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Preface

We would like to present, with great pleasure, the inaugural volume-6, Issue-7, July 2020, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas

Environmental Research:

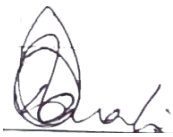
Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.

Mukesh Arora
(Managing Editor)



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Agricultural Sciences	
Soil Science	Plant Science
Animal Science	Agricultural Economics
Agricultural Chemistry	Basic biology concepts
Sustainable Natural Resource Utilisation	Management of the Environment
Agricultural Management Practices	Agricultural Technology
Natural Resources	Basic Horticulture
Food System	Irrigation and water management
Crop Production	
Cereals or Basic Grains: Oats, Wheat, Barley, Rye, Triticale, Corn, Sorghum, Millet, Quinoa and Amaranth	Oilseeds: Canola, Rapeseed, Flax, Sunflowers, Corn and Hempseed
Pulse Crops: Peas (all types), field beans, faba beans, lentils, soybeans, peanuts and chickpeas.	Hay and Silage (Forage crop) Production
Vegetable crops or Olericulture: Crops utilized fresh or whole (wholefood crop, no or limited processing, i.e., fresh cut salad); (Lettuce, Cabbage, Carrots, Potatoes, Tomatoes, Herbs, etc.)	Tree Fruit crops: apples, oranges, stone fruit (i.e., peaches, plums, cherries)
Tree Nut crops: Hazlenuts. walnuts, almonds, cashews, pecans	Berry crops: strawberries, blueberries, raspberries
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Animal husbandry	Ranch
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Aquaculture	
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Silvopasture	Christmas tree cultivation
Maple syrup	Forestry Growth
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Harvesting equipment	Processing equipment
Hay & Silage/Forage equipment	Milking equipment
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Production Manager Zeal Food & Beverages Industry Aladand Road, Amandara Batkhela Malakand Agency KP. He developed the skills for Preparation of different fruit pulp preserve Orange, Peach, Guava, Strawberry, and orange squash, orange marmalade.

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Impact of Farmers' Profile Characteristics on their Knowledge Gain through Need-based Community Radio Programme

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Abstract— *Present study highlights an innovative media technology, Community radio, which has potential to be an effective tool to strengthen agricultural extension system. It also indicates that knowledge of an innovation or technology is the foremost requirement in the way of adoption of the technology by farmers. The pre-knowledge test assessment regarding Integrated Pest Management (IPM) technology of the farmers highlighted that they had significant knowledge gap about the concept and practices of the technology. However, it was also concluded that community radio programmes which are need based and participatory in design could lead to significant increase in knowledge of the listeners. Majorly, the study emphasizes the significant impact of various profile characteristics like education, achievement motivation, scientific orientation, information seeking behaviour and social participation on gain in knowledge of the respondents through community radio programme. This result of the study provides conclusive evidence that audience profile characteristics need to be kept in mind while designing community radio programmes. Moreover, few characteristics can also be modified in favour of knowledge gain of the respondents through appropriate training.*

Keywords— Community radio programme, profile characteristics, knowledge gain, farmers, integrated pest management.

I. INTRODUCTION

Agricultural Extension aims at bringing planned behavioral change in the people in terms of knowledge, skill and attitude so that they may live better life by learning the ways of improving their livelihood especially vocation and enterprises. Knowledge is also considered as the first step of Innovation diffusion process, as described by Everett Rogers. Moreover, Knowledge gained by farmers when followed by proper and effective persuasion may lead to adoption of an innovation or technology. Therefore, understanding the importance of knowledge in the process of innovation diffusion is important in Agricultural Extension for sharing agricultural technologies with farmers. Many times the farmers do not adopt agricultural technologies due to lack of knowledge regarding different aspects of the technology, usage and relative advantage which leads to a vast gap between source and sink. The Tenth Plan (2002-2007) document recognized the problems of the extension sector and stated, "The Agriculture extension machinery, an information support in most states, seems to have become outmoded. There is need to revamp the extension services in the country by using print and electronic media and information technology along with the involvement of the private sector, especially the input agencies and traders, which have emerged as one of the main sources of information for the farmers. Radio, television and the print media have become powerful means of education and technology dissemination." The scientific and technological advancement in the field of agriculture has resulted in the development of high yielding varieties, chemical fertilizers, plant protection measures, etc. However, the advantage of these scientific advancements will give fruitful results only when these are communicated properly and effectively to millions of farmers. Therefore, available communication media has to be utilized to pass on the need based agricultural information effectively. The earlier top-down approach of Agricultural extension has failed to cater the need of the people and faced challenges both in context of reaching and persuading mass of people. Therefore, it leads to the emergence of participatory approach which considers people as equal partners rather than mere passive recipients.

1.1 Community Radio: A participatory communication tool

Jean Servaes, the proponent of Dependency theory of Communication for development, criticized the broadcasting and other mass-media systems as they tend to support modernization and were anti-development; also they were inclined to promote the political agenda. Solution to underdevelopment of third world countries require major changes in media structure that were dominated by commercial principles & foreign interests into media structures which are self-reliant and community oriented (Servaes, 2002). According to UNESCO, the community can be territorial or geographical or a group of people with common interests, who are not necessarily living in one defined territory (Tabing, 2002). Over the time amid the mainstream media, an alternative media tool called community radio station (CRS) has emerged as the voice of community being people centered, development oriented and inclusive. People feel ownership of community radio as one can create, access, utilize, share information and knowledge. It helps people to achieve their full potential in promoting and improving their quality of

life. 'Participation' is often highlighted as a key characteristic, distinguishing community radio from most other kinds of media **(**Mtimde *et al*., 1998).

1.2 Community Radio in India: Development perspective

Community radio was legalised in India on February, 1995 after the declaration passed by Supreme Court that, "airwaves are public property". Initially, community radio stations started as educational (campus) radio stations under somewhat strict conditions. In 2006, the Government of India declared a set of new Community Radio Guidelines that allowed the non-profit organizations, State Agricultural Universities, Indian Council of Agricultural Research (ICAR) institutions, Krishi Vigyan Kendras, registered societies, autonomous bodies and registered public trusts to possess and operate community radio stations. According to Ministry of Information & Broadcasting, as on 31-03-2020 there are 289 operational community radio stations in India, of which total seventeen are under State Agricultural Universities, Agricultural Institutes and Krishi Vigyan Kendras. These seventeen community radios are specifically dedicated to the sharing of agricultural information with farmers and are working for the extension of technologies produced in these institutions (Table 1).

Among the various agriculture based community radio stations, CRS *Pantnagar Janvani* of G. B. Pant University of Agriculture and Technology, Pantnagar, is the first Campus-based Community Radio Service of Uttarakhand and third such service, initiated among agriculture universities of the country (Singh, 2014). The main objective of Pantnagar Janvani is to bridge the information gaps of all sections of the society, especially the farmers of the locality with latest and relevant information. It is working as a part of extension and communication effort of the university.

TABLE 1
LIST OF COMMUNITY RADIO STATIONS OPERATED BY SAUS AND KVKS

S. No.	Name of Organization	State
1.	Krishi Vigyan Kendra, Junagarh	Gujarat
2.	Krishi Vigyan Kendra, Baramati	Maharashtra
3.	Krishi Vigyan Kendra, Ahmednagar	Maharashtra
4.	Sadhana Krishi Vigyan Kendra, Amravati	Maharashtra
5.	Suvide Foundation's Krishi Vigyan Kendra, Washim	Maharashtra
6.	Krishi Vigyan Kendra, Barh	Bihar
7.	Krishi Vigyan Kendra, Sirsa	Haryana
8.	Krishi Vigyan Kendra, Saharanpur	Uttar-Pradesh
9.	Krishi Vigyan Kendra, Namakkal	Tamil-Nadu
10.	Junagarh Agricultural University, Junagarh	Gujarat
11.	Habbington Institute of Agriculture Technology, Allahbad	Uttar-Pradesh
12.	Tamilnadu Agricultural University, Coimbatore	Tamil-Nadu
13.	Bihar Agriculture University, Sabour	Bihar
14.	University of Agricultural Sciences, Dharwad	Karnataka
15.	CCS Haryana Agricultural University, Hisar	Haryana
16.	Indira Gandhi Krishi Vishwavidyalaya, Raipur	Chhattisgarh
17.	GB Pant University of Agriculture & Technology, Pantnagar	Uttarakhand

As reported by Sharma (2013), participatory and need based community radio programme effectively leads to significant gain in knowledge of the audience. Yelvattimath *et al.* (2014) also reported that radio brings significant change in the

knowledge level of the audience by providing useful and required knowledge to them Also, various previous researches studying the relationship of audience profile characteristics with their knowledge gain, indicate that profile characteristics bear significant relationship with gain in knowledge, but most of these researches are in context of print media, radio or mobile phones (Parthsarthy, 2004; Mahara, 2012; Sultana, 2015; and Kumar and Ahmed, 2018). These researches also indicate that various profile characteristics (socio-economic, communication and psychological characteristics) like occupation, income, extension agency contact, mass media exposure, social participation, innovativeness of farmers and risk orientation bear significantly positive relationship with gain in knowledge. Thus, if programmes are tailor-made according to the profile characteristics of the audience keeping in mind those characteristics which have significant relationship with knowledge gain; it will lead to the designing of more effective programmes. Moreover, those people could also be trained in specific characteristics like innovativeness, risk orientation, achievement motivation and scientific orientation so that they may be more positive about knowledge gain through community radio programmes.

However, many such studies have been conducted in relation to other media tools but there is a dearth of studies specifically focusing on studying relationship of the profile characteristics of audience with their gain in knowledge by listening community radio programmes. It becomes all the more important in context of gain in knowledge regarding specific and focussed new technologies like IPM, IPNM, Bio-fertilizers, Organic farming, new varieties etc. Therefore, it was found pertinent to study the impact of farmers' profile characteristics on their knowledge gain through need based community radio programme. The main objective of this study is to assess the relationship between socioeconomic, communication and psychological characteristics of the respondents with their gain in knowledge through community radio programme.

II. METHODOLOGY

2.1 Study area and sample selection

For this study Pantnagar Janvani, the community radio service of the first Agricultural University of the Nation, GB Pant University of Agriculture and Technology was purposively selected. Pantnagar Janvani acts as a medium of extension, of latest technologies and scientific methods to farmers and seeks to bridge the information gaps with the latest and relevant information shared by experts of various different subjects like agriculture, veterinary, animal sciences, etc. The study was conducted in the four randomly selected villages of the Haldwani block of Nainital district of Uttarakhand, which catches the efficient signals of community radio, Pantnagar Janvani. Total 120 respondents were selected through Probability proportionate to size (PPS) sampling method. Keeping the study objectives in mind, the study followed an action research design.

2.2 Selection of Topic

Integrated Pest Management was selected as a topic for this study based on pilot study and through review of secondary sources. It was found that due to severe deterioration of soil quality because of indiscriminate use of chemicals, harmful effects on human health as well as development of resistance in pests against pesticides, there has been a paradigm shift from chemical methods of controlling pest to Integrated Pest Management approach. According to FAO definition, Integrated Pest Management (IPM) means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disturbance to agro-ecosystems and encourages the natural methods of pest control.

Although IPM has been accepted in principle as the most attractive option for protection of agricultural crops from the destruction of pests, its implementation at farm level in India had been limited (Puri, 1998). Many researchers believe that participatory methods can be more effective in IPM technology adoption by farmers (Asiabaka, 2002). Therefore, a knowledge test was designed on Integrated Pest Management which was administered at two stages i.e., before making them listen to community radio programme on IPM and after listening to the IPM based programme.

2.3 Variables

Independent variables: Socio-economic variables (Age, Education, Occupation, Income, Landholding); Psychological variables (Achievement motivation, scientific orientation); Communication variables (Information seeking behaviour, mass media exposure and social participation).

Dependent variable: Knowledge Gain, operationalized as any pre-post test change in a person's cognitive learning behavior resulting from specific experience.

2.4 Effectiveness of community radio program in terms of gain in knowledge assessed through pre and post knowledge test

H_0 (Null hypothesis): There is no difference between the mean pre-test score (μ_1) of respondents and mean post-test score (μ_2) of respondents. (H_0: $\mu_1 = \mu_2$)

H_1 (Alternate hypothesis): Mean post-test score of respondents is significantly greater than mean pre-test score of respondents. (H_1: $\mu_1 < \mu_2$)

Total score obtained by the respondent at the pre and the post test was determined and the difference was calculated:

Where, Gain in Knowledge= $\overline{X2}$ - $\overline{X1}$

$\overline{X1}$ = Mean score for knowledge in pre-exposure test

$\overline{X2}$ =Mean score for knowledge in post-exposure test

To test the significance of the gain in knowledge score of the respondents Paired 't' test was used.

2.5 Relationship of Socio-economic, communication and psychological characteristics with Gain in Knowledge.

H_0 (Null Hypothesis) : Selected socio-economic, communication and psychological characteristics namely age, education, occupation, annual income, landholding, achievement motivation, scientific orientation, information seeking behaviour, mass media exposure and social participation of farmers have no significant relationship with level of knowledge gained by farmers due to community radio programme.

H_1 (Alternate hypothesis): Selected socio-economic, communication and psychological characteristics namely age, education, occupation, annual income, landholding, achievement motivation, scientific orientation, information seeking behaviour, mass media exposure and social participation of farmers have significant relationship with level of knowledge gained by farmers due to community radio programme.

2.6 Data collection tools and technique

A structured questionnaire was administered to study the profile characteristics of the respondents. A Knowledge test was constructed to assess the level of knowledge of respondents on various aspects of IPM. Questions were related to three broad categories i.e., IPM: a concept, Non-chemical methods of integrated pest management and chemical method of integrated pest management. Total number of 37 questions, which covered all possible aspects of the content related to IPM were selected for construction of Knowledge test. Responses were quantified by giving a score of 'one' for appropriate answer and 'zero' for wrong answer. Knowledge test was validated by experts of Agronomy, Entomology and Plant Pathology. Reliability of the knowledge test was assessed through split half method.

2.7 Data Analyses

Statistical technique such as frequency, percentage, mean, weighted mean score, standard deviation, t-test, correlation coefficient and paired t-test were used to analyze the data for meaningful interpretation.

III. FINDINGS AND DISCUSSION

3.1 Socio-economic, communication and psychological characteristics of farmers

The findings of the study revealed that majority of respondents (64.17 %) were of middle age group. None of the respondent was illiterate and maximum (36.67 %) were educated up to high school level. It was found that almost all the respondents (95%) were having marginal landholding yet majority of them (62.5 %) had medium annual income might be because most of them (62.15 %) were engaged in agriculture & other subsidiary occupation. Majority of respondents (62.5 % and 79.17 %) had medium achievement motivation and scientific orientation respectively. It was also found that majority of respondents (80 %) had medium mass-media exposure and 73.33 per cent had high information seeking behaviour. Among various information sources, personal localite sources were mostly preferred by most of the respondents and more than half of the respondents had no membership in any social organization (Table 2).

TABLE 2
DISTRIBUTION OF FARMERS BASED ON SOCIO-ECONOMIC, COMMUNICATION AND PSYCHOLOGICAL CHARACTERISTICS (n= 120)

S. No.	Independent variables	Percentage (%)
1.	**Age**	
	Young (less than 27 years)	17.50
	Middle (27 – 52 years)	64.17
	Old (more than 52 years)	18.33
2.	**Education**	
	Illiterate	-
	Primary education	15.83
	Education up to middle level	10.83
	Education up to High school	36.67
	Education up to Intermediate	23.33
	Graduate	10.83
	Post-Graduate	2.5
3.	**Occupation**	
	Agriculture	40.83
	Agriculture with other subsidiary occupation	59.17
4.	**Annual Income**	
	Low (Less than Rs. 45,720)	20
	Medium (Rs. 45,720 – Rs. 74,815)	62.5
	High (More than Rs. 74,815)	17.5
5.	**Landholding**	
	Marginal (less than 1 hectare)	95
	Small (1 – 2 hectare)	4.17
	Semi-Medium (2 – 4 hectare)	0.83
6.	**Achievement Motivation**	
	Low (< 23.08)	20
	Medium(23.08 to 29.9)	62.5
	High (> 29.9)	17.5
7.	**Scientific Orientation**	
	Low (<20.89)	20.83
	Medium (20.89 to 24.11)	79.17
	High (>24.11)	-
8.	**Mass Media Exposure**	
	Low (<8.95)	-
	Medium (8.95 to 11.79)	80
	High (>11.79)	20
9.	**Information Seeking Behaviour**	
	Low (<20.655)	10
	Medium (20.655-24.727)	73.33
	High (>20.655)	16.67
10.	**Social Participation**	
	No membership	58.33
	Member	41.67
	Office bearer	3.33

3.2 Effectiveness of community radio program in terms of gain in knowledge assessed through pre and post knowledge test

Effectiveness of community radio programme was measured in terms of gain in knowledge of the respondents. Primarily, a knowledge test was given to respondents before the intervention of community radio programme that was called pre-test. Result of pre-test indicated that an overwhelming majority of the people had least knowledge of Integrated Pest Management concept and practices. Pre-test was followed by intervention of need based community radio programme on Integrated Pest Management . IPM programme was designed in local dialect i.e., Kumaoni. Target audience was gathered in a common place in small groups at a pre-decided day and time. Audience collectively listened the community radio programmme on IPM. After the intervention of community radio programme, Post knowledge test was administered on the respondents.

Paired 't' test was calculated to test the significant difference in pre and post knowledge level of respondents. Data presented in Table 3 depicts the relevant values for driving conclusion from paired 't' test.

TABLE 3
PAIRED 'T' TEST FOR RELATIVE EFFECTIVENESS OF COMMUNITY RADIO PROGRAMME (n=120)

Mean of pre-test score $\overline{X1}$	Mean of post-test score $\overline{X2}$	Mean of difference $\overline{d}$	Standard deviation of difference S_d	't' cal	't' tab
9.29	24.1	14.81	3.77	43.02**	-2.36

***** Indicate that value is significant at 1% level of significance***

't' tab (left sided) = - $t_{(n-1,\ a)}$ = - 2.36

It is evident from the above table that value of 't' cal is higher than value of 't' tab at 1% level of significance. Thus, null hypothesis that respondents have same knowledge in pre and post knowledge test was rejected and we accepted alternate hypothesis that mean knowledge score was significantly higher in post-test than pre-test. Hence, it can be concluded that the intervention of community radio programme led to significant gain in knowledge of respondents.

Initially farmers had low knowledge regarding integrated pest management concept and practices as indicated by low score in pre-test (=9.29). Significant increase in knowledge was observed after the intervention of community radio programme as their post-test score increased from 9.29 to 24.1. The gain in knowledge was 14.81. Thus, community radio programme was found to be effective in terms of gain in knowledge of respondents (Figure 1).

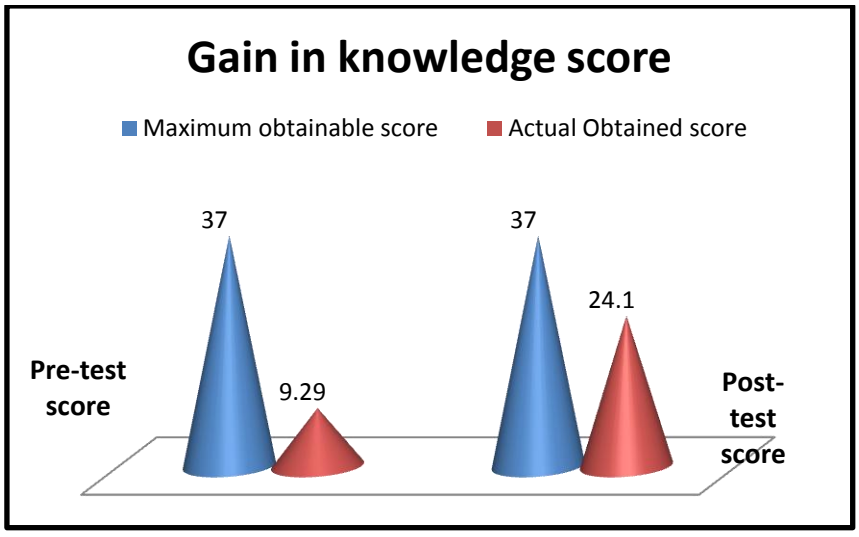


FIGURE 1: Representation of gain in knowledge score of respondents after listening community radio programme.

