi (KHP)	3,450 kW
2. Sinelkhola (CBHP)	750 kW
3. Baramchi (UH)	999 kW
Total	5,199 kW

PRELIMINARY WORK IN PROGRESS

1. Mailung (MPC)	5,000 kW
2. Daram Khola (SHP)	5,000 kW
3. Phemekhola (KHP)	995 kW
4. Langtang (KHP)	10,000 kW
5. Tadikola (ASP Dev.)	970 kW
6. Upper Malkhola (ENDE)	3,000 kW
7. Lower Indrawati (GLP)	4,500 kW
8. Thoppalkhola (THP)	1,400 kW
9. Marsikhola (SHP)	3,100 kW
10. Lower Nyadi (HHP)	4,500 kW
11. Madi-1 (AGPL)	1,000 kW
Total	39,465 kW

SOLAR POWER

1. Simikot	50 kW
2. Gamgadhi	50 kW
Total	100 kW

TRANSMISSION LINE LENGTH

1. 132kV Transmission Line	1881.1 ckt KM
2. 66 kV Transmission Line	561.2 ckt KM
3. 66 kV Underground Cable	7.0 ckt KM
4. 33 kV Single Circuit	2471.0 KM

SUBSTATION CAPACITY

132/11	kV	52.0 MVA
132/33	kV	346.0 MVA
132/66	kV	210.0 MVA
66/11	kV	413.0 MVA
66/33	kV	26.0 MVA
Total		1052.0 MVA

NOTE

* Private & Others

** Leased to the Private Sector

*** Not in normal Operation

IPP's lines not included

These capacities are within the Grid Substations only. Transformers within Distribution Substation, Powerhouses and Local Distributions are not included

Installed Capacity in Nepal Electricity Authority (including Private and Others): 613.597 MW

Source: NEA annual report, 2007/08

Pic. Hydropower project of Nepal Showing the Reservoir and HeadworkComponents(Source,NEA Report,2016).

Pic. Nepal first hydropower plant reservoir, Pharping(Source,NEA Report 2016).

LOAD FORECAST OF NEPAL

The load forecast for Integrated National Power System (INPS) made by NEA according to the power system master plan studies is presented here under table. The load has been forecasted considering the country's macro- economic indicators and rural electrification expansion programs. The forecast revealed that the energy and peak demand is expected to grow more than three times between 2008 and 2026.

Table. Load forecast for INPS

LOAD FORECAST

For Integrated Nepal Power System (INPS)

Year	Energy (GWh)	Growth(%)	Peak (MW)	Growth(%)
2005*	2565.8		556.3	
2006	2600.1	1.3	593.6	6.7
2007	2777.6	6.8	634.2	6.8
2008	3055.9	10.0	697.7	10.0
2009	3317.4	8.6	757.4	8.6
2010	3598.9	8.5	821.7	8.5
2011	3923.6	9.0	878.2	6.9
2012	4271.1	8.9	956	8.9
2013	4640.4	8.6	1038.7	8.7
2014	5032.9	8.5	1126.5	8.5
2015	5450.3	8.3	1220	8.3
2016	5894.5	8.2	1294	6.1
2017	6367.4	8.0	1397.8	8.0
2018	6842.3	7.5	1502.1	7.5
2019	7350.4	7.4	1613.6	7.4
2020	7894	7.4	1733	7.4
Average Growth		7.80		7.87

*Actual

Source: NEA annual report, 2007/08

IMPACT OF EARTHQUAKE ON HYDROPOWER

The massive earthquake of april 25, 2015 and series of aftershocks that followed the main shock of 7.8 scale Richard and still occurring has affected public houses, schools roads and infrastructures of the country and different sector of economy including agriculture ,tourism ,remittance and Hydropower projects directly. It has been estimated around 9.3to 18% of national output is reduced in agricultural sector due to this earthquake. Tourism and remittances are severely affected. Around 9000 life are lost and 22000 people are injured. The hydropower stations which are main source of economy are badly affected. 14 hydropower stations are damaged across the country resulting a loss of 150 MW of electricity from countries power grid. As a result Nepal electricity Authority (NEA) is distributing only 564 MW including 210 MW imported from India(myrepublica.com-2016).

Staff quarters in Trishuli, Devighat, and Sunkoshi projects have been completely damaged. According to NEA staff member there are residing in temporary tents. Sunkoshi hydropower plant has suffered physical damaged yet again. Its 3km canal has multiples leakages. Crackes have been appeared in the dam body of kulekhani hydropower project. Cracks affects the generation in monsoon period mostly.

According to NEA, earthquake has severely affected to independent power producers. This include the 45 MW upperBhotekoshi projects. Of the NEA own project upper Trishuli 60 Mw project is worst affected.24 MW Trishuli, 14 MW Devighat, 22MW Chilime are affected in transmission. As the further earthquakes occur again the domestic power down by 30% at least which may be the worst situation ofthecountry (earthquake-nepal.com). Pictures attached shows the severity of earthquake in hydropower in Nepal the source of pictures is NEA member.

Pic. Damaged building of Devighathydropower plant(Source, NEA Report- 2016).