3.3 Relationship of socio-economic, communication and psychological characteristics of listeners with gain in knowledge

The coefficient of correlation was calculated to find out the relationship between socio-economic, communication and psychological characteristics of farmers with gain in knowledge and the significance of correlation was tested by using test of significance. Table 4 depicts the relationship between independent and dependent variables.

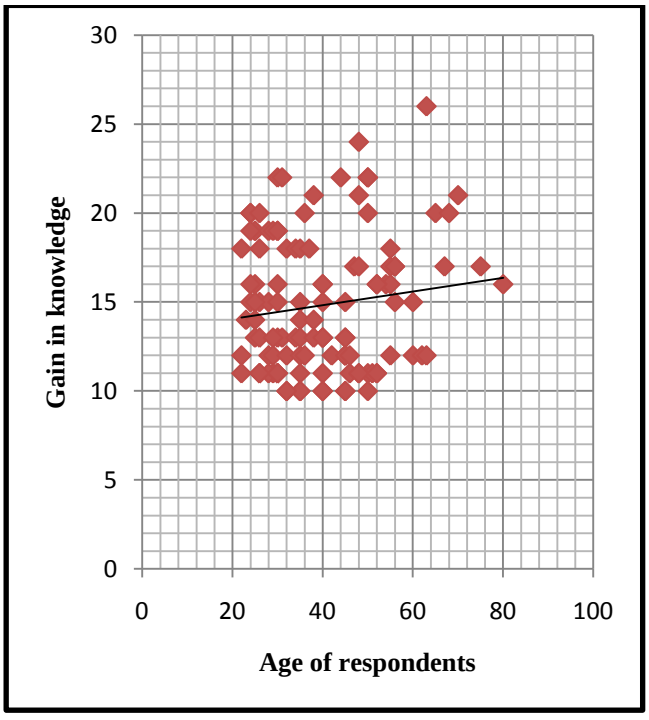
TABLE 4
RELATIONSHIP BETWEEN INDEPENDENT VARIABLES AND DEPENDENT VARIABLE

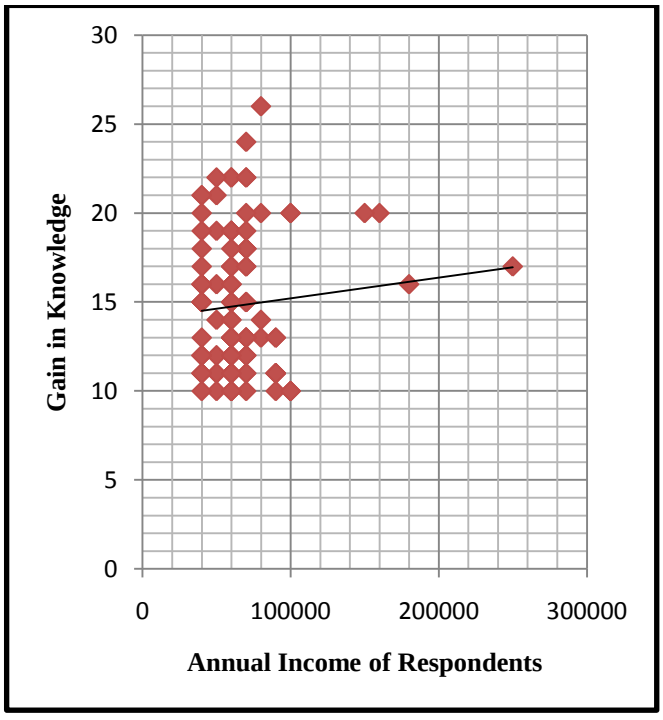
S. No.	Independent variable	Dependent variable (Gain in Knowledge)	t calculated	Null Hypotheses
		r		
1	Age	0.133	1.46	Accepted
2	Education	0.841**	16.88	Rejected
3	Annual Income	0.087	0.95	Accepted
4	Occupation	-0.0104	-1.12	Accepted
5	Landholding	0.115	1.26	Accepted
6	Achievement Motivation	0.888**	21.01	Rejected
7	Scientific Orientation	0.782**	13.63	Rejected
8	Mass media exposure	0.128	1.41	Accepted
9	Information seeking behaviour	0.803**	14.63	Rejected
10	Social participation	0.841**	13.75	Rejected

**** Indicate that value is significant at 1% level of significance**
t tab @ 5% = 1.98 ; t tab @ 1% = 2.62
(**'r'**= coefficient of correlation, **'t' cal** is calculated value of t statistic, **'t' tab** is table value of t statistic for two tailed test at 5% or 1% level of significance and (n-2) df.)

It is indicated in Table 4 that Null Hypotheses stating Education, Achievement Motivation, Scientific Orientation, Information seeking behaviour and Social participation have no significant relationship with level of knowledge gained by farmers due to community radio programme was rejected. Hence, alternate hypotheses stating Education, Achievement Motivation, Scientific Orientation, Information seeking behaviour and Social participation have significant relationship with level of knowledge gained by farmers due to community radio programme was accepted. Thus, it can be concluded that Farmers' profile characteristics like Education, Achievement Motivation, Scientific Orientation, Information seeking behaviour and Social participation have significantly positive impact on their knowledge gain through need based community radio programme.

It is also evident from the above table that there is some extent of positive or negative correlation between independent and dependent variables but to understand the strength of their relationship, visual representation of the relationship on scatter plot is depicted in Figure 2(a & b).





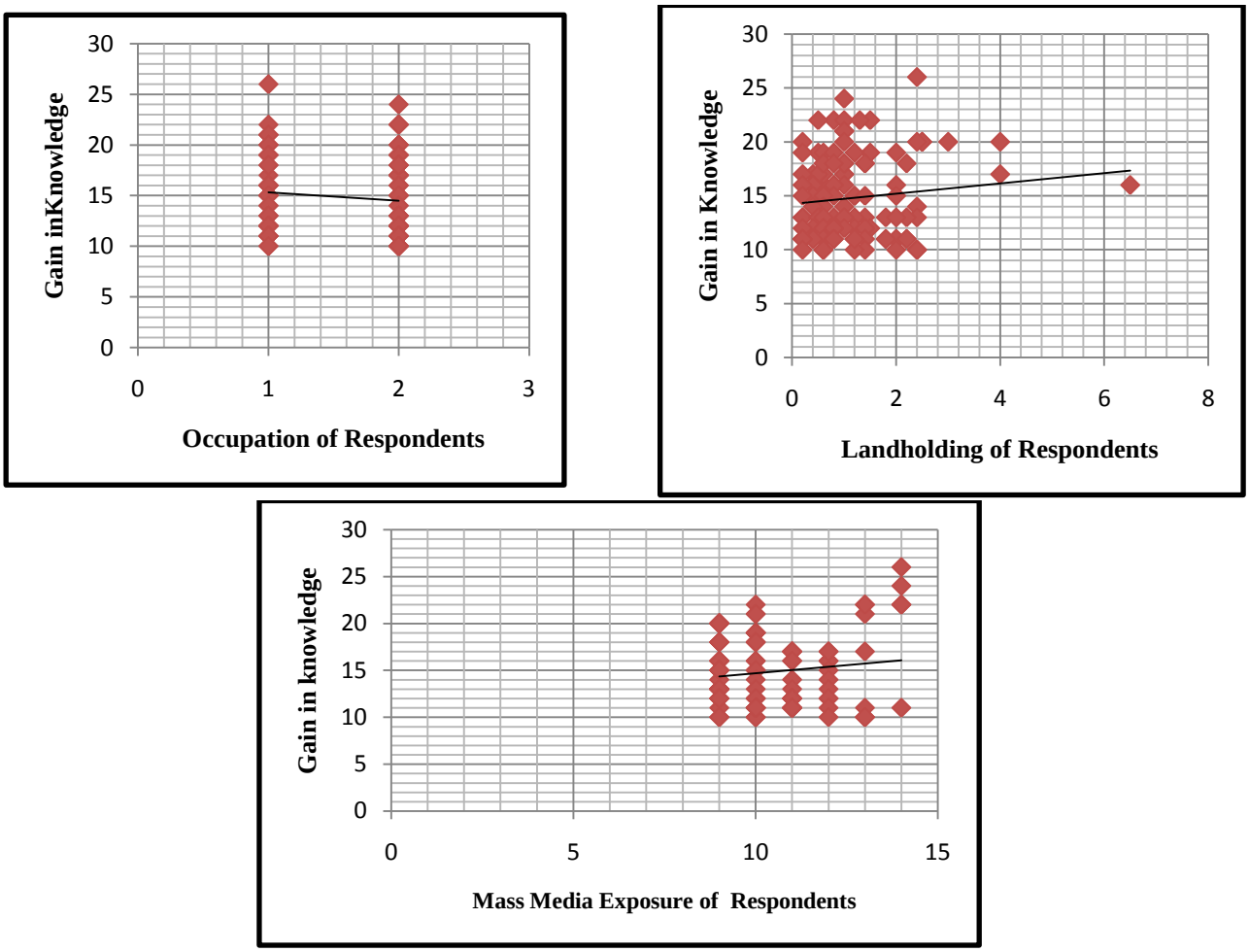
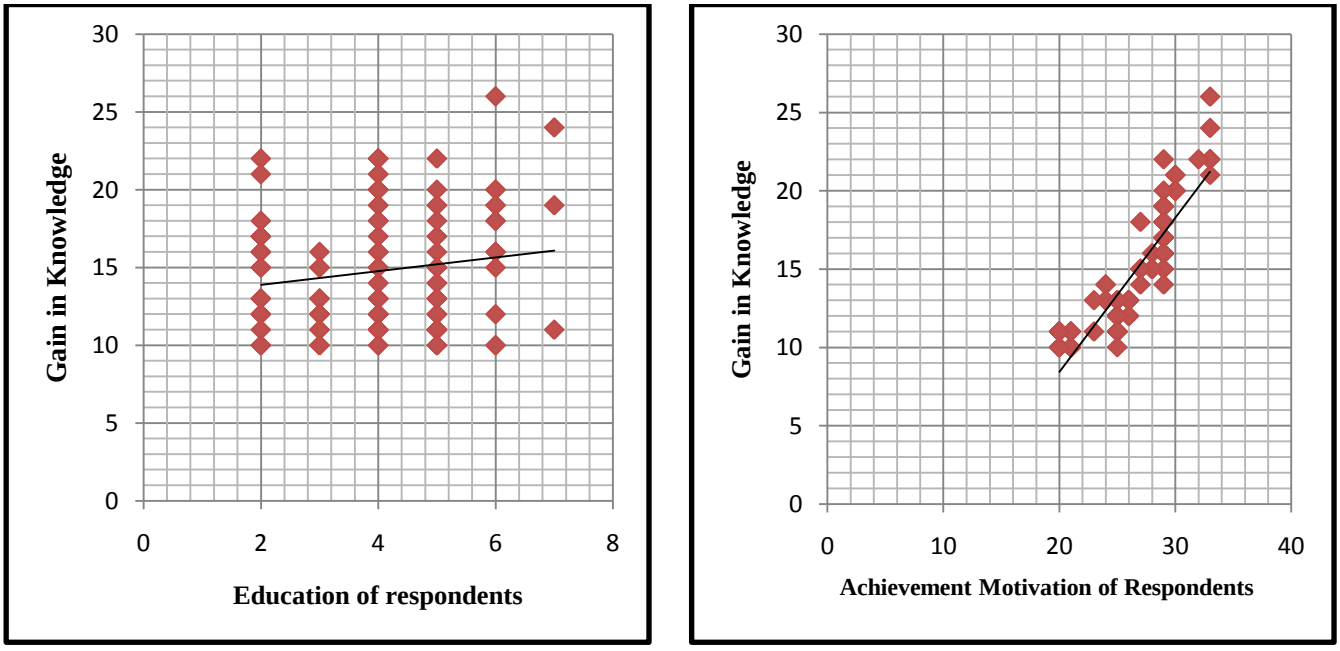


FIGURE 2(a): Representation of Weak relationship between independent and dependent variables

It is clear from Fig. 2(a) that Age, Annual Income, Landholding and Mass Media Exposure have positive correlation with gain in knowledge while Occupation has negative correlation with gain in knowledge. However, as showed by scatter plot the relationship is weak in strength.



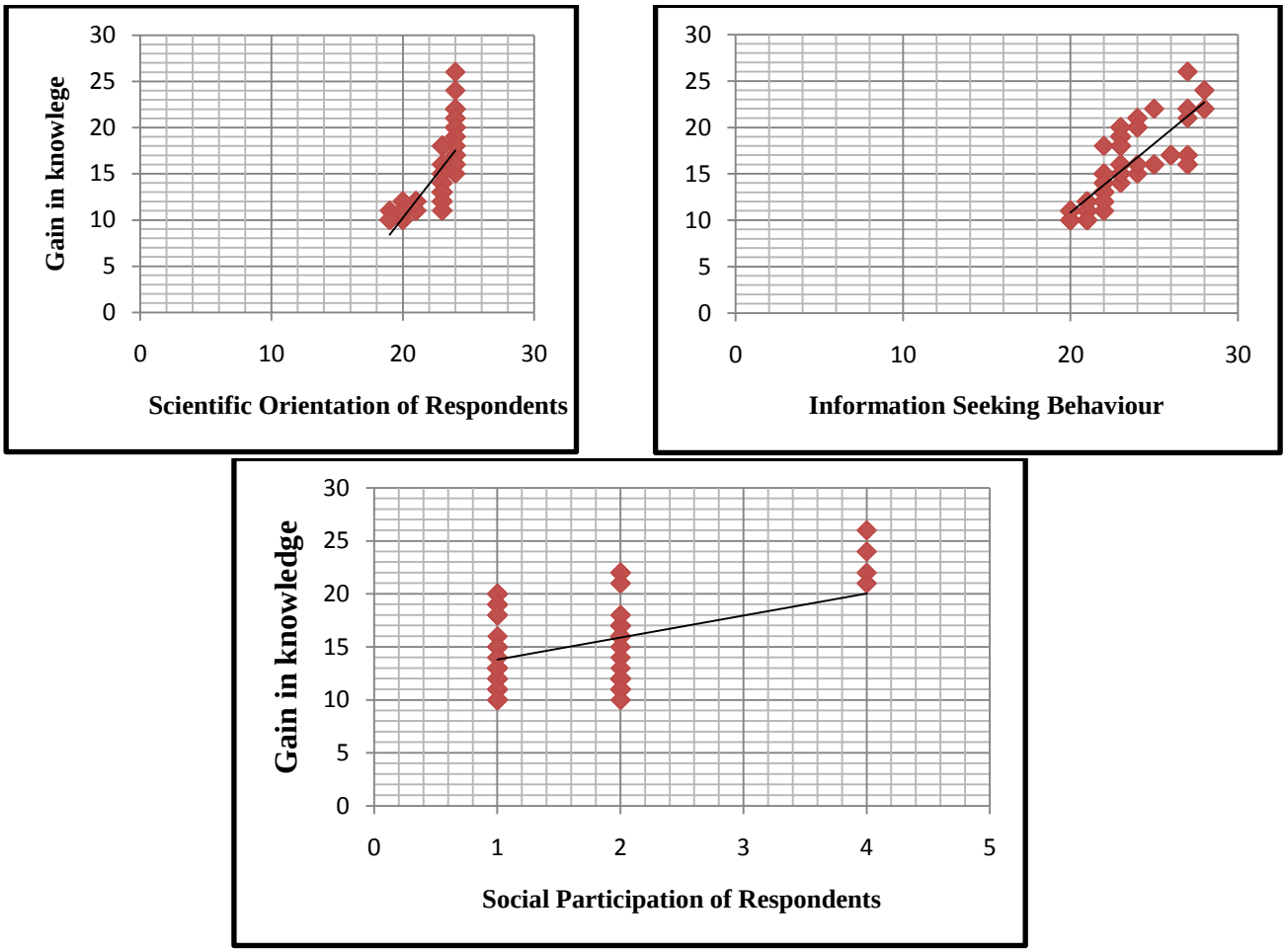


FIGURE 2(b): Representation of Strong relationship between independent and dependent variables

It is visible from the scatter plot representation in Figure 2(b) that there is positive, linear and strong correlation between education, achievement motivation, scientific orientation, information seeking behaviour and social participation with gain in knowledge. From these results it can be inferred that, the significant relationship between education and gain in knowledge might be due to the reason that respondents with higher education level were able to grasp the things readily and quickly. As people with higher achievement motivation are always eager and motivated to know more to achieve something, due to which it might be possible that it has significant impact on knowledge gain. The significant relationship between scientific orientation and gain in knowledge may be because respondents with scientific bent of mind seek to gain knowledge regarding new agricultural practices and technology. Farmers with high information seeking behaviour would have high intent to seek information and knowledge. Therefore, due to their quest for new information and knowledge there would be significant increase in their knowledge score before and after the intervention. Moreover, it can also be concluded that higher the extent of social participation of respondents, higher will be their gain in knowledge.

IV. CONCLUSION

For agricultural development, it is important that dissemination of agricultural information and technologies through planned media intervention like community radio programme must be need based and according to audience profile. Initially, it was found that there was significant gap in farmers' knowledge and awareness level regarding IPM technology and concepts. The study indicated that a planned and strategized media intervention could significantly enhance the knowledge level of the farmers as in case of the present study. Also, the present study brings to light various profile factors like education, achievement motivation, scientific orientation, information seeking behaviour and social participation of respondents, which positively and significantly affect their gain in knowledge. Hence, studying these audience profile characteristics and keeping them in mind before any intervention is most important for the success of that intervention. Moreover, these profile characteristics of audience can also be made favorable according to gain in knowledge, by providing proper training.

Therefore, keeping the above points in mind community radio programme can play a crucial role in effective communication of agricultural technologies and also being a tool of Information and Communication technology it has potential to overcome the challenge of Agricultural extension system by covering wider audience and with a participatory methodology. The study also suggests establishing a strong network between State Agriculture Universities, Krish Vigyan Kendras and Community Radio Stations in the whole country which can together lead to agricultural transformation.

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Efficacy of Various Botanicals against Maize Weevil (*Sitophilus Zeamays*) in Laboratory Condition

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Abstract— *Maize weevil, Sitophilus zeamays (Motschulsky) is one of most important economic pest that causes severe economic damage to store grain and its management at the farmers level is must. To determine the efficacy of different botanicals against maize weevils in stored maize a study was carried out at the laboratory of IAAS, Lamjung Campus at room temperature from January to April. Nine treatments were laid out in Completely Randomized Design with four replications. Number of infected seeds, dead weevils, number of exit holes and live weevils were recorded at every 30 days intervals till four months . Analysis of variance showed significant effect of all botanicals on weevil mortality compared to untreated check, but not as effective as liquid extracts as Cinnamomum (9.75), citronella (9.75), mentha (9) and lemon grass (9) were significantly more effective than the rest botanicals (P <0.05). Upto 90 days statically lower numbers of infected seeds were seen at Cinnamomum, Mentha, Lemon grass, Titepati, and Citronella while on 120th day Cinnamomum showed best results. Among all treatments, Cinnamomum oil was found to be better on every parameter thus can solve poor farmer's problems by integrating them with other cultural measures. However further research are needed to fix the rate graph and the long term effect in large stores of farmers conditions.*

Keywords— Botanicals , Maize (Zea mays), Maize weevil (Sitophilus zeamays Mots), Mortality.