Pic.Crackon dam body at kulekhani hydropower project(Source,NEA Report-2016)

Fig. Tinjure landslide and Sunkoshi river blocked due to earthquake,2015(Source, NEA Report -2016).

CONCLUSION

Having sufficient possibilities for hydropower development from Nepalese river of 8300 MW total potential only a 714 Mw is generated which is very small scale. A clean, environment friendly power resource can be used in extensively for the economic growth of nation but the difficult terrain, earthquake prone zone is equally challenging for sustainable hydropower development. A detail geological investigation and stable site selection is realized to carry out for the power development from the hilly region of Nepal so that the impact of earthquake may not drop down the power production in future.

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ARDUINO BASED SOIL MONITORING SYSTEM FOR SUITABILITY OF RICE PLANTATION

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ABSTRACT

In the past few years, technology has grown to the summit. The use of computers and electronic devices has been applied in almost every aspect of human life. It has thus led to the idea of soil monitoring system. This paper is about soil monitoring system for suitability of rice plantation which would use a smartphone and a web application to enable the farmers to get information about their field for suitability of rice plantation from remote location. The system has three components: an arduino microcontroller and other sensors to collect site data, an ethernet shield to transfer collected data to the web database, a web server to handle the obtained data and a web client and a smartphone to get the valuable information from the processed data. The paper focuses on the features and design of the proposed system.

Keywords: Soil Monitoring, Smart Agriculture, Arduino, Smart Rice Plantation

1. INTRODUCTION

The world is moving towards the era of automation with the main motto of easing human life. Soil monitoring system for suitability of rice plantation aims at automating the farmer's life through the use of current technology. To provide the appropriate information about the field to the farmers without necessity of visiting to farm each time is the main theme of soil monitoring system. Such an automation in the agricultural sector is also called smart agriculture.

In current age, most of the efforts are put on wireless technology for data transfer and cloud computing for data storage. The main wireless technologies used in soil monitoring system are GSM, Internet, Cloud and Bluetooth. Each technology has its own merits and demerits. But Internet based soil monitoring systems have much more merits that other wireless technologies. The main merit is that the end user gets reliable service as they can be able to monitor their farm by sitting in front of a computer or by looking into their smartphones from anywhere in the world.

After the research in the agricultural field, researchers found that the yield of agriculture goes on decreasing day by day. Use of technology in the field of agriculture plays important role in increasing the production as well as in reducing the extra man power efforts. Some of the researches tried for betterment of farmers and provides the systems that use technologies which are helpful for increasing the agricultural yield. Some of such researches carried out in field of agriculture are summarized here.

Simon and Jacob (2012) proposed that the wireless sensor network for crop monitoring in the paddy fields of kuttanad(India) can be applied because the soil of the paddy fields is salty and is extremely acidic. This acidity of the soil is considered a major problem which retards the production of rice in the area. A best solution to overcome this problem which reduce the acidity and increase the production. So, the pumping of water to and from the field is the major activity from plowing to harvesting. Further, they added that Electro-mechanical sensors in the mesh networking and through ZigBee communication can be automated systems which monitor the water level and regulate the water. It can send messages to the farmers. They suggested ZigBee-technology because of its low-cost, low-power consumption, low data-rate, two-way wireless networking standard that is aimed at control and sensor applications which is suitable for operation in harsh radio environments and in isolated locations.

N. G. Shah *et al.* (2008,April) developed a system for precision irrigation using sensor network mainly aimed for monitoring soil moisture and estimating vaporization by considering soil moisture, soil temperature and relative humidity as the critical parameters for measurement. The objectives of the system were to provide precision agriculture and irrigation, to increase the agricultural production, to provide precise monitoring system and to use resources at the fullest extends so as to give efficient system. The system was analyzed for 3-4 months for calculating evapotranspiration rate. For more precise results, the system should be analyzed for 3-4 season.

G. Mendez *et al.* (2011,January) developed a Wi-Fi based smart sensor network for agricultural environment. They considered temperature, humidity, light intensity, air pressure and soil moisture as main parameters. The objectives were to

reduce cost and effort of incorporating wiring, to enhance flexibility and mobility for the system. The system was useful for transferring and logging the data from various nodes.

M. Haefke *et al.* (2011,May) developed a ZigBee based smart sensing platform for monitoring environmental parameters such as temperature, relative humidity, pressure and sunlight with the use of microcontroller which serve as a smart weather station. The research was based on characteristics such as use of low cost equipment, accurate sensors and flexibility in data handling. Use of X Bee module provided the wider range and reduced the current consumption of the circuit.

3. MATERIALS AND METHODS

This study is primarily concerned with the soil monitoring system which uses Internet for interaction between the android mobile application, web application and the on site arduino based monitoring system module. The paper will shed light on the features & design of the system.

3.1 Collection of soil factors

The system will have specific sensors, each one capturing data about specific soil factors responsible for deciding the suitability of rice plantation. The sensors include soil pH sensor, temperature sensor, humidity sensor and soil moisture sensor as per the project scale. All of these sensors are responsible to collect relevant data from the site and provide the data to arduino on real time. The arduino is then responsible to transfer the data to the web server through the use of ethernet shield.

3.2 Visualization of data

The system is designed to provide visualization of the collected data in the form of line graph. This visualization helps the farmer to know about their farm status in an effective manner.

3.3 Fuzzy Logic Analysis

Fuzzy logic is an approach to computing based on “degrees of truth” rather than the usual “true or false” or Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkely in the 1960s. A fuzzy logic system can be defined as the nonlinear mapping of an input data set to a scalar output data. A crisp input will be converted to the different members of the associated membership functions define based on its value, so the output of fuzzy logic controller is based on memberships of different membership function which can be considered as a range of input.

4. RESULTS AND DISCUSSION

To implement fuzzy logic technique to a real application required following three steps:

- **Fuzzification:**
  The given input values of sensor are converted into fuzzy data by mapping to corresponding membership function based on result value. A membership function is used to quantify a linguistic term.
- **Fuzzy Inference Processes:**
  The different membership functions generated through result data are combined with control rules to derived fuzzy output. A fuzzy rule is simple IF-THEN rule with a condition and a conclusion. The evaluations of the fuzzy rules and combination of the results of the individual rules are performed using fuzzy set operation which is different than the operation on non-fuzzy sets. The evaluated result of each rule is combined to obtain a final result. This process is called inference.
- **Defuzzification:**
  The result obtain after inference is defuzzified to obtain a final crisp output. Defuzzification is performed according to membership function of the output variables.

Algorithm

1. Define the linguistic variables and terms(initialization)
2. Construct the membership functions(initialization)
3. Construct the rule base(initialization)
4. Convert crisp input data to fuzzy values using membership functions(fuzzification)

5. Evaluate the rules in rule base (inference)
6. Combine the results of each rule (inference)
7. Convert the output data to non-fuzzy values(defuzzification)

User Notification

The system is also responsible to provide essential notification to the users via an android application.

Authentication

The android application and web application will be password protected. The user of the application will be provided with a password. The user of the application will have to enter the password each time he wishes to open an application. This will ensure that the application won't be used by any unintended user.

Proposed Design

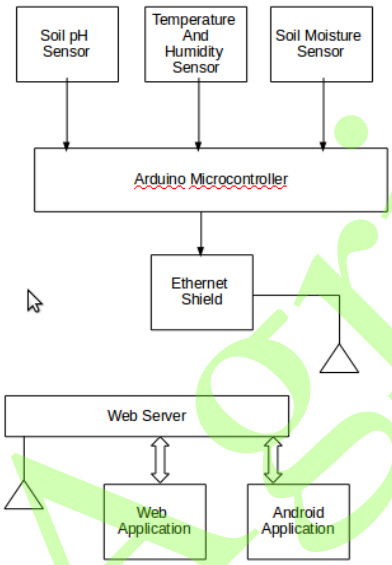

Fig - 1 : Block diagram of Soil Monitoring System for Suitability of Rice Plantation

5. CONCLUSION

In this paper, we have shown the design and features of a Smart Soil Monitoring System. It is based on Internet service. It requires authentication details as a medium of security, thus preventing the use of application by unauthorized users. The system also connects with sensors, thus helping in collection of required data. It includes fuzzy logic for analysis of collected data.

In future, the system could use more concepts of Artificial Intelligence so as make it more user friendly and increase the automation.

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DECREASING COSTS AND INCREASING DEMAND FOR SHALLOW TUBE WELLS: LOW-COST TWO-WHEEL TRACTOR DRILLING RIG

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ABSTRACT

Fulfillment of water requirement of any crop commodity is very essential for its proper growth which affects the yield we get. With the many problems of surface irrigation projects many times outstripping its benefits shallow tube well (STW) ground water is becoming more and more important and widely used source of irrigation. While the construction of STWs for irrigation includes drilling operation, installation of casing and screens and well development can be accomplished with quite sophisticated engineering means many times by large powered drilling rigs and pumps and skilled operators. All these operations depend on the type of formations to be drilled or excavated, the size of wells and its depth and discharge expected. Yet, in CSISA's initial study into the markets for drilling of STWs we have found the vast majority (95%) of STWs drilled in Nepal's mostly rock free alluvial Terai soils are drilled by semi-skilled and unskilled labor, manually by hand using a sludging method with little care to type of formations and expected discharge. What we also found in our initial discussions is that the vast majority of the mistris have never had any technical and marketing skill up gradation and trainings around the STW drilling. Therefore, CIMMYT's USAID funded CSISA MI project to come to the aid of this age old and tedious technique whereby labors lift directly or indirectly through a lever lift the pipe and drop it can be replaced by the use of a simple two wheel tractor powered: attachment for drilling tube wells. And by greatly increasing the speed, reducing the number of labor also decrease the cost of the STW. As per survey manual boring costs Rs 65/ft and 2WT STW costs about Rs 25/ft. So its economically justifiable.

Keyword: Shallow tube well; drilling

INTRODUCTION

Water is a precious natural resource, a basic human need and a prime national asset. The extent, to which water is plentiful or scarce, clean or polluted,beneficial or destructive, profoundly influences the extent and quality of human life. With the many problems of surface irrigation projects many times outstripping its benefits (See Table 1) shallow tube well (STW) ground water is becoming more and more important and widely used source of irrigation.