I. INTRODUCTION

Maize (Zea mays L. Gramineae) is one of the major cereal crops produced worldwide (Blackie & Jones, 1993). Maize is the second most important staple food crops in hills of Nepal (Upadhya et al., 2007). Maize can be grown in all kinds of agro-ecological zones irrespective of land type and seasons because it is widely adaptable to different stress environments and is widely grown from the terai to high mountains in Nepal (Adhikari,2007).It is also known as queen of cereal crops and has high potential in terms of yield and production (Singh, 2002). Maize is cultivated in an area of 891583ha with the production of 2231517Mt and total yield is 2503kg/ha (MOAD, 2015/2016). It contributes about 30% of the total cereal production in the high hills and 40% in the mid-hills and plays important role in the food supply as well as regarding major staple food in the remote area of Nepal (Pandey et al., 2001). In the last decades, annual growing demand of maize production is increasing constantly at the rate of 5% (Sapkota & Pokhrel, 2010). According to Ranum, Pena Rosas, Garcia-Casal (2014) per capita maize consumption in Nepal is 98 g/person/day.

Different insect pest attacked crops both in the field and in the storage condition (Neupane et al., 1991). That attacks may range from sap sucking or leaf damaging or ear damaging insects. Overall 60-70% reductions in the final yield of maize production have been reported due to insect pest hazards (Sharma, 2009). Such attacks are not only confined to the developmental stage of the plant but also continue in the storage period.

On an average about 20-30% yield losses after post harvest of maize due to pest infested have been seen by scatter and accidental (GC, 2006) The major reasons for post harvest losses are ;inadequate knowledge about post harvest losses, careless after harvest or post harvest losses, unavailability of synthetic pesticides in time, misuse of pesticides, poor economic condition, unavailability of improved storage structures, careless and ignorance about importance of botanical pesticide for controlling stored pests, etc.

Several researchers have evaluated insecticide, repellent or antifeedent and development inhibiting effects of various plant parts and plant products on *S. zeamays* with varying degree of success. Among the botanicals used sweet flag rhizome, neem oil, neem seed powder timur, (*Zantthoxylum armatum* DC.) and mugwort (*Artimisia vulgaris*) have been reported to be superior to control the maize weevils (Paneru, Duwadi, Khanal, and Bhandari, 1996; Anonymous, 1988). Some of the metabolites of plants are toxic such as pyrethrum, nicotine, rotenone etc. and some are repellents, antifeedants like azadirachtin, rape seed extract and others, like Acorus calamus act as sterilants *(Ignatowicz and Wesolowska, 2015*). Asian countries have abundantaly used of these plant products which are traditionally used by the rural people for preparations against insect control (*Talukder and Howse, 1993*). Thus,these plant products can be utilized either alone or mixed for controlling stored pest. So, with an objective To develop effective management technique for storage insect pests and particularly, assess damage by maize weevil in storage and identify the effective management option against maize weevil this experiment was performed.

II. MATERIALS AND METHODS

The experiment was carried out in the Entomology Laboratory of IAAS, Sundarbazar, Lamjung at an altitude of about 650 masl with Longitude of 84o 11'- 84o 38' E and Latitude of 28^o 3'- 28^o 30' N. The research was conducted in Completely Randomized Design (CRD) with 4 replications and 9 treatments. The research was conducted with 9 treatments consisting of 8 botanicals in which four of liquid extracts i.e. Cinnamomum Oil, Citronella Oil, Mentha Oil and Lemon Grass Oil and four botanicals Neem, Titepati, Mustard Kati (Biproduct) and Turmeric and Untreated Check (control)

Treatment	**Description**
T1	Turmeric (10gm/kg) + 500g maize, T2 Cinnamomum Oil (2 ml/kg) + 500g maize
T3	Citronella Oil (2 ml/kg) + 500g maize, T4 Mentha Oil (2 ml/kg) + 500g maize
T5	Lemon Grass Oil (2 ml/kg) + 500g maize, T6 Mustard Kati (10gm/kg) + 500g maize
T7	Titepati (10gm/kg) + 500g maize, T8 Neem (10gm/kg) +500g maize
T9	Control (500 g maize)

Liquid Extacts Oil were used in the experiment namely Cinnamomum Oil, Citronella Oil, Mentha Oil and Lemon Grass Oil was obtained from National Herbs Processing Center ,Jadibuti ,Kathmandu and botanicals Turmeric, Mustard Biproduct (Kati), Neem and Titepati were prepared by self.

Fresh leaves of Neem, Titepati , Turmeric and Mustard Biproduct(Kati) were collected from respective plant of Lamjung campus. Leaves were washed and shed dried for 15 days and then crushed by using blender. The powders of leaves were kept in polythene bags until it was used.

The maize weevil (irrespective of sex) were made available from Nepal Agriculture Research Council, Entomology division where they were cultured for research.

500 gm of sun dried maize sample at 12% moisture were taken in each plastic bin of capacity 1000 gm. The samples were then mixed thoroughly with different treatments and 10 maize weevils (irrespective of sex) were released in each bin. The bin then covered with muslin clothes and tightened with rubber band and kept for observation.

Following observations were taken:

Weight loss of the grain at every 30, 60, 90 and 120 days after treatment application

Parameters recorded throughout the experiment period were tabulated in MS-Excel and finally analyzed using RSTAT software and the mean comparisons were done by Duncan test at 5% and 1% level of significance.

III. RESULT AND DISCUSSION

3.1 Effect of treatments on number of infected seeds:

TABLE 1
EFFECT OF TREATMENTS ON NUMBER OF INFECTED SEEDS IN LABORATORY OF IAAS LAMJUNG CAMPUS, SUNDARBAZAR LAMJUNG, 2018

S.N.	Treatment	30 DAT	60 DAT	90 DAT	120 DAT
1	Turmeric	17.5a	19.75ab	19.5ab	20.75a
2	Cinnamomum	12abc	12.25abc	12.25b	12.25b
3	Citronella	14.5ab	17.5abc	19ab	21.75a
4	Mentha	14.75ab	20.5a	20.75ab	21.75a
5	Lemon Grass	17a	14.5abc	23.25a	23.5a
6	Kati	5.25c	10.5bc	12.75b	21.5a
7	Tite pati	7.5bc	18.25abc	17.75ab	20a
8	Neem	6c	9.25c	18.75ab	22a
9	Control	18.25a	15abc	21.25ab	26.25a
	F-Test	0.001**	0.105	0.145	0.00643
	Mean	12.52778	15.27778	18.36111	21.08333
	CV(%)	37.59298	38.19428	30.65929	24.09187
	LSD	6.872123	-	-	-

There were significant differences ($p<0.05\%$) among the treatments on the extent of infection by the weevil. 30 days after the application of treatment high extent of infection (18.25) was seen in control as compared to botanicals but still control it was significantly at par along with turmeric (17.5), cinnamomum (12), citronella (14.5), menthe (14.75) and lemon grass(17) treatments. The second reading after 60 days of treatment application revealed highest extent of infection in menthe treated seeds (20.5) but it was at par with other botanicals treatments like turmeric, cinnamomum, citronella, lemon grass, titepati and with control. After 90 days of treatment application, highest extent of infection was seen in lemon grass treated seeds (23.25) which was significantly at par with all other botanicals treatments and control except for citronella and kati. After 120 days of treatment application, highest extent of seed infection was shown by control (26.25) that was significantly at par with all other treatments except for cinnamomum.

3.2 Effect of treatments on weevil mortality:

TABLE 2
EFFECT OF TREATMENTS ON WEEVIL MORTALITY IN LABORATORY OF IAAS LAMJUNG CAMPUS, SUNDARBAZAR LAMJUNG, 2018

S.N.	Treatment	30 DAT	60 DAT	90 DAT	120 DAT
1	Turmeric	3de	7b	5.25c	6.25d
2	Cinnamomum	9.75a	10a	11a	11ab
3	Citronella	9.25ab	10a	11.5a	11.75a
4	Mentha	9ab	9a	9.75ab	10abc
5	Lemon Grass	9ab	9.5a	10.5a	10.25ab
6	Kati	7.5bc	9.25a	11a	10.5ab
7	Tite pati	6.75c	5.75bc	7.5bc	8.5bcd
8	Neem	4.25d	4c	6.5c	7.25cd
9	Control	2.5e	4.5c	5.75c	5.75d
	F-Test	4.65e-10 **	0.000 **	0.000 **	0.000**
	Mean	6.777778	7.666667	8.75	9.027778
	CV(%)	16.36309	15.96428	19.91	20.09782
	LSD	1.618549	1.786196	2.54245	2.64791

The treatments were significantly different ($p<0.05\%$) on the basis of weevil mortality. 30 days after treatment application highest weevil mortality was seen in cinnamomum (9.75), citronella (9.75), menthe (9) and lemon grass (9) treatments. As obvious it is, the least effectiveness was shown by control (2.5). After 60 days, the highest mortality was shown by cinnamomoum (10), citronella (10), menthe (9) and lemon grass (9). After 90 days, the same four treatments were found significantly superior as compared to other botanicals. The same result was seen in 120 days of counting with the significant result also shown by kati. The least significant result was shown by control.

Among all the treatments, the action of cinnamomum was found to be superior on an average in terms of least seed infection and higher weevil mortality. This is mainly due to the chemical constituents of the essential oils. The main compounds of essential oil from cinnamomum were characterized by more than 94% of monoterpenes. Cinnamomum leaves oil were composed by 68% of camphor and 9% of linalool. These essential oils are similar to the most common compositions described in the literature (Fujita et al., 1974; Dung et al., 1993). Linalool was shown to exhibit fumigant toxicity against S. zeamais (Wang et al. 2011; Liu et al., 2013; Yildirim et al., 2013) and the C. camphora, with camphor as major component, showed repellent activity (Liu et al., 2006) and high insecticidal activity against S. oryzae (Hamed et al., 2012).

The highly toxic and repellent effects of main constituents of these oils, camphor and linalool, have been demonstrated by other researchers also Chen et al., 2013; Ajayi et al., 2014). The cinnamon methanol extract showed the highest repellent activity for S. zeamais adults at all time intervals. Piperine, a pungent substance in black pepper and cinnamaldehyde, a principal component of cinnamon flavour, are reported to possess insecticidal activities (Huang & Ho, 1998; de Paula et al., 2000). These findings indicate that such active compounds may play a role in the repellent activity against S. zeamais and show their potency at much lower concentrations. (Takahiro Ishii et al., 2007) Cinnamon powder also was showed generally a more repellent effective on adults of Sitophilus granarius. Rhyzopertha dominica and T. castaneum. The powders of Piper nigrum, Capsicum annuum and C. zeylanicum (Cinnamon plant) showed a repellent effect on Sitophilus zeamais.

In most of the cases the results shown by turmeric and neem is not so promising so it can be assumed that the pest has already developed resistance to this botanicals since they have been used for a long time in our culture for similar purposes. Similarly, the above result clearly shows that with the increasing number of days the action or effectiveness of botanicals starts to decrease significantly. Within the botanicals those that are applied in volatile form like oil start to loose their effectiveness with the increasing days as compared to that which area applied in powdered form. So, while performing similar experiments this fact should also be kept in mind.

IV. CONCLUSION

The study on "Efficacy of various botanicals against maize weevil (sitophilus zeamais m.) in laboratory condition" was carried out in Entomology Laboratory of IAAS, Lamjung from January to April, 2018. The present study has shown the effectiveness of some botanicals at different rate in controlling maize weevil on stored maize grains. This result shows that the action of cinnamomum was found to be superior on an average in terms of least seed infection, less number of exit holes and higher weevil mortality because chemical constituents of the essential oils which can solve poor resource farmers' problems by integrating them with other cultural measures. However further research are needed to fix the rate graph and the long term effect in large stores of farmers conditions. More research is required in differed climatic conditions and in different ecological zones to draw the conclusion about the effectiveness of botanicals.

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Drought Tolerance and Nitrogen use Efficiency of Upland Rice (*Oryza Sativa* L.) Genotypes Grown under Varying Water and Nitrogen Regimes

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Abstract— *Rice genotypes were grown under different water regimes and nitrogen levels. Sufficient soil moisture content (SMC) and high N level caused optimum growth of the genotypes. Deficient water and N supply both retarded growth of rice. PSB Rc14, P42, and P38 had high number of tillers, number panicles per hill, number of spikelets per panicle, relative growth rate (RGR), water use efficiency (WUE), harvest index (HI), straw yield, grain weight, and grain yield at field capacity (FC). These genotypes also had high values in the aforementioned growth and yield parameters at 120 kg N ha^{-1} treatment. In terms of the efficiency in the use of N as indicated by agronomic efficiency of nitrogen application (AEN), recovery efficiency of nitrogen application (REN), and internal efficiency of nitrogen application, PSB Rc14, P42, and P38 still performed better than the rest of the genotypes tested. Evaluation of the combined effect of water and N application showed that PSB Rc14, P42, and P38 significantly produced high grain yields among the genotypes under SMC at FC with 120 kg N ha^{-1} which suggests that water plays a fundamental role in rice growth in combination with N. P42 showed the less affected by water deficit and low N nitrogen levels, hence, produced the high grain yield.*

Keywords— Upland rice, nitrogen use efficiency, agronomic use efficiency, recovery use efficiency, rice genotypes.

I. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food of over half of the world's population. Globally, it ranks third after wheat and maize in terms of production (Bandyopadhay and Roy, 1992). According to International Rice Research Institute (IRRI) 2012, there is about 50,000 ha of upland rice in Cambodia (2-4% of total rice area) with an average grain yield of 2.97 t ha^{-1}, much less compared to potential yield of the newly-developed varieties (MAFF, 2011). At present, upland rice production contributes about 5-6% of Cambodia's national rice production (CRD, 2008), which is one of the potential areas considered in maintaining the country's rice production level.

The major factor for the low productivity in rainfed uplands is the lack of water. Rice is usually subjected to prolonged drought due to less rain as well as erratic rainfall pattern in the certain years (NARC, 1996). This inadequacy and untimely availability of rainwater is a major limitation of rice production resulting to low yield in the rainfed ecosystems (Kamoshita *et al*., 2000). The effect of drought differs with varieties, growth stage, level and duration of drought stress occurrence (Kato, 2004), hence, results to varying yields (Lafitte *et al*., 2007). The reduction in growth and photosynthetic rate in such fragile environment are the major causes of yield reduction (Zlatev and Lidon, 2012). In addition to its direct effect on yield, drought can also reduce the potential beneficial effects of improve crop management practices, such as fertilizer application, pest and disease management.

The use of varieties that are adapted under limited water is one of the strategies to enhance production in rainfed uplands. Different varieties may have varying degrees of drought tolerance (Zeigler *et al*., 1994). Water deficit during the vegetative stage may have lesser effect on grain yield, but have tremendous effect during reproductive and grain filling stages (Fukai and Cooper, 1995). Growing appropriate varieties in rainfed areas that are drought-prone could be a practical strategy to enhance production. Selections of early maturing rice varieties that are adaptable to drought stress could be one of the pragmatic strategies (Juliano *et al*., 2007). Selection of drought tolerant rice varieties with good N efficiency could improve rice production in rainfed upland areas that are gradually becoming water limited.

Okonje *et al*. (2012) reported that application of low N levels results to low yields, considering that N deficiency is a major abiotic stress that limits rice productivity in rainfed upland soils, such as ultisol and alfisol that are acidic in general (Kirk *et al*., 1998). The low yield of upland rice is a consequence of infertile soils and drought conditions, that are adapted to low harvest index (HI) traditional cultivars (George *et al*., 2001).

Among essential plant nutrients, N is one of the most yield-limiting nutrients for upland rice production. Farmers relate the N deficiency in upland rice to low soil organic matter, low soil pH, soil erosion, and low application of N fertilizers. Nitrogen use efficiency in rice production is subjected to N loss by leaching, volatilization, denitrification and erosion (Fageria and Baligar, 2005). Thus, the use of N-efficient varieties in combination with proper fertilizer application is an important complementary strategy in improving rice yield.

II. MATERIALS AND METHODS

Experiment 1 involved two factors, namely: Factor A: six upland rice genotypes that included 4 test genotypes, 1 drought susceptible check genotype and 1 drought tolerant check genotype; and Factor B: 3 water regimes: field capacity (FC), 50% FC and 75% FC. The experiment was laid out in two factorial randomized complete block designs (RCBD) with three replications. The rice genotypes evaluated were: P31, P38, P42 and P44, PSB Rc14 (N responsive check) and Salumpikit (non-responsive to N check).

Experiment 2 was laid out in two factorial RCBD with three replications which involved two experimental variables, namely: 1) six rice genotypes (4 test genotypes, 1 N-responsive check, 1 non-responsive to N check); and 2) three N levels (0, 60, and 120 kg ha^{-1}). The rice genotypes evaluated were: P31, P38, P42, P44, and PSB Rc14 (N responsive check) and Salumpikit (non-responsive to N check).

Three experimental variables were considered in this experiment, namely: 1) three rice genotypes selected from Experiment I, 2) Two water regimes (FC and 50% FC, and 3) two N levels (0 and 120 kg ha^{-1}). The experiment was laid out in 3-factorial RCBD with three replications analyzed by SAS (9.1) to compare mean LSD at 5 % and 1% level.

TABLE 1
CHEMICAL PROPERTIES OF THE SOIL USED IN THE EXPERIMENTS

Chemical Properties	Concentration Value	Description
pH	6.8	Slightly acidic
Total N (%)	0.31	Low N
Available P (ppm)	90	High P
Exchangeable K (me/100 g soil)	0.66	Low K
Organic Matter (%)	3.87	Medium OM

Results analyzed by Soil Laboratory, Agricultural Systems Cluster, UPLB

III. RESULTS AND DISCUSSION

3.1 Genotypes Responses to Varying Soil Moisture

3.1.1 Number of tillers per hill

The number of tillers per hill was significantly influenced by the soil moisture condition and genotypes (Table 2). P38 and P42 had a comparable number of tillers per hill to PSB Rc14 (11.52, 12 and 12.15 tillers per hill, respectively), while Salumpikit had the lowest number of tillers per hill (6.44 tillers per hill) at FC.

TABLE 2
NUMBER OF TILLERS $HILL^{-1}$ OF SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING WATER REGIMES AT 72 DAS.

GENOTYPE	NUMBER OF TILLERS PER HILL					
	Water Regime			Difference (%)		
	FC	75% FC	50 % FC	FC-75% FC	FC-50%FC	75% FC-50% FC
P31	8.56e	6.11g	5.44h	33.4	44.6	11.6
P38	11.52ab	9.89de	8.92e	15.2	25.4	10.3
P42	12a	10.78cd	9.87de	10.7	19.5	8.8
P44	8.44e	6.21fg	4.84hi	25.8	54.2	24.8
Salumpikit	6.44fg	4.89hi	3.90i	27.4	49.1	22.5
PSB Rc14	12.15a	11bc	10.22cd	9.9	17.3	7.4

CV(%) = 3.27 (FC: Water at field capacity)

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter are not significantly different based on LSD at 5 % and 1% level.

Water ** Variety ** W x V *

3.1.2 Water use efficiency (WUE)

Highly significant differences in water use efficiency under varying soil moisture content were observed in six upland rice genotypes (Table 3). PSB Rc14 (2.30) had the highest water use efficiency, which is comparable to the check P42 (2.27) followed by P38 (2.10) at FC. When SMC was reduced to 75% FC, WUE of the genotypes were still significantly different from each other. P42 obtained the highest WUE (1.86) similar with PSB Rc14 (1.84) followed by P38 (1.59).

TABLE 3
WATER USE EFFICIENCY OF SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING WATER REGIME TREATMENTS.

GENOTYPE	WATER USE EFFICIENCY					
	Water Regime				Difference (%)	
	FC	75 % FC	50 % FC	FC-75% FC	FC- 50% FC	75% FC -50%FC
P31	1.60 d	1.14h	0.78j	34.1	68.9	37.5
P38	2.10b	1.59 d	1.24g	28.4	51.5	24.7
P42	2.27a	1.86c	1.34g	21.7	51.5	32.5
P44	1.53e	1.11hi	0.75j	31.8	68.4	38.7
Salumpikat	1.41g	1.02i	0.70j	33.5	67.3	37.2
PSB Rc14	2.30a	1.84c	1.43hi	22.2	46.7	25.1

CV (%) = 3.40 (FC: Water at field capacity)

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Water ** Variety ** W x V *

3.1.3 Harvest index (HI)

HI (ratio of grain yield to above ground biomass) of the six upland rice genotypes was significantly affected by varying water regimes (Table 4). Despite the comparable high number of panicles produced by the test genotypes P38 and P42 to the drought tolerant check, PSB Rc14 significantly had the highest HI (0.32), while Salumpikit and P44 did not differ from each other at FC. Further increased in water deficit up to 50% FC resulted to significant decreased in HI value. Sharmar *et al.* (2003) reported that high HI was attained in well-irrigated genotypes compared to that of the genotypes grown under water stress condition.

TABLE 4
HARVEST INDEX OF SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING WATER REGIMES.

GENOTYPE	HARVEST INDEX					
	Water Regime			Difference (%)		
	FC	75 % FC	50 % FC	FC -75% FC	FC -50% FC	75 % FC - 50 % FC
P31	0.25c	0.20e	0.18ef	26.1	32.6	10.5
P38	0.28b	0.24cd	0.22de	14.4	24.0	8.7
P42	0.28b	0.27bc	0.25e	3.6	11.3	7.7
P44	0.22de	0.19ef	0.16fg	14.6	31.6	17.1
Salumpikit	0.20e	0.17f	0.13g	16.2	42.4	26.7
PSB Rc14	0.32a	0.29b	0.25c	9.8	24.6	14.8

CV (%)= 4.63 (FC: Water at field capacity)

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Water ** Variety ** W x V *

3.1.4 Number of panicles per hill

At FC the drought tolerant check (PSB Rc14) had the highest number of panicles per hill (10 panicles), which is comparable to P38 and P42 (9.78 and 8.67 panicles, respectively) (Table 5). P31 and P44 had the same number of panicles per hill (7.33 and 7.11 panicles) while Salumpikit had the lowest number of panicle produced (5.68 panicles).

TABLE 5

NUMBER OF PANICLES PER HILL IN SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING WATER REGIMES.

GENOTYPE	NUMBER OF PANICLES PER HILL					
	Water Regime			Difference (%)		
	FC	75 % FC	50 % FC	FC -75% FC	FC -50% FC	75 % FC-50% FC
P31	7.33ef	6.78fgh	5.33hij	7.8	31.6	23.9
P38	9.78ab	9.33cde	7.93def	4.7	20.9	16.2
P42	9.67ab	9.21cde	7.83def	4.9	21.0	16.2
P44	7.11fg	6.22gh	4.46ijk	13.4	45.8	26.4
Salumpikit	5.68ghi	4.22jk	3.27k	29.5	53.9	19.2
PSB Rc14	10a	9.56bcd	8.18 de	4.5	20.0	14.1

CV (%) = 6.07 (FC: Water at field capacity)

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Water ** Variety * W x V *

3.1.5 Number of filled grains per panicle

The number of filled grains is one of the most important yield attributes in rice. The results showed significant differences in the number of filled grains per panicle among rice genotypes tested under different water regimes (Table 6). PSB Rc14 (77.69) had the higher number of filled grains, which was not significantly different to P42 (74.84) and P38 (74.33), while P44 and Salumpikit both had the lowest number of filled grains per panicle (65.51 and 63.60, respectively) at FC. At 75% FC, the highest percent reduction in the number of filled grains per panicle was observed in P44 (11%) while P38, P42, and PSB Rc14 had the lowest percent reduction (7.3, 7.2 and 7.2%, respectively).

TABLE 6

NUMBER OF FILLED GRAINS PER PANICLE OF SIX RICE GENOTYPES AS AFFECTED BY VARYING WATER REGIMES.

GENOTYPE	NUMBER OF FILLED GRAINS PER PANICLE					
	Water Regime				Difference (%)	
	FC	75 % FC	50 % FC	FC-75% FC	FC-50% FC	75 %FC-50%FC
P31	68.42c	63.11de	51.53hi	8.1	28.2	20.2
P38	74.33ab	69.09bc	60.51fg	7.3	20.5	13.2
P42	74.84ab	69.67bc	60.62fg	7.2	21.0	13.9
P44	65.51d	58.42gh	49.18i	11.0	28.5	11.1
Salumpikit	63.60de	57.71gh	48.33i	9.7	27.3	17.7
PSB Rc14	77.69a	72.29b	63.62de	7.2	19.9	12.8

CV (%) = 1.84 (FC: Water at field capacity)

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Water ** Variety ** W x V *

3.1.6 Thousand-grain weight

Thousand-grain weight was significantly differed among genotypes at FC. P42 had the heaviest 1000-grain weight (24.61 g), while Salumpikit(19.69 g) had the lightest (21.13 g). Reducing SMC from 100 % FC to 75% FC and 50% FC resulted to significant reduction in 1000-grain weight. At 75% FC, P42 had the heaviest grain weight (23.82 g) with a percentage difference of 3.3 %, while Salumpikit had the lightest grain weight (18.82 g) with a percentage difference of 4.5% when grown under 100% FC.

3.1.7 Grain yield per hill

Significant differences in grain yield were observed among the values of grain yield of the genotypes (Table 7). At sufficient SMC (FC), PSB Rc14 had the highest grain yield (10.92 g) which was comparable to P42 (10.61 g) followed by P38 (9.60 g). Salumpikit (5.36g) had the lowest grain yield. Significant reduction in grain yield in all genotypes was observed after

reducing SMC from 100 % FC to 75% FC and 50% FC. At 75% FC and 50% FC, PSB Rc14 had the highest grain yield (8.96 g and 7.82 g, respectively) which was comparable to P42 (8.54 g and 7.63 g, respectively). Shani *et al.* (2001) reported that drought stress at filling grains period caused acceleration in ripening time, thus reduction growth duration and number of filled grains per panicle. P42, PSB Rc14 and P38 had the number of filled grains was not much affected by water deficit, hence, showed tolerance to drought.

TABLE 7
GRAIN YIELD AS AFFECTED BY VARYING WATER REGIMES OF SIX RICE UPLAND GENOTYPES.

GENOTYPE	GRAIN WEIGHT (g per hill)					
	Water Regime			Difference (%)		
	FC	75 % FC	50 % FC	FC-75% FC	FC-50% FC	75 % FC -50 % FC
P31	7.61cd	4.75fg	3.04hi	46.3	85.8	43.9
P38	9.60b	6.92d	5.88e	32.5	48.1	16.3
P42	10.61a	8.54c	7.63 cd	21.6	32.7	11.3
P44	6.13de	4.05fg	2.98hi	40.9	69.2	30.4
Salumpikit	5.36e	3.91gh	2.56i	31.3	70.7	41.7
PSB Rc14	10.92a	8.96c	7.82 cd	19.7	33.1	13.6

CV (%) = 5.09 (FC: Water at field capacity)

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Water ** Variety ** W x V *

3.2 Genotypes Responses to Varying Nitrogen Levels

3.2.1 Number of tillers per hill

The number of tillers per hill was significantly differed among the genotypes without N treatment at 72 DAS (Table 8). PSB Rc14 had the highest number of tillers (10.38), while Salumpikit had the least number of tillers (3.51). The number of tillers of P42 and P38 did not significantly different (9.48 and 8.87, respectively). Increasing N level from 0 to 60 kg ha^{-1} and 120 kg ha^{-1} significant increased the number of tillers among the genotypes by 1-2 tillers after application of N. PSB Rc14 had the highest number of tillers with medium and high N application (11.83 and 12.9, respectively), while Salumpikit also had the least number of tillers (5.02 and 6.56, respectively). Chaturvedi (2005) reported that higher number of tillers might be due to the more availability of N, which played a vital role in cell division. He also reported that the maximum numbers of tillers were attained at 200 kg N ha^{-1} level while the minimum number of tillers was observed at 0 kg N ha^{-1} level.

TABLE 8
NUMBER OF TILLERS PER HILL OF SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING N LEVELS AT 72 DAS.

GENOTYPE	NUMBER OF TILLERS PER HILL					
	Nitrogen Level			Difference (%)		
	0 N	60 N	120 N	60 N - 0 N	120 N - 0 N	120 N - 60 N
P31	7.44ghi	8.89def	11.22bcd	17.8	40.5	23.2
P38	8.87fg	10.33cde	11.78abc	15.2	28.2	13.1
P42	9.48efg	10.89bcd	12.33ab	13.8	26.1	12.4
P44	6.04hi	7.55hg	9.78def	22.2	47.3	25.7
Salumpikit	3.51j	5.02i	6.56hi	35.4	60.6	26.6
PSB Rc14	10.38cde	11.83bc	12.9a	13.1	21.7	8.7

CV(%) = 5.57

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Nitrogen ** Variety ** N x V *

3.2.2 Relative growth rate (RGR)

At 30 DAS without N application, significant differences were observed in RGRs among the genotypes (Table 9). However, there were no significant differences between the RGRs of P38, P42, and PSB Rc14 (0.12, 0.13, and 0.13 g $g^{-1}d^{-1}$,

respectively) and between the RGRs of P31, P44, and Salumpikit (0.08, 0.06, and 0.05 g $g^{-1}d^{-1}$, respectively). Application of 60 kg N ha^{-1} and 120 kg N ha^{-1} significantly increased RGR among the genotypes. Tisdale and Nelson (1984) observed that an adequate supply of N to the plant during the early growth period is very important to increase RGR and the initiation of leaves.

TABLE 9
RGR (g $g^{-1}d^{-1}$) OF SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING N LEVELS

GENOTYPE	RELATIVE GROWTH RATE (g $g^{-1}d^{-1}$)					
	Nitrogen Level			Difference (%)		
	0 N	60 N	120 N	60 N - 0 N	120 N - 0 N	120 N - 60 N
P31	0.08h	0.11ef	0.15b	31.6	60.9	30.8
P38	0.12e	0.15b	0.18a	22.2	40.0	18.2
P42	0.13e	0.16b	0.19a	20.7	37.5	17.1
P44	0.06hi	0.08g	0.11ef	28.6	58.8	31.6
Salumpikit	0.05hi	0.07g	0.10f	33.3	66.7	35.3
PSB Rc14	0.13e	0.15b	0.18a	14.3	32.3	18.2

CV(%) = 3.37

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Nitrogen ** Variety ** N x V *

3.2.3 Straw yield

Significant differences in the straw yields were observed among the genotypes in control treatment. P42 had the highest straw yield (26.74 g $plant^{-1}$) while Salumpikit had the lowest straw yield (16.09 g $plant^{-1}$). Straw yield significantly increased after application of N in all genotypes. P42 and Salumpikit consistently had the highest and lowest straw yields after applications of 60 kg N ha^{-1} to 120 kg N ha^{-1}. Hence, these genotypes were least affected under N is limiting condition. Dry matter production increased with increasing N levels. Hence, N is an indispensable nutrient to rice production, and its uptake is affected by different factors such as soil condition (Martin *et al.* 2002).

3.2.4 Harvest Index (HI)

Table 10 shows the different HI of the different genotypes as affected by different N levels. The rice genotypes evaluated have significantly varying HI among genotypes in control treatment (0 N). PSB Rc14 had the highest HI (0.25), followed by P38 and P42 (0.22 and 0.21, respectively). Application of 60 kg N ha^{-1} significantly increased HI among the genotypes, wherein PSB Rc14 (0.28) had the highest HI followed by P38 and P42 (0.26 and 0.25, respectively). Further increase in N level to 120 kg ha^{-1}, significant increased HI. Cai *et al. (*2002) when observed that increasing N up to 120 kg ha^{-1} can increase HI in different genotypes.

TABLE 10
HARVEST INDEX OF SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING N LEVELS.

GENOTYPE	HARVEST INDEX					
	Nitrogen Level			Difference (%)		
	0 N	60 N	120 N	60 N - 0 N	120 N - 0 N	120 N - 60 N
P31	0.18hij	0.22 efg	0.26cd	20.0	36.4	8.3
P38	0.22efg	0.26cd	0.28ab	16.7	24.0	7.4
P42	0.21ghi	0.25de	0.27bc	17.4	25.0	7.7
P44	0.18hij	0.22efg	0.25cd	20.0	32.6	12.8
Salumpikit	0.14k	0.17hij	0.21fg	19.4	40.0	21.1
PSB Rc14	0.25de	0.28ab	0.30a	11.3	18.2	6.9

CV (%) = 4.63

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Nitrogen ** Variety ** N x V *

3.2.5 Agronomic efficiency of nitrogen application (AEN)

AEN significantly differed among the genotypes (Table 11). P38 had the highest AEN (6.99) and was comparable to PSB Rc14 (6.25) and P42 (5.13) at 60 kg N ha^{-1}. Increased N level to 120 kg ha^{-1} significantly increased AEN among the genotypes. P38 had the highest AEN (7.98) but not significantly different with PSB Rc14 (7.21), followed by P42 (6.09) and P31 (5.58). High AEN with the low percentage difference was observed in P38, PSB Rc14 and P42, which suggest that these genotypes were least affected after decreasing the rate of N application. Hence, achieving higher yield. Application of 120 kg N ha^{-1} in these rice genotypes with SMC at field capacity under screen house condition showed significantly higher AEN values than those plants applied with 60 kg N ha^{-1}. Ladha *et al.* (1998) claimed that rice varieties with high NUE should have the higher AEN at low and high N supply.

TABLE 11

AGRONOMIC EFFICIENCY OF NITROGEN IN SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING N LEVELS.

GENOTYPE	AGRONOMIC EFFICIENCY OF NITROGEN APPLICATION		
	Nitrogen Level		Difference (%)
	60 N	120 N	120 N- 60 N
P31	4.58c	5.58bc	19.7
P38	6.99 b	7.98a	13.2
P42	5.13bc	6.09b	17.1
P44	3.51ef	4.63cd	27.5
Salumpikit	2.45 f	3.57de	37.2
PSB Rc14	6.25bc	7.21a	14.3

CV (%) = 7.02

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Nitrogen ** Variety **N x V

3.2.6 Recovery efficiency of nitrogen application (REN)

Significant difference was also observed in REN among genotypes as affected by different N levels (Table 12). At 60 kg N ha^{-1} rate, P42 had the highest REN (0.45), but this value was not significantly different from the REN of P38 (0.44) and PSB Rc14 (0.43). On the hand, Salumpikit had the lowest REN (0.28). At 120 kg N ha^{-1} rate, higher REN values were obtained compared to the other treatment. P42 had the highest REN value (0.82), which was not significantly different in the REN value of P38 (0.77). As observed in this experiment, doubling the rate of N from 60 to 120 kg ha^{-1} also doubled the REN values in each genotype. Since not all of N applied remains in the soil, particularly under aerobic condition, addition of N increases biomass including root biomass, which might contribute to absorb more native N from the soil Cassman *et al*. (2002).

TABLE 12

RECOVERY EFFICIENCY OF NITROGEN IN SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING N LEVELS.

GENOTYPE	RECOVERY EFFICIENCY OF NITROGEN APPLICATION		
	Nitrogen Level		Difference (%)
	60 N	120 N	120 N - 60 N
P31	0.25e	0.50bc	66.7
P38	0.44c	0.77a	54.6
P42	0.45c	0.82a	58.3
P44	0.30de	0.61b	68.1
Salumpikit	0.28e	0.54bc	63.4
PSB Rc14	0.43cde	0.52bc	26.1

CV (%)= 9.67

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly based on LSD at 5 % and 1% level.

Nitrogen **, Variety **, N x V *

3.2.7 Internal efficiency of nitrogen application (IEN)

Like AEN and REN, IEN was significantly differed among genotypes in response to varying N levels (Table 13). P42 had the highest IEN (1.95), but not significantly different with P38 (1.95) and PSB Rc14 (1.92) while Salumpikit had the lowest IEN (1.06). Increasing N level to 60 kg ha^{-1} significantly increased IEN of the test genotypes. The highest IEN was noted in P42 (2.44), which was not significantly different with P38 (2.40) and PSB Rc14 (2.20). Further increase in N level to 120 kg ha^{-1} also resulted to significant increase in IEN among genotypes. P42 remained to have the highest IEN (2.94) but not significantly different with P38 (2.92), P31 (2.72) and PSB Rc14 (2.72).

TABLE 13

INTERNAL EFFICIENCY OF NITROGEN IN SIX UPLAND RICE GENOTYPES AS AFFECTED BY VARYING N LEVELS.

GENOTYPE	INTERNAL EFFICIENCY OF NITROGEN APPLICATION					
	Nitrogen Level			Difference (%)		
	0 N	60 N	120 N	60 N - 0 N	120 N - 0 N	120 N - 60 N
P31	1.1gh	1.92gf	2.72ab	27.15	84.82	34.48
P38	1.95fg	2.40bc	2.92a	20.69	39.84	19.55
P42	1.96fg	2.44bc	2.94a	21.82	40.00	18.73
P44	1.74gh	1.99fg	3.01a	13.59	53.47	21.14
Salumpikit	1.06h	1.47gh	1.87efg	32.41	55.29	39.52
PSB Rc14	1.92fg	2.20cde	2.72ab	21.84	34.48	31.54

CV (%) = 6.7

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Nitrogen ** Variety ** N x V *

3.2.8 Number of panicles per hill

Without N application, P42 had the highest number of panicles (8.87), which was similar with PSB Rc14 (8.65) and P38 (8.48). Increasing N level to 60 kg ha^{-1} and 120 kg ha^{-1} significantly increased the number of panicles among genotypes. P42, PSB Rc14, and P38 consistently have the highest number of panicles (9.66, 9.44, and 9.33, respectively).

3.2.9 Number of filled grains per panicle

Table 14 shows that there are significant differences in the number of filled grains per panicle among the genotypes as affected by N application. At 0 N level, P42 had the significantly highest number of filled grains (71.33) which was comparable to PSB Rc14 (70.09), followed by P38 (66.04), and the lowest value was observed in Salumpikit (56.54). When N level increased to 60 kg ha^{-1}, significant increase in the number of filled grains was observed among the genotypes. P42 (77.51) still had the highest number of filled grains, which was comparable to the values obtained in PSB Rc14 (75.84) and P38 (72.49).

TABLE 14

NUMBER OF FILLED GRAINS PER PANICLE AS AFFECTED BY APPLICATION OF VARYING N LEVELS IN SIX UPLAND RICE GENOTYPES.

GENOTYPE	NUMBER OF FILLED GRAINS PER PANICLE					
	Nitrogen Level			Difference (%)		
	0 N	60 N	120 N	60 N - 0 N	120 N - 0 N	120 N - 60 N
P31	62.18ijk	69.07ef	72.67bcd	10.5	15.6	5.1
P38	66.04fgh	72.49bcd	75.67bc	9.3	13.6	4.3
P42	71.33de	77.51b	80.42a	8.4	11.9	3.7
P44	59.02jk	65.29fgh	71.84de	10.1	18.7	9.6
Salumpikit	56.54k	63.08ij	67.98fg	10.9	18.4	7.5
PSB Rc14	70.09def	75.84bc	79.20a	7.9	12.2	4.3

CV (%) = 1.54

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Nitrogen ** Variety ** N x V *

3.2.10 Thousand-grain weight

Grain weight among genotypes were significantly differed at 0 N (Table 15). P42 (23.22 g) had the highest grain weight which was not significantly different with P38 (21.91 g). At 60 kg N ha^{-1} level, significant increase in grain weight was observed among genotypes.

TABLE 15

1000-GRAIN WEIGHT OF SIX RICE GENOTYPES AS AFFECTED BY APPLICATION OF VARYING N LEVELS.