While the construction of STWs for irrigation includes drilling operation, installation of casing and screens and well development can be accomplished with quite sophisticated engineering means many times by large powered drilling rigs and pumps and skilled operators. All these operations depend on thetype of formations to be drilled orexcavated, the size of wells and its depth and discharge expected. Yet, in CSISA's initial study into the markets for drilling of STWs we have found the vast majority (95%) of STWs drilled in Nepal's mostly rock free alluvial Terai soils are drilled by semi-skilled and unskilled labor, manually by hand using a sludging method with little care to type of formations and expected discharge. Even the various district level Department of Irrigation Officessubsidize a few hundred wells in a district per year (and only on group basis of 3 to 5 farmers), hire local "mistris" to drill these government subsidizedSTWs- while at the same time complaining about the mistri's lack of knowledge. What we also found in our initial discussions is that the vast majority of the mistris have never had any technical and marketing skill up gradation and trainings around the STW drilling. Yoder and Adhikari2015) also note that resources for this very important, we might argue vitally important, group of technicians simply does not exist.

We have compared some of benefits and problems of Surface versus STW irrigation in Nepal and shallow tube well irrigation. Former is much cheaper while later can provide Water when farmer-crop needs it, less prone to wastage/over watering, Costs of electric and internal combustion engine power and solar powered pumps continue to come down in price, Water service provision can earn owner more income, use of lay flat hosepipe decreasing waste , over water, conjunctive use possibilities. And while talking about problems associated to surface and STW we can consider like Mismanaged

Politicized WUA's, Water released by India late, Water arrives after rain has begun- after farmer-crop needs it, Tail enders never get water, Lack of maintenance- Silting reduces, Systems damaged by floods, earthquake etc., Land for canal taken out of production, Seepage near canal keeps land out of production and that associated to STW are, Farmer needs initial investment in STW installation and pumps, Much higher costs, Maintenance costs of pump. From above comparison we can see that problems associated to STW can be solved to much more extent than that with surface irrigation.

Therefore, CIMMYT's USAID funded CSISA MI project to come to the aid of this age old and tedious technique whereby labors lift directly or indirectly through a lever liftthe pipe and drop it can be replaced by the use of a simple two wheel tractor powered: attachment for drilling (sludging) shallow tube wells. And by greatly increasing the speed, reducing the number of labor also decrease the cost of the STW. This technique is currently under testing by CIMMTY and its local partner technician toexplore its capacities in terms of depth, fuel consumption, time it takes, labors used as well as its economy.

MATERIALS USED:

Readily available materials (or tools):

Tochan wire (wire rope- of capacity 2tonnes), pulley, GI pipes of various diameters and lengths , various standard pipe wrenches, chain pipe wrench, chain/cable shackles, tool storage box, two-wheel tractor (2WT or power tiller), 2WT trailer to carry equipment and to weight down the 2WT while lifting the pipe. Optional: 250 litre water tank, drilling mud.

To be fabricated;

Tripod stand, Rim - hub of axle assembly (functioning here as a winch), 2WT stand.

Working Principle:

This system uses the simple principle of cutting by impact (when stones are found) and sludging (Nepali: dhikuli, dhiki, wash tarika) where the drilling pipe is lifted and dropped causing the tailings/cuttings (soil) to be lifted hydraulically through the pipe and expelled. Normally this lifting and dropping is managed by a group of laborers and is quite tiring especially as the pipe lengthens. Instead CSISA is testing the idea of using the ubiquitous and existing two-wheel tractors or power tillers as a winch. Many 2WT owners are looking for opportunities to use their tractors in other ways during the off season. If successful this "drilling kit" will be marketed to existing power tiller owners as simply another 2WT attachment with a projected costs of less than 50,000 NRs and will speed up drilling of STWs and reduce their costs. Initial tests have gone down to 100 feet but we expect that 150 -200 feet may be possible.

METHODOLOGY

Following process is implemented and took around mentioned time during the testing of the technology.