GENOTYPE	1000-GRAIN WEIGHT (g)					
	Nitrogen Level				Difference (%)	
	0 N	60 N	120 N	60 N - 0 N	120 N - 0 N	120 N - 60 N
P31	19.31ij	19.76hi	21.68efg	2.3	11.6	17.7
P38	21.91def	23.23cd	24.89ab	5.8	12.7	6.9
P42	23.22cd	24.38bc	26.12a	4.9	11.8	6.9
P44	20.84ghi	21.49efg	22.72de	5.8	8.6	5.6
Salumpikit	18.25j	19.82hi	20.52ghi	8.2	11.7	7.8
PSB Rc14	19.34ij	19.91hi	20.56ghi	3.1	6.12	3.2

CV (%) = 2.71

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Nitrogen **Variety **N x V *

3.2.11 Grain yield per hill

Significant differences in grain yield per hill were observed among genotypes in all the treatments. At 0 N, P38 had the highest grain yield (7.41 g) comparable to the grain yields of PSB Rc14 (6.88 g) and P42 (6.97 g), while Salumpikit had the lowest grain yield per hill (3.02 g). Application of 60 kg N ha^{-1}, significantly increased grain yield per hill in test genotypes, particularly P38 having the highest grain yield (9.44 g) but not significantly different with P42 and PSB Rc14 (8.78 and 8.37 g, respectively). The result implies that P38, PSB Rc14 and P42 had better response to increasing rates of N application. P38, P42 and PSB Rc14 produced high number of spikelets per panicle, hence, produced high number of filled grains per panicle. Less affected by increasing N rate application.

TABLE 16

GRAIN YIELD PER HILL OF SIX UPLAND RICE GENOTYPES AS AFFECTED APPLICATION OF VARYING N LEVELS.

GENOTYPE	GRAIN WEIGHT (g per hill)					
	Nitrogen Level				Difference (%)	
	0 N	60 N	120 N	60 N - 0 N	120 N - 0 N	120 N - 60 N
P31	4.51gh	6.95def	8.69bc	42.6	63.3	22.3
P38	7.41cd	9.44b	11.11a	24.1	39.9	16.3
P42	6.88def	8.78bc	10.12a	24.3	34.3	14.2
P44	4.25gh	6.32de	8.61bc	39.2	67.8	30.7
Salumpikit	3.02i	4.22gh	6.05def	33.2	66.8	35.6
PSB Rc14	6.97def	8.37bc	10.89a	18.3	43.9	26.9

CV (%) = 6.17

In a column or row (treatment effect) or row by column (if indication effect is significant), means followed by the same letter by the same letter are not significantly different based on LSD at 5 % and 1% level.

Nitrogen **Variety ** N x V *

3.3 Genotypes Responses to Varying Water and Nitrogen Levels:

The result shows that P42 had better RGR than PSB Rc14 and P38. Generally, low application of N and reduced SMC resulted low growth rate due to inaccessibility of nutrients because of limited root growth (Briggs and Shantz, 1993; de Wit, 1988). Stem partitioning coefficients at maturity stage showed that the combined effect of N level and water regime significantly affected the genotypes (Table 17). Yang *et al.* (2001) claimed that N fertilization generally reduce the remobilization of pre-stored carbon from vegetative tissue to the grain.

TABLE 17

STEM PARTITIONING COEFFICIENT AT MATURITY STAGE IN THREE UPLAND RICE GENOTYPES EXPOSED TO VARYING N LEVELS AND WATER REGIMES.

GENOTYPE	STEM PARTITIONING COEFFICIENT			
	Nitrogen Level (Kg ha^{-1})	Water Regime		Mean
		FC	50 FC	
P38	120 N	0.54 b	0.44 d	0.49 B
	0 N	0.46 c	0.41f	0.44 D
P42	120 N	0.52 b	0.47c	0.50 B
	0 N	0.48 c	0.41f	0.45 C
PSB Rc14	120 N	0.61 a	0.48 c	0.55 A
	0 N	0.50 b	0.42e	0.46 C
Mean		0.51 A	0.44 B	

CV (%) = 5.71 G x W *, G x N **, W x N **, G x N x W *

Means followed by a common letter across nitrogen levels x water regimes x rice genotypes are significantly differentbased on LSD at 5 % and 1% level.

Leaf partitioning coefficient increased from flowering to maturity stage (Table 18). At FC level with 120 kg N ha^{-1} application, PSB Rc14 (0.36) had the highest leaf partitioning coefficient among the genotypes. When SMC was reduced to 50% FC, significant reduction in leaf partitioning coefficient was observed among the genotypes. The lowest reduction in partitioning coefficient was recorded in PSB Rc14 (0.22) when grown under FC level without N application.

TABLE 18

LEAF PARTITIONING COEFFICIENT AT MATURITY STAGE OF THREE UPLAND RICE GENOTYPES EXPOSED TO VARYING N LEVELS AND WATER REGIMES.

LEAF PARTITIONING COEFFICIENT				
GENOTYPE	Nitrogen Level (Kg ha^{-1})	Water Regime		Mean
		FC	50 FC	
P38	120 N	0.34 b	0.27d	0.31 A
	0 N	0.24de	0.23ef	0.23 D
P42	120 N	0.30 c	0.25de	0.28 B
	0 N	0.26 d	0.22ef	0.25 C
PSB Rc14	120 N	0.36 a	0.24e	0.30 A
	0 N	0.28 cd	0.20f	0.24 C
Mean		0.30 A	0.24 B	

CV (%) = 10.51 G x W *, G x N **, W x N **, G x N x W *

Means followed by a common letter across nitrogen levels x water regimes x rice genotypes are significantly differentbased on LSD at 5 % and 1% level.

At maturity stage, root partitioning coefficients increment was low but still significantly differed among the genotypes (Table 19). Highest coefficient was observed in PSB Rc14 (0.27) when grown under 100% FC and 120 kg ha^{-1}. Lowest value was also obtained in PSB Rc14 (0.23) when grown under 100% FC without N application.

TABLE 19

ROOT PARTITIONING COEFFICIENT AT MATURITY STAGE IN THREE UPLAND RICE GENOTYPES EXPOSED TO VARYING N LEVELS AND WATER REGIMES.

ROOT PARTITIONING COEFFICIENT				
GENOTYPE	Nitrogen Level (Kg ha^{-1})	Water Regime		Mean
		FC	50 FC	
P38	120 N	0.25 b	0.21d	0.23 B
	0 N	0.23 c	0.18 e	0.21 C
P42	120 N	0.23 c	0.2d	0.22 B
	0 N	0.21 d	0.19 e	0.20 D
PSB Rc14	120 N	0.27 a	0.23 c	0.25 A
	0 N	0.22cd	0.17ef	0.20 D
Mean		0.24 A	0.2 B	

CV (%) = 3.11 G x W *, G x N *, W x N **, G x N x W *

Means followed by a common letter across nitrogen levels x water regimes x rice genotypes are significantly differentbased on LSD at 5 % and 1% level.

3.3.1 Water use efficiency (WUE)

Significant interaction was found among the treatment variables in terms of WUE (25). Highest WUE obtained in P42 (2.49) under FC applied with 120 kg N ha^{-1}, followed by PSB Rc14 and P38 (2.33 and 2.30, respectively). Reduction in SMC to 50% FC applied with 120 kg N ha^{-1}, significantly reduce WUE among the genotypes. PSB Rc14 (1.82) had the highest WUE followed by P42 then P38 (1.27 and 1.25, respectively). Zhao *et al.* (2003) reported that WUE increases with water stress because of higher reduction in conductance than the reduction in assimilation, while severe water stress decreases the activity of photosynthetic enzyme that results to decrease in WUE.

TABLE 20

WATER USE EFFICIENCY IN THREE UPLAND RICE GENOTYPES AS AFFECTED BY THE INTERACTION OF VARYING WATER REGIMES AND N LEVELS IN SELECTED RICE GENOTYPES.

WATER USE EFFICIENCY				
GENOTYPE	Nitrogen Level (Kg ha^{-1})	Water Regime		Mean
		FC	50 FC	
P38	120 N	2.30 b	1.27 f	1.79 C
	0 N	1.73 d	1.09 g	1.41 E
P42	120 N	2.49 a	1.25 f	1.87 B
	0 N	1.74 cd	1.06 g	1.4 E
PSB Rc14	120 N	2.33 b	1.44 e	1.89 A
	0 N	1.82 c	1.28 f	1.55 D
Mean		2.07 A	1.23 B	

CV (%) = 1.76 G x W *, G x N **, G x N **, G x N x W *

Means followed by a common letter across nitrogen levels x water regimes x rice genotypes are significantly different based on LSD at 5 % and 1% level.

3.3.2 Total nitrogen uptake (TNU)

P38 (3.15) had the highest TNU was found in but not significantly different with P42 (3.09) under 100% FC applied with 120 kg N ha^{-1} (Table 21). When SMC was reduced to 50% FC applied with the same level of N, the TNU was significantly reduced. PSB Rc14 and P42 had TNU values of 2.78 and 2.70, respectively. According to Yaduvanshi (2003), increases in N fertilizer rates, from 60 to 120 and to 180 kg N ha^{-1}, resulted to decreased NUE by 7 and 27% although the difference among 60 kg N 120 kg N was not significant. Dobermann *et al.* (2005) claimed thatapplication of N at optimum rate of 103 kg ha^{-1} increased aboveground N uptake by 38 kg ha^{-1} or about 37%.

TABLE 21

TNU IN THREE UPLAND RICE GENOTYPES AS AFFECTED BY THE INTERACTION OF VARYING WATER REGIMES AND N LEVELS IN SELECTED RICE GENOTYPES.

TOTAL NITROGEN UPTAKE				
GENOTYPE	Nitrogen Level (Kg ha^{-1})	Water Regime		Mean
		FC	50 FC	
P38	120 N	3.15 a	2.92 c	3.03 A
	0 N	2.64 ef	2.45 gh	2.37 E
P42	120 N	3.09 ab	2.70 de	2.89 B
	0 N	2.57 f	2.35 hi	2.33 F
PSB Rc14	120 N	2.98 bc	2.78 d	2.88 C
	0 N	2.56 fg	2.34 i	2.45 D
Mean		2.83 A	2.59 B	

CV (%) = 1.4 G x W *, G x N ns, W x N *, G x N x W *

Means followed by a common letter across nitrogen levels x water regimes x rice genotypes are significantly different based on LSD at 5 % level.

3.3.3 Grain yield

Nitrogen level, water regimes, genotypes and their interactions significantly affected grain yield (Table 22). At 100% FC without N application, P42 had the highest grain yield (7.44 g), while P38 had the lowest grain yield (6.79 g). Significant increase in grain yield was observed with the application of 120 kg N ha^{-1}. Miah and Panuallah (1999) had similar tending wherein the rate of yield reduction was higher when higher amount of N was applied in stress-affected rice especially at reproductive stage.

TABLE 22

GRAIN YIELD OF THREE UPLAND RICE GENOTYPES AS AFFECTED BY THE INTERACTION OF VARYING WATER REGIMES AND N LEVELS IN SELECTED RICE GENOTYPES.

GRAIN YIELD (g per hill)				
GENOTYPE	Nitrogen Level (Kg ha^{-1})	Water Regime		Mean
		FC	50 FC	
P38	120 N	10.56 b	5.53 e	8.05 C
	0 N	6.79 cd	3.75 f	5.27 E
P42	120 N	12.61 a	5.75 de	9.18 A
	0 N	7.44 c	4.08 f	5.76 D
PSB Rc14	120 N	11.66 a	5.70 e	8.68 B
	0 N	7.38 c	3.57 f	5.48 F
Mean		9.41 A	4.73 B	

CV (%) = 5.81 G x W *, G x N **, W x N **, G x N x W *

Means followed by a common letter across nitrogen levels x water regimes x rice genotypes are significantly different based on LSD at 5 % level.

IV. CONCLUSION

The first experiment determined the effect of different water regimes in selected upland rice genotypes in terms of agronomic parameters, yield and its components, and water use efficiency. The six upland rice genotypes used in the study were: 1). Salumpikit (susceptible drought check), 2). P31, 3). P38, 4). P42, 5). P44, and 6). PSB Rc14 (drought tolerant check). Water regime treatments were: 1) SMC at FC; 2) SMC at 75% FC, and 3) SMC at 50% FC. Genotypes grown under adequate SMC (at FC) were taller than those grown under water deficit condition. Salumpikit was the tallest plant among the genotypes but it also had high percentage reduction from 100% FC to 75% FC and 50% FC among the genotypes. PSB Rc14, P42 and P38 were among the genotypes that had low percentage reduction when SMC was decreased to 75 % FC and 50 FC %. Indicating that these genotypes were less affected by water deficit. The RGR was significantly affected by the interaction of water regime and rice genotypes. P42 had the highest RGR among the genotypes and result was consistent when exposed to decreasing water regime treatments at 75 % FC and 50 % FC. PSB Rc14, which is a drought-tolerant genotype, had similar

performance with P42 in terms of RGR and WUE parameters, which lead to have better grown.

Flowering occurred earlier in genotype the PSB Rc14 while other genotypes had later day to flowering. At reproductive stage, the allocation of photosynthates started to become directed to the production of grains (10.92 g). Shoot weight lower (14.26 g) compared to the previous crop stage as senescence of old shoots started. High values of HI in PSB Rc14, P42, and P38 (0.32 and 0.28, respectively) imply that these genotypes efficiently allocated the photosynthates in the production of grains under different water regimes. Subsequently, the numbers of panicles per hill (10 panicles), number of filled grains per panicle (77.69), number of spikelets per panicle (101.49) and grain weight per hill (10.92 g) were high in these genotypes. Water limitation (50 FC %) is one of the main factors that determinations of rice growth and grain yield, significantly affect grain filling. Among the genotypes evaluated, PSB Rc14, P42, and P38 had good performance under drought condition based on growth and yield parameters, hence can be considered as drought-tolerant genotypes while P44, P31 and Salumpikat were least tolerant to water deficit.

The second experiment revealed the importance of N in upland rice production. N rates applied in the experiment were 60 kg ha^{-1} and 120 kg ha^{-1}. Indicator genotypes were PSB Rc14 as the N-responsive and Salumpikit as the non N-responsive. Application of N significantly increased all the growth and yield parameters measured and significant differences were also observed in all parameters among the genotypes. Moreover, maximum N rate of 120 kg ha^{-1} application resulted to optimum growth of the genotypes. PSB Rc14, P42, and P38 performed well under varying N treatments as indicated by their high RGR values. P42 also had the highest straw yield than other genotypes, although was not significantly different from P38 and PSB Rc14. This means that these genotypes allocated most of their photosynthates in the maintenance of vegetative parts, while the other genotypes concentrated most of their photosynthates for the production of reproductive parts. Thousand-grain weight (23.22 g), number of spikelets per panicle (95.16), number of filled grains (71.33), and grain yield (7.41 g) were also high in PSB Rc14, P42, and P38 suggesting the good grain filling qualities of rice genotypes. The efficiency of N use as calculated in AEN, REN, and IEN showed that with doubled N rate (120 kg N ha^{-1}), P38 and P44, and N-responsive check, PSB Rc14, had high values for the aforementioned parameters. Nitrogen application increased the dry matter partitioning, grain yield and its components. Without N application, reduction in growth parameters, dry matter and grain yield were observed. Further increased N level up to 120 kg N ha^{-1} increased growth parameters and grain yield by 35%.

The effect of combined N levels and water regimes three selected upland genotypes were evaluated in the last experiment. Nitrogen rates applied were 0 kg N ha^{-1} and 120 kg N ha^{-1} under SMC at 100% FC and 50% FC. The genotypes that performed well in experiments 1 and 2 were used: PSB Rc14, P42 and P38. Significant differences were observed in all growth and yield parameters measured among the genotypes. Optimum growth of the genotypes was observed under 100% FC applied with 120 kg N ha^{-1} wherein P42 obtained the highest RGR, WUE, IEN, TNU, straw yield, and grain yield. Therefore, varying water regimes at FC, together with proper N level application up to 120 kg ha^{-1}, can be used as an effective and practical agronomic strategy to get good or high economic yield under water-limited conditions. Apparently, efficiency in rice cultivation can be addressed by providing the necessary and precise inputs of water and nitrogen regimes since the experiment was done in screen house and pot experiments. P42 showed the number of filled grain was not much affected by water deficit, hence showed drought tolerance and produced high yield.

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Application of Geospatial Techniques for Monitoring Gikondo Wetland Management: from Industrial Park to Eco-Tourism Park

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Abstract— *For several years, Gikondo Wetland has been serving as home for industries, warehouses, garages, and was critically degraded by various anthropogenic activities since its establishment as industrial park in 1960s. The objective of this study is to analyse quantitatively and qualitatively the dynamics of Gikondo Wetland degradation and its rehabilitation progress from industrial to eco-tourism Park. Geo spatial techniques (GIS and Remote Sensing) have been used to analyse changes induced by management techniques from 1987 to 2019. Results show that wetland area has reduced from 32.03% (1987) up to 25.70% (2010) indicating its degradation due to the increase of built up areas and bareland over the wetland area. From 2010 to 2019, the area of wetland has increased. This positive change of land cover is indicating a good progress of Gikondo wetland restoration process. Continuing reinforcement of national legal framework is required and the implantation of development programs should be done with minimum tradeoffs in order to achieve the transformation of this former industrial park into an eco-tourism park. Rehabilitation process should consider wetland functions, services, and replacement options for achieving sustainable use and management of wetlands in Rwanda.*

Keywords— Geospatial techniques, Gikondo Wetland, Industrial Park, Historical Dynamics, Eco-tourism Park.

I. INTRODUCTION

In 1950, only 30 % of the world's population was urban. In 2018, the world's population was residing in urban areas reached 55 % and the figure is estimated to be 68 per cent by 2050 (UN, 2019). Cities and towns are continuingly becoming the primary human living space as countries develop. However, different studies highlight that accelerated urbanization is blamed to have negative impacts on urban environment especially on wetland ecosystems. This is due to fact that many world wetlands were taken as wastelands, difficult to use for agriculture or urbanization purposes.

The above perspective has found place in Rwanda wetland management. Rural urban migration, high population growth, and provision of improved urban infrastructures such as roads and industries have contributed to increased urbanization by 26.70%. Moreover, lack of coordination between environment and urban planning sector has contributed to human occupation of wetland ecosystems especially in Kigali. Residential expansion, industrial and commercial activities have contributed to the loss or degradation of wetlands of Kigali city. Uncontrolled engineering activities have contributed much on destruction of wetland flora and fauna. In the same vein, the lack of effective wetland management strategies has resulted in the development of infrastructures such as roads and buildings within wetland area.

The case of Gikondo wetland has drawn the attention on the underperformance of industry and urban planning. This wetland, stretching from Gikondo to Nyabugogo was selected as industrial area since the independence. Therefore, it was greatly affected, and its ability to control siltation, and clean wastewater and buffer flooding was jeopardized[2]. The development of some infrastructure such as factories, warehouses and paved roads has reduced the surface area available for infiltration, and the increased runoff causes erosion on bare soils and siltation of water ways in the lower parts of the wetlands.

It was until 2005 that the government of Rwanda started to establish the clear linkages between development and sustainable wetland. In this regard, the Rwanda government promulgated the Organic Law on Environmental Management and established the agency charged with supervision, follow-up and ensuring of environment mainstreaming in all national and local policies. The policy making has continued to focus on the importance of the Gikondo Wetland. Following the publication Sustainable Development Goals, specifically the SDG 11 on "Make cities inclusive, safe, resilient and sustainable and its inclusion in the National Strategy for Transformation NST1 in its objective 6 on "Sustainably exploit natural resources and protect the environment", The Gikondo Wetland received the policy attention due to its functions and services. This shows that the motive to restore this wetland is enshrined in the above international, national and local

policies. This calls for the need to provide decision making on historical evolution of the functions and services of the Gikondo Wetland to guide future decision making in the restoration and sustainable use of this wetland.

However, there have been few studies on the integration of the Gikondo Wetland restoration in the sustainable urban management of Kigali. For instance, Bizimana & Schilling, (2010) have studied the flood risks and stressed the importance of integrating flooding risks in Kigali Master Plan. Kabanda, (2008)has analysed the level of environmental compliance to organic law in Gikondo wetland. His study demonstrated not only the low level of compliance, high level of violation and lack of capacity to monitor the violation in Gikondo Wetland. Etale,(2011)has studied the risks of cadmium and lead uptake from agriculture products farmed in Gikondo Wetland and demonstrated that high Cadmium and Lead concentration exceeding the EU standard. In the same vein, Sekomo et al., (2011)have analysed pollution level in Nyabugogo Wetland, and showed that pollutant from Gikondo Industrial Park were discharged without treatment in Nyabugogo Wetland. In sum, these studied have demonstrated environmental and health risks posed by inefficient management of the wetland. However, none of them has shown the spatial dynamics of these risks through a spatio-historical perspective. Therefore, this study aims at using geo-spatial technology to unravel historical dynamics of the degradation of Gikondo wetland to guide future decision in the sustainable use of Gikondo Wetland.

II. MATERIAL AND METHODS

2.1 Description of the study area

Gikondo Wetland is located in three districts, Gasabo, Nyarugenge and Kicukiro . Gikondo study area has over 385.39 hectares. The wetland is surrounded by small mountains inhabited on all the sides (fig.1). This wetland has been used as industrial park. However, there has been a plan to relocate the industries and convert the wetland to Gikondo Lake Park for nature based tourism attraction site in Kigali city. The park will feature indigenous plantation and allows passive recreation use [7]. The figure below illustrates some examples of wetland parks highlighted in Kigali City Master Plan.

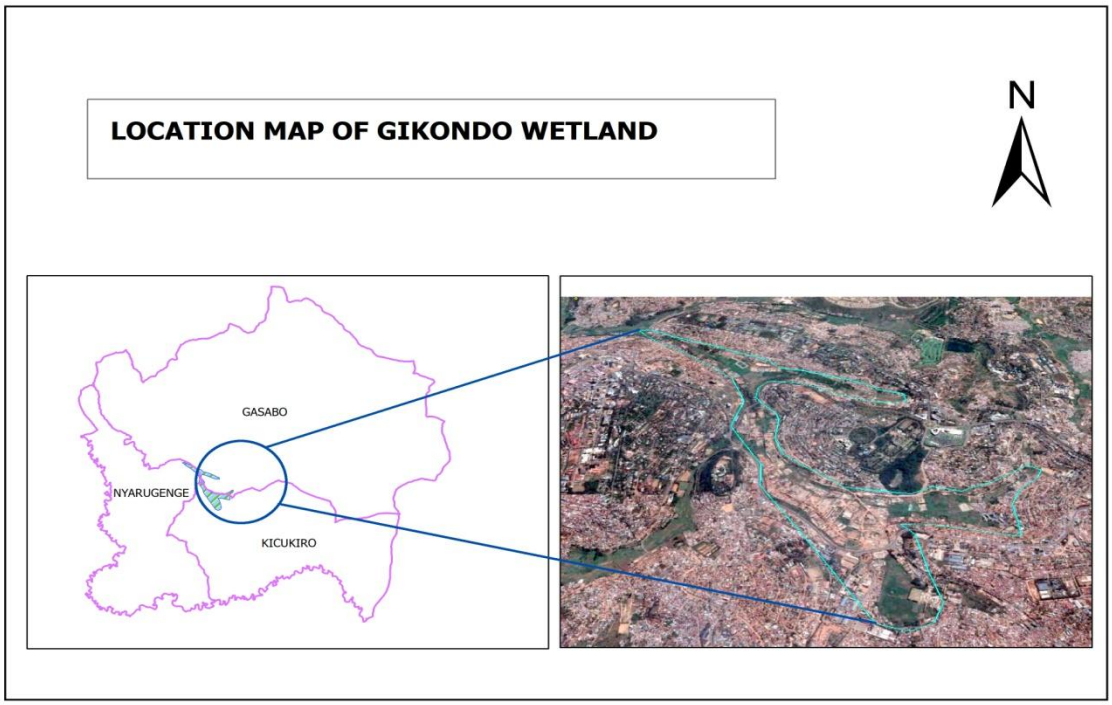

FIGURE1: Location of the study area

2.2 Methods

2.2.1 Data collection

This study has sought to use spatial data spanning long time series (ranging from 1987 to 2019). Therefore, Landsat imagery was found suitable as it provides historical data for almost 40 years and free availability. It also has a much better spectral resolution, which is important for land cover classification. Landsat images were downloaded in separate files from the United State Geological Survey (USGS) through the website which is https://earthexplorer.usgs.gov. To advance to high

level of details, Building Stock and Building Typology of Kigali, Rwanda [8] was collected to produce the building footprint and building archetypes using the Pleiades satellite images produced in 2009 and 2015.

2.2.2 Data analysis

Data analysis was conducted in three steps. Firstly, the image processing was carried out using Texture analysis through Gray level co-occurrence matrix (GLCM) features. This was performed to be integrated in the classification. GLCM-Variance which was identified as best performing texture measures while combined with spectral bands and NDVI for generally improving land cover classification accuracy [9] and particularly isolating formal and slum areas in urban environment. Secondly, the ENVI 5.3.1. software was used for image classification. Before proceeding with the classification, it is important to know the data to use and the number of classes.After getting training samples, pixel-based Support Vector Machine (SVM) classification was done using ENVI 5.3.1. This method is able to avoid over fitting problem and requires no assumption of data type. Although no-parametric, the method is capable of developping efficient decision boundaries and therefore can minimize misclassification [10].And finally, the post classification was done using the new training samples selected by using the Region of Interests (ROIs). In this study, a combination of local knoweledge (socio-economic features) with remotely sensed data was done in order to gain better insights into urban land uses more accurately. It is in this regard that after post-classification refinement, the following overall accuracies and Kappa coefficients were obtained.

TABLE 1
CLASSIFICATION ACCURACIES AND KAPPA COEFFICIENTS

Period	1987	2000	2010	2019
Overall accuracy	81.04%	86.30%	83.70%	85.70%
Kappa Coefficient	0.78%	0.81%	0.79%	0.82%

III. RESULTS AND DISCUSSION

Results show that land cover has been changing for 32 years. The built up area has increase at the expense of the wetland. In 1987, the landscape of Gikondo was dominated by wetland. However, the increased human occupation led to the encroachment at large extent until 2010. This human settlement encroachment on wetlands was driven by the importance of this wetland as source of land for industrial construction and private dwellers. That is why the wetland area has considerably decreased untill 2010. These anthropogenic activities were motivated by the lack of coordination among government insitutions on ecological importance of this urban wetland.

However, a shift was observed in the period between 2010 and 2019.There was an increase in wetland area but it is still bellow its extent in 1987. The wetland area increased by 25.70% from 2010 to 2019. Despite this increase, the wetland area has not recovered to the 1987 extent (32.03%). Bare land has been increasing from 1987 (5.28%) to 2019 (8.82%) with high pick in 2010 (9.66%) (Fig.2 and 3). This indicates that within wetland boundary there is a degraded space requiring more restoring activities.

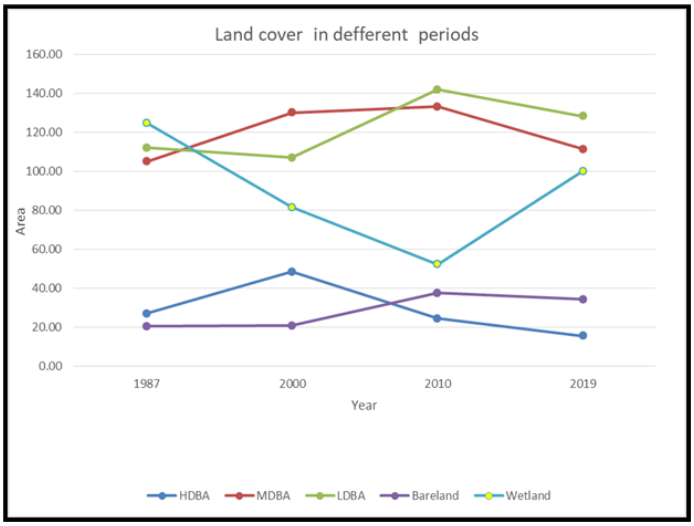

FIGURE 2: Land cover evolution from 1987 to 2019

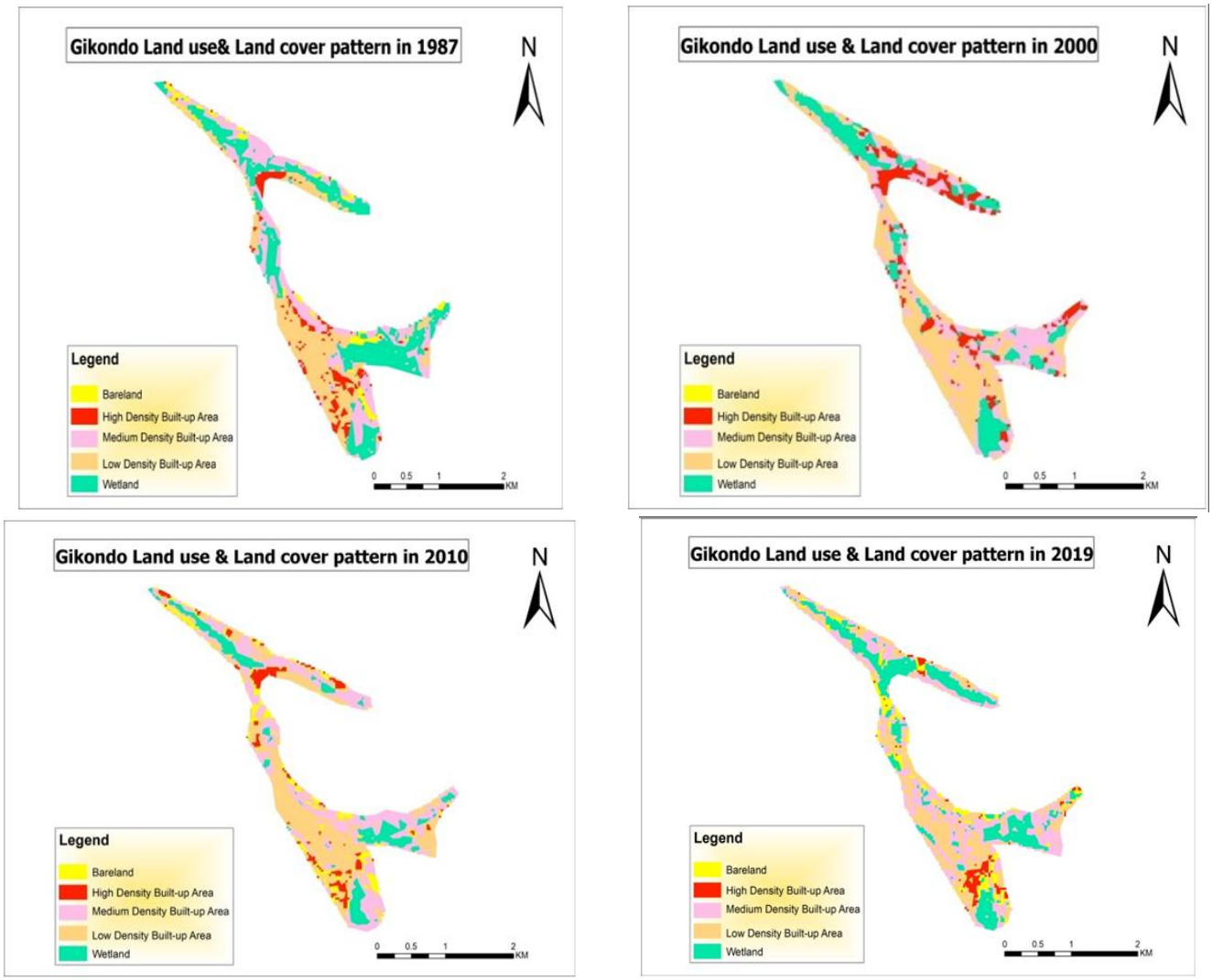

FIGURE 3: Spatial changes and land cover in different periods

In addition, other laws were promulgated and supported and were implemented to conserve the wetland. They include: 1) Law N°10 of 02/05/2012 governing the urban planning and building in Rwanda [12]. This law requires the city of Kigali and districts to develop master plans in which different land uses conforming to environmental regulations are established. 2) The Law N° 43 of16/06/2013 governing Land in Rwanda [13]stipulates that wetlands constitute public land and construction in wetland are prohibited. This law served the ground for the relocation of the industrial park in Gikondo. In addition, it is in the framework of this law that the Prime Minister promulgated the Order N°006/03 of 30/01/2017 drawing up a list of swamps, lands, their characteristics and boundaries and determining modalities of their use, development and management.4) The Law N° 70 of 02/09/2013 governing biodiversity in Rwanda (GoR, 2013) establishes not only endangered ecosystems but also those that needs to be protected due to the national importance[14]. Finally, the Law N° 32/2015 of 11/06/2015 relating to expropriation in the public interest (GoR, 2015) establishes activities of public interests for which expropriation will be undertaken. Through this laws industries owners were compensated with industries facilities in Kigali Special Economic Zone. Referring to this law, the ministry of Trade and Industries issued the instruction n°20/MINICOM/2013 of 20/05/2013 modifying instructions n°15/2012 of 23/04/2012 related to the relocation of factories and other facilities located in the Gikondo industrial park [15]

The implication of the mainstreaming of the Gikondo Wetland in the Kigali City Master Plan has also been revealed by the change in building stock and building typology. The latter shows decrease in buildings between 2009 and 2010. For instance, the number of buildings decreased from 4208 in 2009 to 3455 buildings in 2015. This leads to a decrease of 17.89% in the number of buildings. The building typology "Basic" was predominant with 3358 buildings representing 79.8 % of the total buildings. Most of these buildings are located in the area of informal settlement such Kimicanga, the part surrounding UNILAK. In this year 2015, wetland protection improved as the built-up area decreased from 64.26 ha to 57.01ha. This is

largely due to the relocation of the informal settlement of Kimicanga in 2010. The number of buildings of typology which is "Basic" decreased from 3358 to 2623. This implies a decrease of 21.8%

The restoration of wetland services and replacement options in order to minimize the tradeoffs in wetland functions, services, and replacement options (Table 1). This facilitates its sustainable management and the minimization tradeoffs that usually occur during the implementation of different government policies. The detailed aims to contribute to development of Kigali City as the significant destination for adventure and nature related to tourism. This is why Gikondo Industrial Parks is being converted into Gikondo Lake Park for nature based tourism attraction site in Kigali City. In addition, the rehabilitation of this wetland is considering other functions such as: removal and control of pollutants, flood reduction, groundwater recharge, wildlife habitat, and other services as previous studies have shown higher health risks resulting from heavy metal concentration in soil and water [6].

TABLE 1
GIKONDO WETLAND FUNCTIONS, SERVICES, AND REPLACEMENT OPTIONS

Function	Services	Alternatives
Pollutant removal	Maintain the quality of water; cycle nutrients; retain sediment; filter runoff	To establish water filtration plants where incoming water and sediments are treated before entering in wetland; To develop storm water facilities with water quality criteria around Gikondo wetland
Flood attenuation	Capacity to reduce downstream flood volume; slow flow to reduce peak discharges; protect downstream property; public safety	To adopt storm water treatment practices, dikes and levees construction, and advanced floodplain construction design around and in the wetland
Groundwater recharge and discharge	Maintain base flow conditions in streams	To create artificial lakes within wetland boundaries
Wildlife habitat	Home for aquatic and terrestrial species; support biodiversity; connective wildlife corridors	Wetland restoration, and stocking of new plant and animal species to improve the biodiversity in wetland
Other	Recreation, education, and aesthetics,	Wetland restoration, creation of more urban parks and thematic recreational areas around the Gikondo rehabilitated wetland, and to maintain wetland buffers undisturbed.

Source: Adapted from Wright et al, (2006)

IV. CONCLUSION AND RECOMMENDATIONS

Geospatial technologies based on Geographic Information System and Remote Sensing have the potential to contribute to the understanding of historical and spatial changes in wetland ecosystems services. The use of geo-spatial techniques has shown how the land use change resulted in the degradation of wetland as results of lack of policy integration and coordination in urban planning. This resulted in the increase in built up area at the expense of the wetland area from 1987 to 2009. The same techniques also were able to show that it is possible to monitor the shift in land use policy. They demonstrated that the implementation of a comprehensive legal and institutional framework resulted in the increase in wetland area at the expense of other land use. This means that this shift which is interpreted as the integration of wetland in urban planning policies and related policy coordination has benefit to the resilience of wetland ecosystems in the urban context. Geospatial techniques have demonstrated that changes that are contributing to the recovery of wetland services have been taking place since 2010.

Despite the strength of geospatial techniques, this study has only focus on their application in tracking historical and spatial changes using the land cover/ land use change perspective. The latter has not allowed to track change in water (flooding and drying), and biological and chemical concentration of pollutants. It is imperative that the interpretation in land use/ land cover change be combined with change in moisture and pollution concentration to fully grasp how the restoration in Gikondo Wetland is contributing to the recovery of ecosystems services. There is a need of interdisciplinary study to analyse these changes. This study will not only analyse past change but also future changes resulting from the restoration and recreation use of the Gikondo Wetland.

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Use of Medicinal Plants of Brazilian Caatinga in a Perspective of Solidarity Economy

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Abstract— *The culture of using medicinal plants is a practice that has been present since ancient times and is passed on from generation to generation by indigenous peoples, traditional populations that are made up of farmers, researchers. This work aims to perform a survey of the ways in which medicinal plants are used by students of Youth and Adult Education and their perspectives for a solidarity economy in a Municipal School in the Picuí city, Paraiba, Brazil. This research has a qualitative and quantitative character, which involves the obtaining of descriptive data, obtained in the direct contact of the researcher with the studied situation, emphasizes the process more than the product and is concerned with portraying the perspectives of the participants about the use of medicinal plants, using as main tools the application of questionnaires and a lecture-class. According to the characteristics of the system of production of medicinal plants described in this research, family farming presents favorable conditions for its cultivation. It is, therefore, another alternative in the generation of employment and income through a solidarity economy for this segment so important and representative of Brazil.*

Keywords— Medicinal Plants, Solidary Economy, Family Agriculture.

I. INTRODUCTION

The culture of using medicinal plants is a practice that has been present since ancient times and is passed on from generation to generation by indigenous peoples, traditional populations that are made up of farmers, researchers and so on [1]. According to the World Health Organization medicinal plant is any and all plant which possesses, in one or more organs, substances which may be used for therapeutic purposes or which are precursors of semi-synthetic drugs, which when used for the treatment of both human as of animals, through their pharmacological action are capable of alleviating, curing or preventing physical or mental illnesses [2].

According to Heinrich et al. [3], a plant with a relatively high index can suggest a real effectiveness in the treatment of the disease, because in ethnobotanical studies this index will facilitate the selection of species for pharmacological tests that may prove an efficacy of its active principles. The study of medicinal plants and their relationship with the people over the years is studied by ethnobotany [4]. The term ethnobotany was formally designated in 1895 as the study of plants used by primitive and aboriginal peoples and, by virtue of this initial definition, has long been understood on the basis of this concept.

Brazil has the greatest biological diversity on the planet, becoming a target of greed for scientific communities around the world. The Brazilian cerrado contains more than 6000 vascular plants, many of them used as food and for therapeutic purposes. In the area of medicine, tropical plants offer properties for the production of analgesics, tranquilizers, diuretics, laxatives and antibiotics among others. The global commercialization of secondary products totals an average of 200 million dollars a year [5, 6].

The Caatinga biome occupies an exclusively Brazilian area of 850 thousand km², representing 10% of the Brazilian territory and encompassing the nine states of the Northeast, plus the north of Minas Gerais. Rich in biodiversity, the Caatinga biome houses 591 bird species, 177 reptiles, 79 amphibian species, 241 fish species, 221 bees and 178 mammal species. The flora of the Caatinga has peculiar characteristics that differentiate it from the variety of exuberant colors of the humid tropical forests, the physiognomies visualized by many transcends the idea of biome of very low diversity starting from the assumption of the aspects as its vegetation presents / displays aspects of an ugly one and dry. The vegetation that characterizes the Caatinga is composed mainly by plants like umbuzeiro (*Spondia tuberosa*), the belly (*Chorizia ventricosa*), the kidney beans (*Capparis yco*), the barauna (*Schnopsis brasiliensis*), the favelone (*Cnidosculus phyllacanthus*), the iron-dick (*Caesalpinia ferrea*), juazeiro (*Ziziphus joazeiro*), the camaratuba (*Cratylia mollis*), catingueira (*Caesalpinia pyramidalis*), canafistula

(*Peltophorum dubium)*, amburan (*Commiphora leptophloeos*) and the pinhão-bravo (*Jatropha molíssima*) and the *cactaceae* that occur most frequently in the region are the palms *Opuntias*, mandacaru (*Cereus jamacaru*), xique-xique (Pilocereus *gounellei*), crown of monks (*Melocactus Zehntneri*) [7-10].