First of all Tripod (Nepali: *teen kuti*) stand is erected and centered (20 minutes, 3 men) then make a trench of about 1m*1m*0.5m centre of tripod stand lying within it. (20 min, 1 man) after that the trench is filled with from nearby water source. If no local source a tank of water will be needed to be brought to the site. A large cable-chain shackle is placed securely at the tripod apex – joint. The pulley is secured to the shackle, and then wire rope is threaded through the pulley.(10 min, 2 man) the power tiller is pulled as close to hole as possible and its tire (right or left side) is aligned with pulley as close as possible so that the weight of the power tiller counters the pulling-lifting action from the wrenching up of the pipe.(10 min , 1 man). The tire that is aligned with the hole and pulley is removed and wrench spool (in this case an old tire rim modified to fit on the hub of axle of the power tiller) wound with wire rope of sufficient length (about 10 meters).(20 min, 1 man). Then opposite tire is blocked or jammed and its axle is disengaged (2WT steering clutch is securely tied to the handle by rope string to keep axle/tire disengaged throughout the operation (2 min , 1 man). Power tiller is kept level-balanced to avoid having the rim touching to the ground. This is done by special made stand or various blocks of wood (10 min, 4 men). The process of starting the hole is currently a bit laborious. A ten foot length of pipe is inserted manually and pounded into the ground directly under the pulley and into the standing water. After getting down 6-8 feet (45 min to 1 hr for 2 men depending upon soil type, harder the soil profile more the time and vice versa) a longer heavier section of pipe can be used and lifted by the 2WT. After that Pulley cable is lowered is tied or lashed by chain with the pipe at or just above surface (20 min , 2 men). Then Power tiller is started. In forward low forward gear (1^{st} 2^{nd}gear) slow wrap tight the cable. Do this by using the steering clutch to engage and disengage the wench. The cable will then begin lifting of the pipe. Once pipe has lifted a few feet (depending on the height of the person whose hand is being used as a foot valve) disengage the gear with the steering clutch which will free the rim and pipe will fall impacting the bottom of the hole. As it begins to fall the persons hand is removed slightly to eject the water and soil (tailings) (2 min , 2 man). This process is repeated over and

over. Initially as the pipe is light weight progress will be slow. But once a few lengths of 10 – 20 foot pipe is added the weight and speed in falling will increase and the boring will greatly speed up.

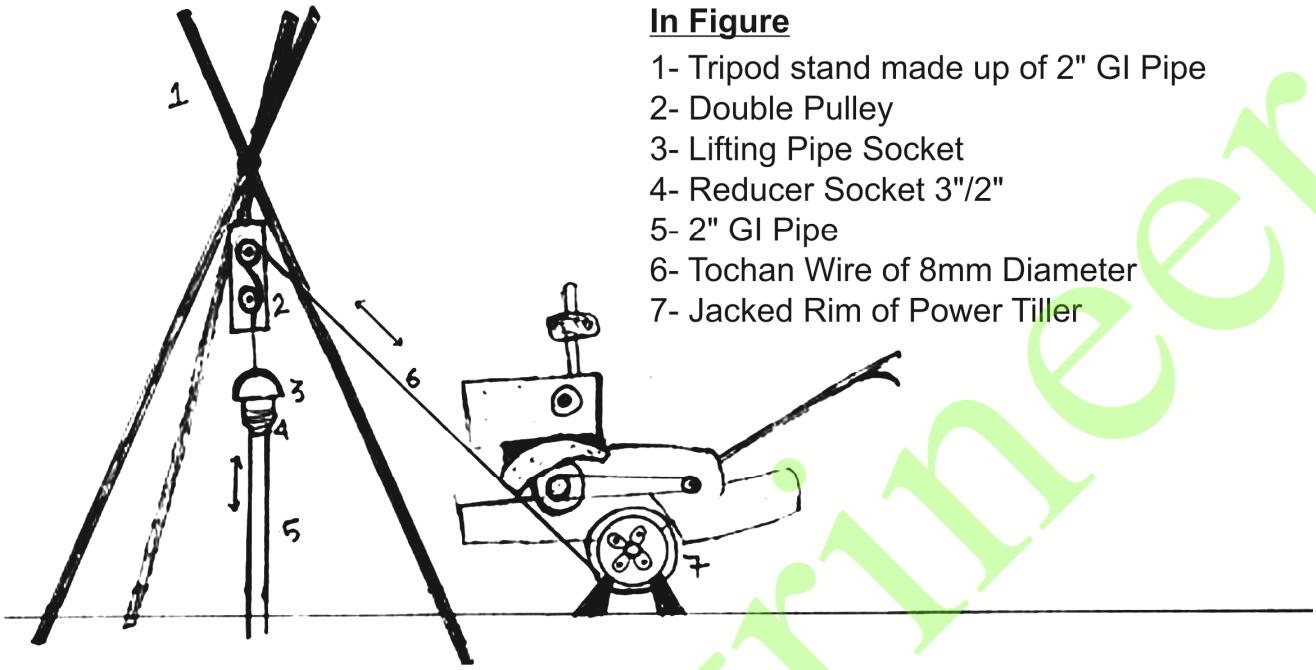

Fig.: Schematic Diagram of Boring with Power Tiller

BENEFITS OF 2WT SWT OVER MANUAL BORING

1. Easy to operate.
2. Multi use of power tiller after plowing / seeding season, the STW boring season generally starts and one can earn extra income from power tiller by deploying to drilling.
3. Lower operating cost.
4. Less energy consuming and low man power requiring3 people (1 skilled operator, and 1-2 unskilled laborers).

SAFETY MEASURES

Safety should be major concern during any type of manpower deploying works. The system should be checked for its wear and tear (cable etc.) and also the above head parts such as pulley and cable wire should be checked frequently. Safety, construction site**Helmets**, good quality works **Gloves** should be used by all workers. If any problem in moving and stationery parts is observed, the engine should be stopped immediately. While adding, changing, removing the pipes, much care has to be given to not drop the pipe inside the hole. That means much care given to ensuring the pipe in the hole is secured by means chain type pipe wrench or better still a metal or wooden clamp properly placed and properly tightened.