In relation to the knowledge how medicinal plants are used for medicinal purposes are the most diverse in the Caatinga areas. The knowledge practiced in the daily life in rural communities about medicinal plants are intrinsically related to the natural resources available in the environment in which they are inserted as well as in the reproduction of customs and practices that are passed on over the years from generation to generation. According to Albuquerque [11], rural communities are responsible for maintaining a large number of native and exotic plants to meet the most varied needs, especially food and medical needs, so empirical knowledge of these populations can provide important information for research and thus, many scientific discoveries can and will happen.

According to Albuquerque [11], medicinal plants are plant species that have several types of active principles, which can act in the organs of humans and animals, combating various diseases, eliminating causative agents such as worms, fungi and bacteria. Strong preventive action against many other health problems. In a number of forums, claims and scientific research have identified the need for a directive that will provide guidelines to be followed by all in order to promote the conscious and sustainable use of plants used to treat pathologies [12].

A large part of the world's population relies on traditional approaches to day-to-day health care, and about 80% of the population, especially in developing countries, relies on medicinal plant derivatives for their health care are worked by groups of people who share and exercise the principles and actions of the Solidarity Economy [13].

A characteristic aspect of this type of situation is the combination between the valorization of the local space and the search for answers to specific problems, inserting the solidarity in the collective elaboration of the economic activities involved in the planting. This concern with the local community can lead to two other key characteristics of experience: a combination of economic activities with other social, educational, and political activities; the concern with the appreciation of the sense of work and the commitment to the community. The opening of Solidarity Economy enterprises or ventures is seen as an important basis of competitiveness and as a way of creating new jobs.

The Solidarity Economy is an important tool that goes against the consequences caused by social exclusion for presenting as an alternative income generation to an audience that on several occasions feel the margins in society for being part of a group of people who experience a series of needs arising from social inequalities [14]. The Solidarity Economy is practiced by millions of workers and workers of all extracts, including the most excluded and vulnerable population, organized collectively managing their own work, fighting for their emancipation in thousands of economic solidary enterprises and thus guaranteeing the reproduction of popular life. They are initiatives of collective productive projects, popular cooperatives, collecting and recycling cooperatives of recyclable materials, production, commercialization and consumption networks, financial institutions focused on joint ventures, self-managed companies, family farming cooperatives and Agroecology, service cooperatives, among others, that stimulate local economies, guarantee decent work and income to the families involved, and promote environmental preservation.

Most communities of family farmers have low levels of education, and therefore attend Youth and Adult Education. The new identity with which the Education of Young and Adults presents itself is very heterogeneous, fragmented and complex; Their brand seems to be in the diffusion that people should seek, in education, skills and abilities that endow them with the possibility of employability. This conception is guided by the individualistic horizon and submission, and is expressed in the idea that being educated is to be employable [5]. Farmers attending youth and adult education have various perspectives on the future, they believe that this education can be determinant in school formation as well as in socialization thus promoting improvements in the quality of life, and this can be done through practices of Solidary Economy.

Several daily activities can be incorporated into the Solidarity Economy as a source of income for communities of needy family farmers. Practical knowledge of traditional communities about medicinal plants is closely related to the available natural resources and their cultural heritage, being a sociobiocultural and economic reproduction of their ancestors, which has been transmitted to the present generations. With regard to cultural traits, there is evidence that certain cultures tend to stimulate values that contribute to a greater propensity to entrepreneurship, in that they value initiative and autonomy.

This study aims to provide information to the residents of the city of Picuí, Paraiba, on the benefits of the use of medicinal plants as well as their implications for human health, as well as their viability as a presupposition for the practice of the Solidarity Economy. Therefore, it intends to contribute knowledge that leads to the proper use of plants and, consequently, to the wellbeing of individuals. The poorest communities, and even those with little study, are responsible for maintaining knowledge of a large range of native and exotic plants, to meet the most varied needs, especially food and medical needs, thus empirical knowledge of these populations, can provide important information for research and thus, many scientific discoveries. In this way, the general objective of this work is to perform a survey of the ways in which medicinal plants of the Caatinga are used by family farmers of young and adult education and their perspectives for a Solidary Economy.

II. MATERIALS AND METHODS

2.1 Public Studying

The study site was the municipality of Picuí that is located in the mesorregion of Borborema, in the microregion of the eastern semiarid of Paraiba, Brazil. The climate is semiarid (desert), hot and dry, with average temperature of 26ºC. The native vegetation predominant in the municipality is the Caatinga, of the arboreal shrub type. The study was conducted with 220 farm students attending the Youth and Adult Education in a Municipal School.

2.2 Research Characterization

This research has a qualitative and quantitative character, which involves the obtaining of descriptive data, obtained in the direct contact of the researcher with the studied situation, emphasizing the process more than the product and is concerned with portraying the perspectives of the participants about the use of medicinal plants of the Caatinga.

2.3 Procedure

The research activities began with a classroom in the form of a talk wheel; we use media resources where we approach concepts about youth and adult education. A semi-structured questionnaire was used to know the socioeconomic profile of the farmer's students and also served as the basis for a second part of the research where the participants' perspectives on Youth and Adult Education, medicinal plants and the Solidarity Economy were investigated through a Lecture-class. The questionnaire briefly explains the intentions of the research in which no participant is identified. To fulfill the research objectives, the questionnaire was divided into two parts. The first part includes socioeconomic data such as sex, age, schooling, family income and number of people per residence. The second part investigates the use of medicinal plants of the Caatinga, the expectations regarding the return to the school environment and the perspectives of the use of medicinal plants in the Solidarity Economy.

A brief quantitative analysis of students' perspectives and a qualitative evaluation of the relationship between knowledge about medicinal plants from the Solidarity Economy perspective were carried out. For the organization and processing of data we use elements inspired by content analysis to identify what is being said about a given topic. The answers of the interviewees, when they appear, will be transcribed in italics and in quotation marks for a better differentiation in relation to the text of the discussion.

III. RESULTS AND DISCUSSIONS

The study was carried out with 220 family farmers' students attending the Municipal School in the form of Education of Young and Adults, sixth and seventh year. Approximately 60% of the family farmers of the Education of Youths and Adults, interviewed are male. The data obtained in the aforementioned study suggest that women are more difficult to return to the school environment, but when they return to the classroom, drop-out is lower. Interviewees attending school have varying ages, ranging from 15 to 59 years of age: 36% up to 20 years; 18% between 20-30 years; 23% between 30-40 years; 5% between 40-50 years and 18% between 50-60 years. These data show that the profile of the pupil in this school is made up of young and middle-aged adults, raising the hypothesis that the search for education is present in the most diverse age groups.

Regarding the time that the participants of this study were distant from the classroom, there was enormous variation between the answers. Among those interviewed, approximately 50% are adolescents who, for reasons of work in agriculture, were transferred from other shifts. The time they spent outside of school ranged from one to three years. They do not consider that they stopped studying, say that because of various difficulties they have not yet been able to complete their studies and see in

teaching young people and adults a possibility to move forward to achieve better opportunities in life. Given the results obtained, it is observed that many people are returning to the school environment due to the consequences generated by the knowledge gap and others because they did not attend school when children and adolescents due to residing in rural areas at the time and help parents in the Agriculture being, at that time, unable to study because of difficulties in access to education.

When asked why they wanted to go back to school, the reasons were varied. The objectives are distributed on a large scale that covers the most diverse searches of knowledge, which go from learning to perform calculation of simple sum to the pleasure of writing a letter to a friend. They are desires and dreams that can be achieved with a learning built in the school environment and in the coexistence with other students. When questioned about the importance of youth and adult education, 70% of respondents broadly answered that it is important, because they work during the day and study at night, thus being a way to progress in studies. Some lines are quoted below:

"The right and opportunity to make up for lost time and qualify for the job market."

"Learning is life-enhancing and having the day to hunt a job."

It was sought to know the importance of Youth and Adult Education in the lives of the agricultural students. In the interviewees' speeches, it was observed that the search for systematized knowledge and the return to the school environment is of the utmost importance for workers citizens who need to learn new knowledge for the development of their abilities, to seek a job and for the well-being of the social individual. According to data related to the size of the families of the students interviewed in this study, it is observed that approximately 65% belong to families composed of more than four members, with houses with up to seven people found. The data show that families are numerous and survive on low pay.

Inquiring whether the research participants use medicinal plants, it was found that 85% of the interviewees use the plants for the purpose of curing the diseases and only 15% said they do not use the plants for that purpose. However, some of these participants contradict themselves when they report using a specific plant to cure fever and flu. The use of medicinal plants is a customary practice. It was questioned if the medicinal plants offer some benefit and among the participants it was almost unanimous that the plants always cure the diseases. The students highlight the healing power of various pathologies, mainly of problems related to the respiratory system, digestive system and in the treatment of inflammatory processes. There is mention, several times, of the low cost and benefit ratio caused by medicinal plants. Among the methods of preparation and use of medicinal plants, we sought to know which are most frequently used: Tea, plaster, licker, mixtures of plants with solvent, cooking and others.

The plants are used for phytotherapic purposes in the forms of lickers, bottles and cooking in most cases to treat flu, stomach problems and inflammatory processes. Most of the interviewees (85%) use medicinal plants in the form of teas. Tea is a drink that can be prepared through maceration, infusion and decoction. The most used method of preparation is to take the part of the plant along with water to the fire until it reaches the boil. In this process it is common to use flowers, leaves, stems and roots [15].

If on the one hand these new ways of life assimilate the essence of the urban forms of coexistence, on the other, they retain old practices from their rural origins, which continue to manifest themselves in vocabulary, cooking, arts, sociability, etc. In these communities, high levels of unemployment and underemployment are observed, as well as serious shortages of basic services [16]. Vulnerability to food, nutritional and health insecurity is a recurring characteristic among families, due to the combination of two interdependent factors: the difficulty of access to food, due to low levels of family income, and the tendency towards homogenization of dietary habits, which prevails the low nutritional quality of the diets, usually lacking vitamins and minerals. The interviewees were asked which plants were most used in phytotherapic form and what the purpose of use was. The above-mentioned plants and herbs can be seen in Table 1.

Regarding the way of acquisition of medicinal plants, it is noticed that the majority of the interviewed grows in their backyards or acquires with neighbors and relatives for free. There is an interchange of plants and related knowledge, this is generally passed down from generation to generation and constitutes an important traditional knowledge that must be preserved.

TABLE 1
NAMES OF PLANT FAMILIES VERSUS INDICATIONS AND NUMBER OF CITATIONS.

Plant Family	Scientific name	Popular name	Indicated use	Number of quotes
Amaranthaceae	*Chenopodium ambrosioides.*	Mastruz	Flu and Worm	30
Anacardiceae	*Myracrodruon urundeuva*	Aroeira	Cured bad flu	40
	Anacardium occidentale	Cashew	Infections	30
Asteraceae	*Achyrocline satureioides*	Marcela	Intestine	20
Caprifoliáceas	*Sabucus ebulis L.*	Elderberry	Fever	70
Euphorbiaceae	*Cnidoscolus phyllacanthus*	Favelone	Anti-inflammatory	20
Fabaceae	*Amburana cearensis*	Imburama	Inflamation	10
	Dipteryx odorata	Cumaru	Flu and Fever	10
	Bauhinia forficata	Mororó	Diabetes	20
Lamiaceae	*Rosmarinus offcinallia*	Rosemary	Heart, Soothing	20
	Mentha x villosa	Small Flower Mint	Flu	30
	Ocimum basiliam	Basil	Earache and Cholesterol	20
	Melissa officinali	Bee balm	Intestine	110
	Mentha spicata	Broad Leaf Mint	Infections and Influenza	40
Liliaceae	*Aloe vera*	Slug	Worms	50
Monimiaceae	*Peumus boldus*	Boldo	Intestine	110
Mytaceae	*Eucalyptus globulus*	Eucalyptus	Flu and Fever	10
Poaceae	*Cymbopogon citratus*	Holy grass	Soothing and Intestine	20
Rubiceae	*Moringa citrifolia*	Noni	Inflamation	10
Rutaceae	*Citrus sinensis*	Orange	Soothing	10
	Ruta graviolens	Rue	Heart	30
Sapotáceae	*Sideroxylon obtusifolium*	Quixabeira	Anti-inflammatory	20

One of the principles of the Solidarity Economy is the collective appropriation of the means of production by the members of collective decisions and deliberations on the directions of production, the use of surpluses and also on collective responsibility for the eventual losses of the economy organization Bauhardt [14]. A solidarity practice occurs in the relations of coexistence between the students farmers. This became clear at the time the questionnaires were being applied in the classroom, as well as when respondents stated that they purchased the plants at family sites with almost no financial cost whatsoever. There is a Solidarity Economy established in actions of good neighborhood, using and passing on knowledge about the use of medicinal plants. In the definition of Solidary Economy, the answers were the most diverse: two participants did not respond, one said they did not understand and the others exposed their concepts even in a practical way:

"It is a work that acts in groups and one helps the other and divides the profits in half"

"Sharing with the other helps next."

"Work groups without anyone taking advantage of the other in profits."

"The economy that benefits the people in my house."

Analyzing qualitatively the answers of the questionnaires, it is possible to verify that the collaborators of this study know, understand and practice Solidary Economy. In their statements they emphasize that it is the correct partition [of goods] without using illicit means with the companion. Another participant recognizes that in their family they practice solidarity

economy, because their parent makes wooden toys and members of the whole family participate in the process, either assisting in the finalization of the products or performing sales services.

Some strategies have been considered as priorities to support and intermediate the adaptation of family agriculture to the new market requirements, including in the Solidarity Economy. According to Suess-Reyes and Fuetsch [17], values-oriented markets such as ethics, tradition, natural and ecological production, and social justice have emerged and have shown significant growth. The cultivation of differentiated products is a good example of this movement. Meeting new requirements in terms of quality and respecting the environment, these alternatives reveal great opportunities for the use of production systems suitable for small properties.

In this context, the production of medicinal plants also forms part of an interesting solidarity economy alternative for family producers [18]. From these plants, active principles are extracted for the manufacture of medicines used for the treatment and cure of diseases (herbal medicine). Its sustained production, both cultivated and exploited (extractivism), sees great market potential, whether for artisanal or industrial use, or for the internal or external market.

IV. CONCLUSION

It was verified that the interviewed farmers know a great amount of native and exotic plants, belonging to several botanical families, and informally practice a type of Solidary Economy. The planting and cultivation of medicinal plants in the Picuí city, by young and adult educators, have important interfaces with several other aspects of the urban ecosystem that go beyond the production of herbal products. One of the fundamental dimensions is the cultural rescue, of relation and care with the environment and with the plants, besides propitiating new sociabilities. The fact is that the recovery of ties of sociability and the elevation of self-esteem provided by urban culture dynamics contribute directly to the search for collective and individual strategies to promote higher levels of food, nutritional and health security.

According to the characteristics of the system of production of medicinal plants described in this research, family farming presents favorable conditions for its cultivation. It is, therefore, another alternative in the generation of employment and income through a Solidarity Economy for this segment so important and representative of Brazil.

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Agrometeorological Indicators based on Satellite Imagery in Western Bahia, Brazil

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Abstract— *The western region of Bahia stands out for its large-scale agricultural activity, which uses advanced technology and produces high yields of soybeans, corn and cotton, making it the largest grain producer in Northeast Brazil. The aim of this study is to apply the SAFER algorithm to biophysical indicators, in order to analyze the dynamics of natural vegetation and irrigated crops throughout the crop cycle. The model requires data from meteorological stations and satellite images for its application. Sixty-nine MODIS satellite images with a 250-m spatial resolution and a 16-day temporal resolution taken from 2016 to 2018 were used. The method was effective as a tool to monitor agricultural crops, and to distinguish the phases and vigor of the crops according to the spectral characteristics of their surface. The results of this study may assist in the monitoring of crops and in decision making, and may contribute to the rational use of water resources for irrigation and management of rainfed crops.*

Keywords— biomass, evapotranspiration, irrigated crop, SAFER, water production.

I. INTRODUCTION

Western Bahia stands out for its large-scale agricultural activity, which employs advanced technology and produces high yields of soybean, corn, and cotton. Geographical features, soil correction, and public policies have transformed the region's agribusiness, making it one of the most productive in the country, and increasing its relevance for agricultural industry and for exportation, making it the largest grain cluster in the Northeast region of Brazil. Soybean is the region's main crop, and occupies 69% of its agricultural areas. Although crops such as corn and cotton supplement the local productive matrix, soybeans drive the region's economy: 50% of fresh soybeans are sold to industries in the region, and 47% of the production is exported to countries like China (66%), Japan (11%) and the Netherlands (8%) (AIBA, 2016).

Western Bahia has well-defined seasons, flat topography and rainfall indices that contribute to the definition of territory limits, as well as an extensive watershed with perennial rivers over the Urucuia aquifer, which enhances the region's potential for irrigated crops. With a well-defined rainy season, this stretch of large extensions allowed the development of various agricultural activities. Rainfall indexes up to 1,800 mm and other favorable climate and soil conditions contribute to the success of the region's agribusiness.

The scarcity trend in water resources, a counterpoint to the increasing demand for them, has caused serious conflicts over water use. In recent years, the supervision of the Brazilian National Water Agency (ANA) has been more rigorous, and new plantations in irrigated areas have been interrupted due to water scarcity.

The major benefits of irrigated agriculture practices should be opposite to the huge consumption of water demanded by irrigation systems, which consume about 70% of the waters derived from rivers, lakes and aquifers, and require effective management to prevent environmental impacts and water-use conflicts. These conflicts are aggravated especially in years of severe drought like 2014, when water scarcity impacted human use, energy generation, agriculture, navigation and water transport. In Brazil, the situation becomes more complex due to the strong dependence on water resources for the generation of electricity, and the spatial distribution of irrigated areas clearly shows a concentration trend in regions with strong risk of conflict over water use for energy generation and human consumption.

In the last years, in Western Bahia, irrigated crops have quickly replaced natural vegetation. This land-use change highlights the importance of developing tools to quantify large-scale water productivity parameters, enabling dynamic analyses of mixed agroecosystems (Teixeira et al., 2015).

Considering the effects of land-use changes on irrigation perimeters, quantifying biophysical parameters is important for the development and application of tools to evaluate the dynamics of agricultural systems in irrigated areas at Western Bahia, such as in the municipalities of Riachão das Neves and Barreiras.

Evapotranspiration estimation methods generally enable obtaining data on a local scale. However, regions featuring heterogeneous surfaces with different types of soil and vegetation show quite different evaporation rates, which cannot be perceived in traditional estimation methods. Remote sensing enables estimating evapotranspiration over large areas, as a function of the biophysical characteristics detected in each pixel. Another major advantage of the use of satellite imagery to estimate evapotranspiration on a regional scale is that the amount of water consumed in the evapotranspiration process may be detected without the need for quantifying other hydrological parameters, such as soil moisture.

Remote sensing using satellites is an efficient tool for estimating water parameters, and provides spatial information, location, and status on different agroecosystems (Teixeira et al., 2010).

Remote sensing techniques make it possible to obtain surface information without making direct measurements. Instead, they are obtained by capturing the converted energy as digital information. Thus, information on crops obtained from satellite images may be coupled to data obtained by meteorological stations, and used for estimating parameters, such as evapotranspiration and biomass, on a large scale. To obtain biophysical parameters, the agrometeorological-spectral model SAFER (Simple Algorithm for Retrieving Evapotranspiration) was applied to MODIS (Moderate Resolution Imaging Spectroradiometer) satellite images (Teixeira et al., 2013).

The SAFER algorithm was developed and validated using data from field experiments and Landsat images depicting natural vegetation and irrigated crops under Brazilian semi-arid conditions.