ECONOMIC COMPARISON OF THE SYSTEM WITH MANUAL SYSTEM OF THE SAME SIZE:

It is noted that much of the costsare same no matter manual or powered. Cost of pipes, tools etc. required is the same for both the systems.Additional costs for the 2WT system are need for improved tripod, wire rope, spool, and of course 2WT and trailer.

From the initial first trail of the 2WT STW boring system and research (90-foot hole completed) conducted near the Cotton Board in Khajura, Banke district by CSISA-MI, it is found that total operating cost is cost of labors plus fuel cost, initially neglecting wear and tear cost,

Cost = Rs.100(skilled labor/hr)+Rs. 50*2 (two unskilled labor/hr)+80(fuel)
[wage for skilled labors is Rs. 800 per day and that for unskilled labor is Rs. 400/day, if 8 hour of working day considered]

= Rs280/hr

- On average 1ft of depth can be drilled **in 5.4minutes.**
- Therefore, **for 1ft it only costs Rs 25.20** (Excluding wear and tear of the system).
- According to the survey conducted among the boring technicians it costs around **Rs. 65/ft for 2" boring manually.**

We assume wear tear cost per hour be Rs 20/hour then also 2WT STW system is still more economic. Thus, far nohigh cost parts have been found to wear quickly so it is thought this cost might be less.

At 2nd gear time of cutting as tested with 2" GI pipe by this system was found to be 5.4minutes/feet. And fuel consumption is around 0.75 liters/hour.

CONCLUSION

From the research of CSISA-Np at Khajura, it is concluded that the 2WT STW drilling system is economical than manual system and also less fatigue, less time consuming i.e. just 5.4 minutes per feet at test condition. The program is working in developing a foot valve to be placed at the top of the pipe to replace the remaining human drudgery or of using human hand as a foot valve. Also while using hand as foot valve the lift by cable can only be 3-4 feet for the comfort of the human. But this reduces the capacity of the wrench that when standard foot valve is used a higher lift and drop can be achieved and drilling speeds up.

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Some Modern Technologies in Agricultural Engineering

1. Zero till seed cum fertilizer drill

Seed cum fertilizer drill is used for sowing different crop seeds such as wheat, barley peas, lentils, etc. in the land. It will become very useful and important agricultural machine for the farmer. It helps them to seed a crop directly into the cultivated field just after the harvest of previous crop. It eliminates or reduces time and energy intensive conventional tillage operation reducing cultivation cost apart from improving crop yields and profits.

Seed Cum Fertilizer Drill

These machines continuously show the seeds in row by maintaining the recommended spacing between row to row. There is present of seed and fertilizer metering mechanism which maintain the recommended sowing rate (kg/ha) of seeds and fertilizer rate (kg/ha) for a specified crop. Seed-cum fertilizer drill having 7-13 tines and has a field capacity of 0.4-0.8 ha/hr.As the one experiment conducted in India, for the wheat using conventional method (Broad casting method) of sowing and by the seed cum fertilizer drill in sandy loam soil.

Table 1. : Comparison of farmers practice and recommended practice

Technology Assessed	*Production per unit	Net Return (Profit) in Rs. / unit	BC Ratio
T1- Farmers Practice-Seed sowing in dry soil with broadcast method and seed rate 100 kg/ha.	8.0 q/ha	2038	1.46
T2- Recommended practice –Sowing of wheat using tractor operated seed cum fertilizer drill seed rate 40 kg/ha	16.4 q/ha	8798	2.50

(Source: International journal of innovative of science, Engineering and Technology, VOL 2, June 2015)

From above table, we finally assured that production rate of crops is much higher by using of this machine than conventional method .so that this machine is suitable for the sowing above type of crops.

2. Rice transplanter

Rice transplanter is used to transplant seedlings in the paddy field. Mainly there are two types of rice transplanters:

(i) Riding type rice transplanter

It also called self-propelled rice transplanter.
It can usually transplant 6-8 line in one pass.
It has field capacity of 0.19-0.245 (ha/hr).
Seedling is prepared by mat type method.

The production rate of paddy using rice transplanter is similar to conventional method while transplanting but only difference in operation is time and labour which minimizes the cost of production.

Fig. Self-propelled rice transplanter

(ii) Walking type rice transplanter

It includes the manually operated rice transplanter which transplant 2-4 line in one pass. It is generally two types:

Type 1:

It transplant mat type paddy seedling. By pressing the handle the fork pick up the seedling and plant them in 2-4 rows. It can cover the 0.25 ha/day. It saves the time and money.

Figure: mat type seedling transplanting manual transplanter

Type 2:

It is manually operated and backward type of rice transplanter.
It transplants the seedlings which is conventionally prepared.
It is also called Hand cranked rice transplanter.
Especially 2 rows rice transplanter have field
ccapacity of 0.22-0.33 ha/day.

Figure : transplanting the seedlings by hand cranked rice transplanter

Figure: hand cranked rice trans planter

3. Vertical Conveyer Reaper

A machine called vertical conveyor reaper–cum-windrower can cut the crop and lay it in the form of windrow for easy picking. It consists of a conventional cutter bar assembly, crop row dividers with star wheels, covers, pressure springs and vertical conveyor belts. Cutter bar is given reciprocating motion by crank wheel. Crop row dividers with star wheels enter the standing crop, help in lifting, gathering and guiding the crop towards the cutter bar. After the crop is cut, held in a vertical position during its passage by means of pressure springs and star wheels.

Vertically held crop is then delivered towards right side of the machine in a windrow perpendicular to the direction of movement of machine with the help of lugged conveyor belt. The gearbox and windrower is coupled to the drive shaft of the prime mower. A front mounted vertical conveyor reaper is the most common reaper, to harvest wheat and paddy crops. It can also be used for harvesting of soybean and other similar crops. Engine operated reaper can be operated with a 5-6 hp engine. Whereas, tractor operated reapers can be operated with 25-35 hp tractor. Width of cut is about 1.6 m in power tiller reaper, and about 2.05 m in tractor operated reapers. Stroke per min of cutter bar is 1225 and 1550 in case of power tiller and tractor operated reapers, respectively. Power tiller and tractor-front mounted vertical conveyer reaper windrower can cover about 0.2 ha/h and 0.4 ha/h, respectively.

Figure : harvesting paddy by tractor mounted vertical conveyer reaper

Figure : power tiller mounted vertical conveyer and harvesting paddy by it

4. Disc harrow

A **disc harrow** is a farm implement that is used to till the soil where crops are to be planted. It is also used to chop up unwanted weeds or crop remainders. It consists of carbon steel and sometimes the longer-lasting boron discs, which have many varying concavities and disc blade sizes and spacing.

Figure :off setdic harrow

5. Multi-crop thresher

A threshing machine or thresher is a farm equipment that threshes grain, that is, removes the seeds from the stalks and husks. Multi crop threshers are used in Nepal due to its good field performance. It threshes paddy, wheat, and other crops such as lentils etc.

Figure : multi crop thresher

6. Rotavator

Rotavator is an excellent secondary tillage implement which is effectively used in dry land as well as wet land condition for the seed bed preparation. For wet land, it churns, mixes and disperse the finer particle in muddy conditions so that the slit and clay particles are settled on the surfaces and restrict s the infiltration of irrigation of irrigation water. Thus, it provides the conducive to the growth of wet land plants. Similarly for dry land, it gives excellent pulverization of soil and land mixes the thrashes, crop residuees, weeds, etc. into the soil for their rapid decay.

Figure : preparing seed bed usingrotavator

Figure : tractor mounted rotavator

The planking attachment given behind the equipment ensures breaking of big clods, leveling of field and packing of soil moisture that can make a very fine seed bed suitable for effective planting of crops. It is available as tractor mounted tillage implement. It take its drive from tractor PTO.

7. Green house technology

Greenhouse technology is the technique of providing favorable conditions to the plants. Even in extreme adverse climatic conditions where no crops can grow, green house can be used to grow high value crops. This method is used to protect the plants from adverse climatic conditions, such as cold, wind, precipitation, excessive radiation, extreme temperatures, insects and disease, etc. In Green house technology, the environmental conditions are modified to favorable conditions for plant.

Greenhouses are framed or inflated structures covered with transparent or translucent materials large enough to grow crops under partial or fully controlled environmental conditions to get optimum growth

and productivity. There is increase in yield from 10 to 12% depending upon the type of greenhouse, type of crop, environmental control facilities. Reliability of crop increases in green house cultivation. It expands the growing season, the variety among the produce and minimizes the external threats to the crop.

Figure : Growing crops under the green house

8. Drip irrigation

Drip irrigation is a type of irrigation which saves water by allowing water slowly to the roots of plants, either onto the soil surface or directly into the root zone, through a network of valves, pipes, tubing and emitters. It is done through narrow tubes that deliver water directly to the base of the plant. It is chosen instead of surface irrigation for various reasons, often including concern about minimizing evaporation. Drip irrigation is used in farms, commercial greenhouses, and residential gardeners. Drip irrigation is adopted extensively in areas of acute water scarcity and especially for crops and trees. A drip irrigation system with plastic mulching directs the water at the root systems of plants and effectively reduces pests, weeds and harmful fungal growth. With a properly installed drip irrigation system, one can save up to a 50% of irrigation water annually.

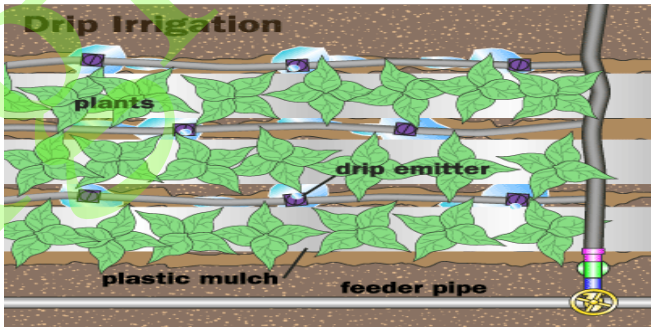

Figure : Growing crops using drip irrigation and plastic mulching

9. Hydroponic System

Hydroponic is a system where plants are grown in growth media other than natural soil. All the nutrients are dissolved in irrigated water and are supplied at regular basis to plants. We can grow virtually any plant at virtually any time of the year.

Advantages

- Hydroponically produce vegetable can be of high quality and need little washing.
- Soil preparation and weeding is reduced or eliminated.
- It is possible to produce very high yields of vegetable on small area because an environment optimal for plant growth is created. All the nnutrient and water that plants need, are available at all times.
- One does not need good soils to grow vegetables.

Basically high value crops such as tomato, cucumber, lettuces and herbs are grown by this method.

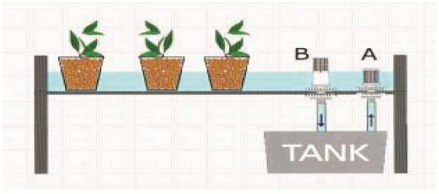

Figure : Ebb and Flow system

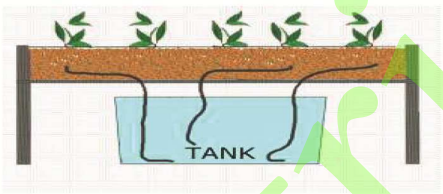

Figure : Wicks system

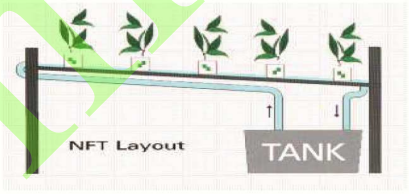

Figure : Nutrient Film Technique system

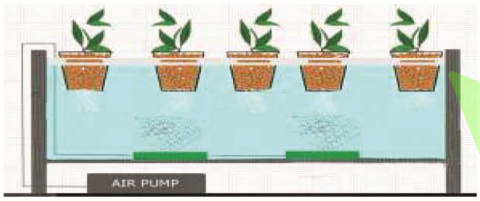

Figure : water culture system

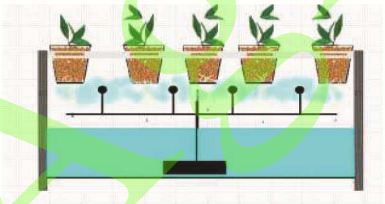

Figure :Aeroponic System

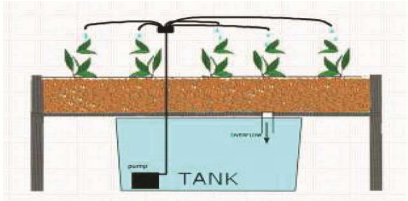

Figure : Drip system

Fig : different method of hdroponic system.

10 . Ram pump

A hydraulic ram pump is cyclic water pump which is operated by kinetic energy of following water. It takes water at one hydraulic head and flow rate and outputs water at a higher hydraulic head and low flow rate. The device uses water hammer effect to develop pressure that allows a portion of input water that powers the pump to lift to a point higher than where the water originally started. There is no need of fuel or external power to operate this type of pump.

Figure : pumping of water using ram pump

Figure : ram pump

11. PLASTIC MULCHING

Plastic mulching is used in a similar fashion to mulch, to suppress weeds and conserve water in crop production and landscaping. Crops grow through slits or holes in thin plastic sheets. Plastic mulch is often used in conjunction with drip irrigation. This method is predominant in large-scale vegetable growing, with millions of acres cultivated under plastic mulch worldwide each year. Disposal of plastic mulch is cited as an environmental problem, however, technologies exist to provide for the recycling of used/disposed plastic mulch into viable plastic resins for re-use in the plastics manufacturing industry.

Advantages

- The use of plastic mulch alters soil temperature. Dark mulches and clear mulches applied to the soil intercept sunlight warming the soil allowing earlier planting as well as encouraging faster growth early in the growing season. White mulch reflects heat from the sun effectively reducing soil temperature. This reduction in temperature may help establish plants in mid-summer when cooler soil might be required.
- Plastic mulches reduce the amount of water lost from the soil due to evaporation. This means less water will be needed for irrigation.
- Plastic mulch prevents the growing of weeds.
- The use of drip irrigation in conjunction with plastic mulch allows one to reduce leaching of fertilizers.
- This reduced contact with the soil decreases fruit rot as well as keeps the fruit and vegetables clean.

12. Power Tiller

Power tiller is designed mainly for tilling of seedbed in small farms and in hill farming. The adoption of power tillers by the farmers for carrying out farming operations is low when compared to tractors. Power tiller is also used as a power source for other agricultural operations such as seed bed preparation, sowing and fertilizer application. Power Tillers are also useful in intercultural operations in wide spaced row crops (more than 1.0 m row to row spacing) and harvesting of cereals under upland conditions including transportation of farm products and power source for stationary farm operations.

As the land holding capacity is low and the economic condition of farmers do not support for having large farm power source, it is seems to be economical to introduce power tiller in Nepalese agriculture and its matching equipment whose initial cost initial cost, running cost is low and which could be made busy throughout the year. There are various models of power tiller in the market with the various capacity such as 5-12 hp. Versatile power tiller which is suitable for the all operations in the farm should be chosen.

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