Monitoring actual evapotranspiration using remote sensing on irrigated crops is an important tool for applications such as agricultural management, water resources monitoring, analysis of water productivity, biomass estimates and agricultural production (Morris et al., 2013).

The model proposed for estimating biomass production (BIO) and the development of plant canopies based on global solar radiation (RG) has acceptable accuracy, and may be used remotely, with any satellite imagery, for different ecosystems (Bastiaanssen, 2003). Although several studies have already been conducted on large scales, research on the use of models for the combination of evapotranspiration (ET) and BIO are still needed, especially for applications on different surfaces under conditions of water scarcity and rational use of water resources.

The purpose of this study was to apply SAFER along with satellite images and meteorological data, made available by INMET (Brazilian National Institute of Meteorology), to quantify evapotranspiration and biomass on a large scale at irrigated areas in Western Bahia, to analyze the dynamics of natural vegetation and irrigated crops throughout the crop cycle.

II. MATERIAL AND METHODS

The study area comprises part of the municipalities of Barreiras (12° 8' 54" S, 44° 59' 33" W, 454-m altitude) and Riachão das Neves (11° 44' 49" S, 44° 54' 23" W, 501-m altitude), in Western Bahia (Fig.1). According to the Koeppen classification, the study area's climate is Aw, typical for savannahs, and features dry winters, average air temperature above 18°C in the coldest month, and rainfall rates of 1,800 mm.

The analysis period ranged from 2016 to 2018, and used meteorological data – air temperature, relative humidity, wind and solar radiation – from INMET (Brazilian National Institute of Meteorology) stations, and 69 processed MODIS (Moderate Resolution Imaging Spectroradiometer) data – product MOD13Q1, tiles H13V10, reflectance bands 1 ($\alpha 1$) and 2 ($\alpha 2$), with a spatial resolution of 250 m and a temporal resolution of 16 days –. The SAFER (Simple Algorithm for Retrieving Evapotranspiration) model, which requires agrometeorological data and satellite images, was used to obtain evapotranspiration and biomass rates (Teixeira, 2012).

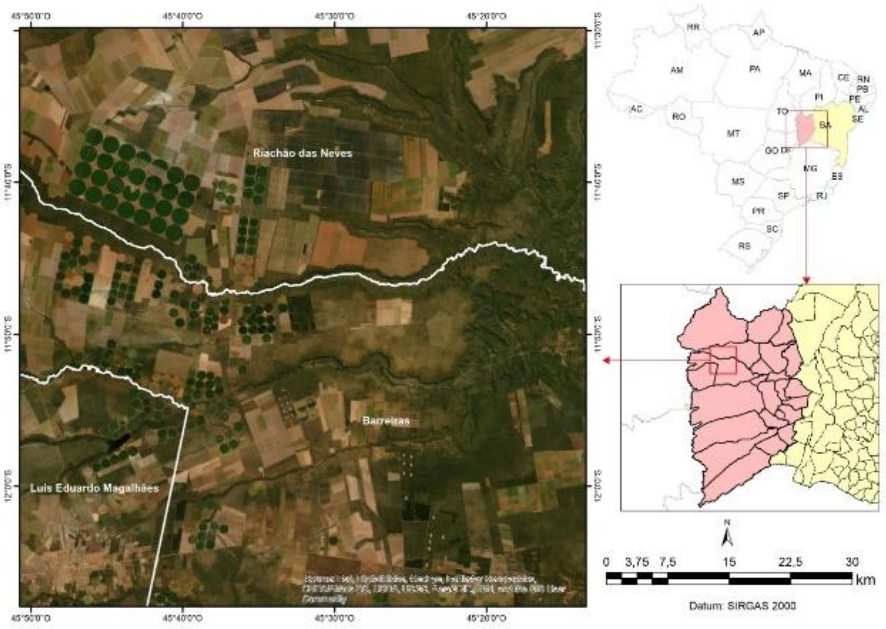

FIGURE 1: Location of the study area, area with central pivots, agricultural areas, and natural vegetation in Western Bahia, Brazil.

Daily weather data on global solar radiation (Rg), air temperature (Ta) and reference evapotranspiration (ET0) were used, and averages were calculated for 16 days, to correspond to the temporal resolution of the MODIS images, for the purpose of obtaining evapotranspiration (ET) and biomass (BIO) parameters on a large scale. The parameters calculated using remote sensing for input in the models were surface albedo (α0), surface temperature (To) and NDVI. ET was obtained by applying the SAFER algorithm (Teixeira, 2012). The Python programming language was used to process the model.

III. RESULTS AND DISCUSSION

The temporal variability of the meteorological data provided by INMET from 2016 to 2018 (Fig. 2), for 16-day periods (which coincide with the temporal scale of the MODIS images used). A period of low rainfall, and high air evaporative demand due to high solar radiation values was observed. The highest solar radiation values occurred in October, and reached 25 MJ, causing high rates of ET0 for the period of 16 days. Low rainfall rates occurred in few days and were concentrated along the year, interspersed with long periods of drought and high temperature, which are characteristic of the El Niño event (Silva et al., 2009). These weather conditions have favored drought occurrence, for the longer periods without presence of clouds and with high atmospheric demand and high values of solar radiation.

The effects of El Niño's latest most active period (ENOS) of 2016/2017 (until the beginning of 2018) on the vegetation in Western Bahia was verified. Meteorological data indicate an intense incidence of solar radiation (Rg) and decreased rainfall (P). NDVI and BIO were of 0.26-0.50 and 20-40 kg ha-1 day-1, respectively, over the studied period in areas occupied by central pivots. The lack of rain occurred when most areas were in the grain filling period, thus influencing their agricultural productivity. In January 2016, intense rains were registered in Western Bahia, but throughout the year only about 800 mm of rainfall were registered, which damaged the region's agricultural production, since it is directly dependent on rainfall.

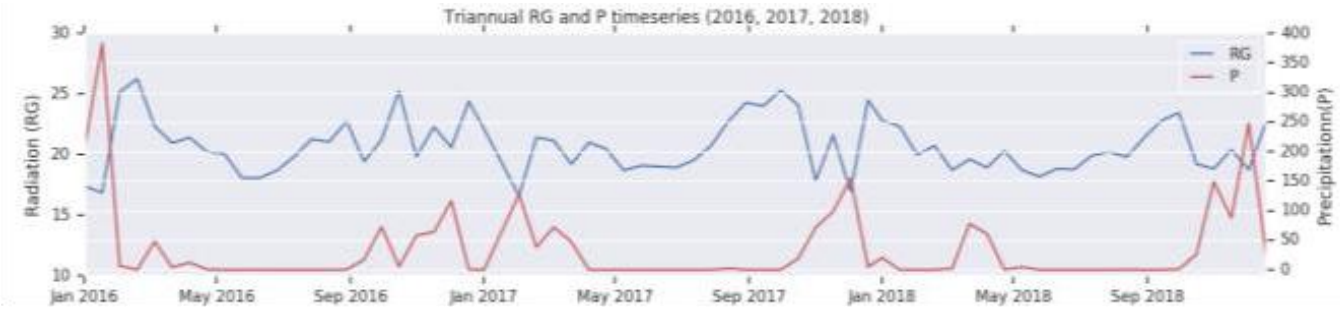

FIGURE 2: Rainfall (precipitation) – P (mm) – and global average solar radiation – Rg (W.m-2) –, from 2016 to 2018 in Western Bahia, Brazil, in 16-day intervals.

The spatial distribution for NDVI, ET and BIO over two distinct periods (DOY – day of the year – 049 and 321) for the years 2016, 2017 and 2018, and cover agricultural area (pivots and plots) and natural vegetation in Western Bahia (Fig. 3 and Fig. 4). NDVI is an indicator for the quantity and condition of green vegetation, therefore its value shows crop vigor. NDVI values reached close to 0.9 at the pivot areas, thus enabling an analysis of the crops' dynamics over time. In 2016, the vegetation showed lower greenness than in 2017 and 2018.

ET analysis in the period between February 2 to 18 (DOY 049), from 2016 to 2018, showed differences between the plants' response to irrigation. Pixels of higher values depict irrigated areas, which reached ET values higher than 5 $mm.d^{-1}$. Biomass showed higher values in 2017 and 2018.

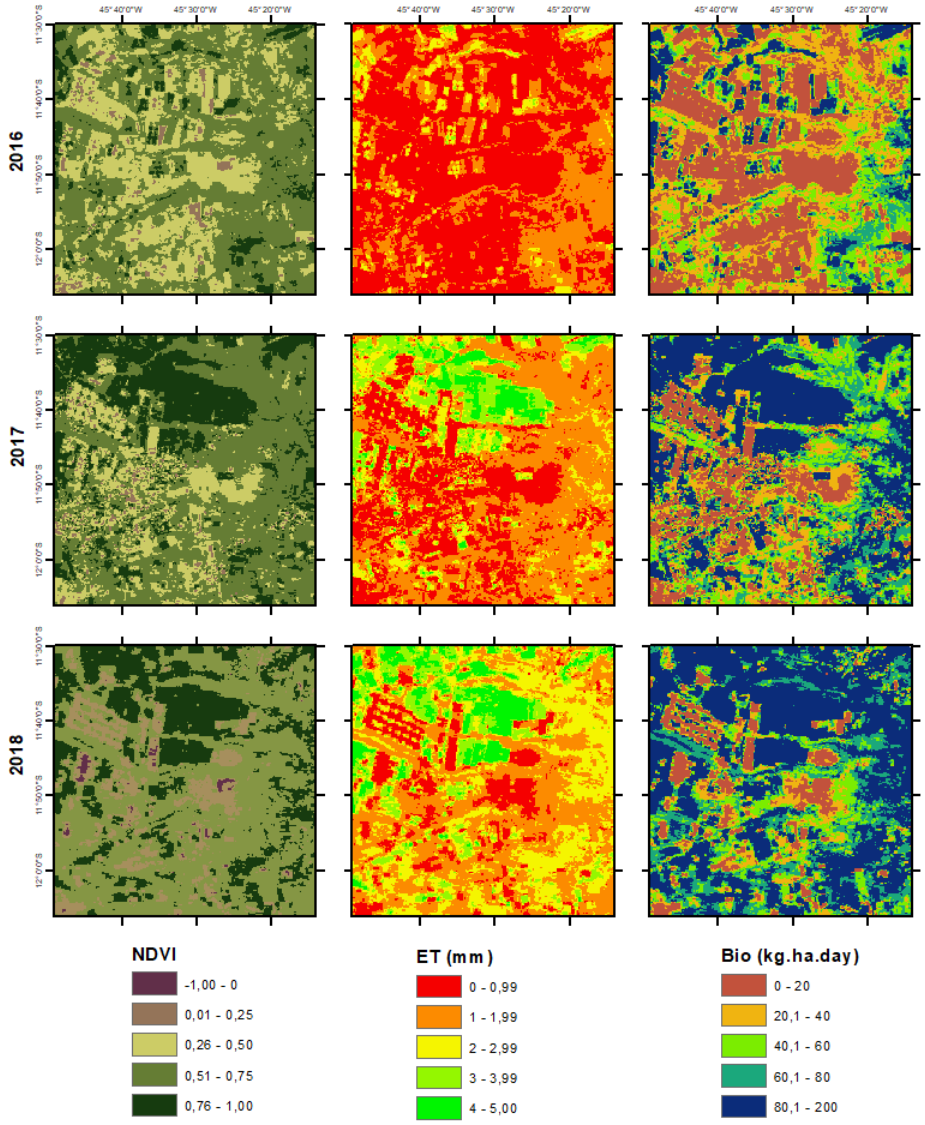

FIGURE 3: Spatial distribution of NDVI, daily average evapotranspiration (mm) (ET) and biomass (BIO), on DOY 049, in the years 2016, 2017 and 2018, in Western Bahia

In November (DOY 321) (Fig. 4), due to the occurrence of rainfall, the natural vegetation's response was similar to that of irrigated areas, and there was a reduction in contrast between the analyzed surfaces. Evapotranspiration rates increased, due to the high evaporative demand. In areas without irrigation, ET was lower and showed less variation, due to the conversion of the energy available for heating the air in the driest periods of the year. During the dry season, the natural vegetation converts part of the energy available to sensible heat (H), while irrigated crops show high ET values (Teixeira et al., 2008).

These analyses agree with the highest water demand of crops in the flowering and grain development period. Many applications of MODIS satellite images combined with meteorological data were used to obtain BIO. At the Submédio São Francisco river basin, Brazil, BIO estimates were made using Landsat to obtain large-scale water productivity data (Teixeira, 2009).

Dependence between BIO and water conditions (Figures 3 and 4) for the year 2016 was observed: high solar radiation and low rainfall caused contrast between natural vegetation and irrigated crops. The BIO daily averages in irrigated areas were below 120 kg ha-1.d-1. BIO values for both ecosystems are sensitive to the spatial distribution of precipitation and soil moisture (Claverie et al., 2012). In the 2017 and 2018 harvests, biomass reached values above 200 kg ha-1.d^{-1}. Data from the Institute of Agricultural Economics show that Bahia had a 45.5% increase in soybean productivity during this period. Nebraska features the largest irrigated cultivated area in the United States (3,357,903 ha in 2013; USDA NASS). In a study carried out using empirical modeling, seeking to understand how irrigated crops respond to various climatic scenarios, in order to anticipate changes in food security and in the state's agricultural economy, Lu et al (2017) showed that irrigated crops are less sensitive to climate change than rainfed crops.

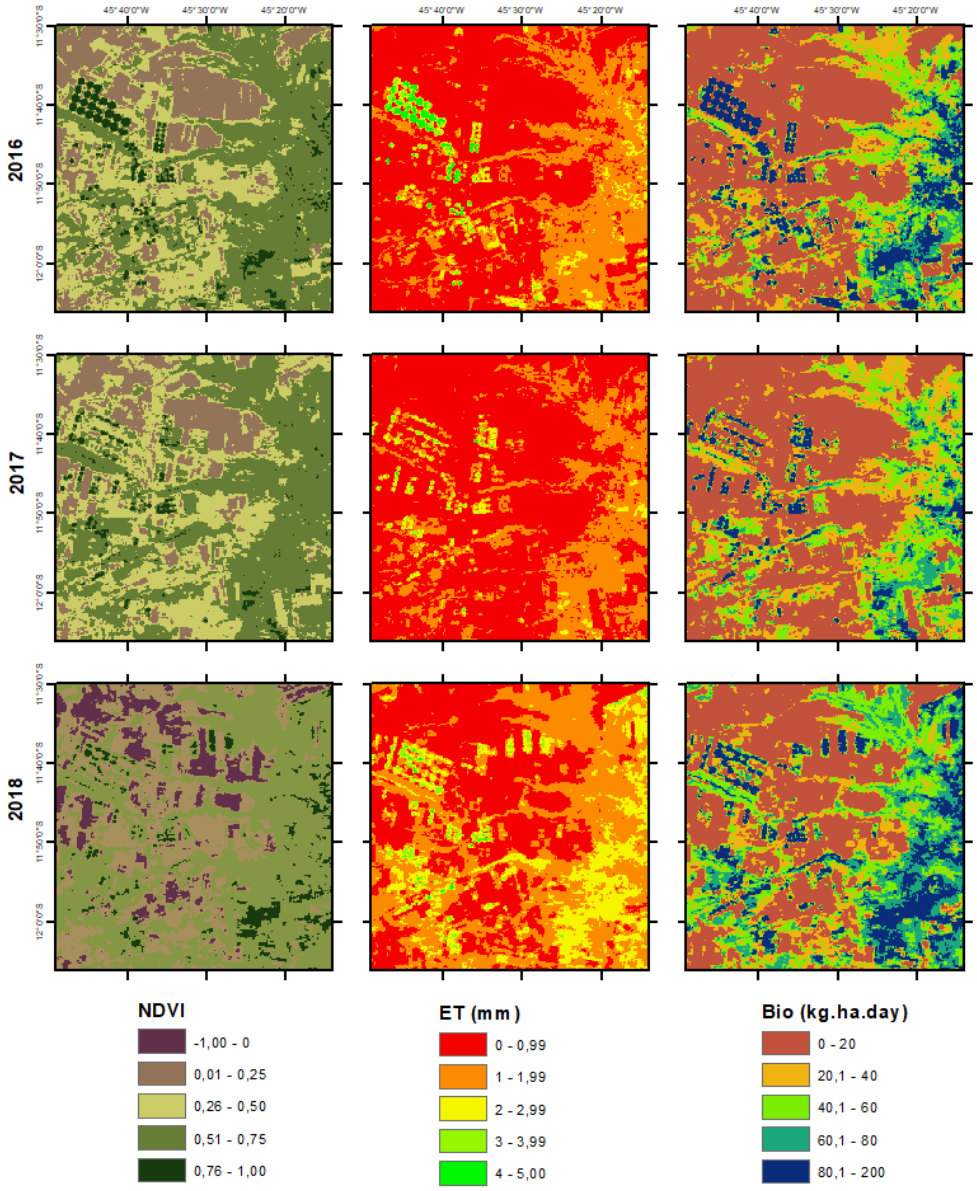

FIGURE 4: Spatial distribution of NDVI, daily average evapotranspiration (mm) (ET) and biomass (BIO), on DOY 321, in the years 2016, 2017 and 2018, in Western Bahia.

Meteorological data used with MODIS satellite images enabled monitoring and evaluating biophysical indicators in agricultural areas, at 16-day intervals. In Western Bahia, there was a significant variation in ET and BIO values throughout the year, in a period of water scarcity. These results enable monitoring the conditions of vegetation vigor throughout the cycle, thus assisting farmers in decision making. This preliminary study is part of a research project that aims to update spectral agrometeorological information for Western Bahia using indicators available every 16 days, thus allowing farmers to monitor crop development and assisting them in decision making regarding agricultural management practices.

IV. CONCLUSION

The results obtained indicate that the method used is an effective tool for monitoring agricultural crops using satellite images and data from meteorological stations. The SAFER model proved effective for estimating biophysical parameters, like evapotranspiration and biomass production, in irrigated areas in Western Bahia, and distinguished crop phases and vigor according to the spectral characteristics observed in the application of the spectral agrometeorological model. These results may assist in the monitoring of crops, in decision making regarding crop vigor (soybean, corn, cotton and others), and may contribute to the rational use of water resources for irrigation purposes and for the management of rainfed crops.

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The Impact of Land Degradation on Agricultural Productivity in Nyabihu District-Rwanda, A Case Study of Rugera Sector

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Abstract— *This study looked at the impact of land degradation on agricultural productivity in Nyabihu district. Specific objectives were to assess the factors influencing land degradation in Nyabihu district, Rugera sector, the vulnerability level of land degradation and propose suitable land management conservation strategies.*

Geographical Information system (GIS) and Remote sensing data were used for the assessment of factors influencing land degradation, where Land cover (classified) maps were produced based on data extracted from google earth and cultivated slope was computed based on the Digital elevation model (DEM) of 2018 downloaded from earthexplorer.usgs.gov. GIS vulnerability assessment and classification method was used to assess level of vulnerability to soil degradation and land slide. To propose suitable land management conservation strategies practical Tools on Soil and Water Conservation measures alongside with W4GR matrix of soil and water conservation measures documents were consulted. The data collected were analyzed using ArcGIS 10.4software, and Excel; the results were presented using maps, bar graphs and tables. Based on two main factors (slope and soil depth) a conservation map and matrix were developed with proposed options of restoration and conservation of land degraded.

Keywords— land degradation, agricultural productivity, soil fertility, GIS.

I. INTRODUCTION

Land degradation in the world stands at about 85% and this is associated with soil erosion, most of which occurred since the end of World War II, causing a 17% reduction in crop productivity. The extent of soil erosion shows that it's a worldwide environmental problem with some areas such as the horn of Africa and majority of sub – Saharan region being extremely prone to erosion due to prolonged dry periods and heavy erosive rainfall, falling on steep slopes with fragile soils, causing in considerable amounts of erosion. (Abdallah, 2016)

According to Sileshi (2016), land degradation is one of the most serious environmental challenges and an issue in both developed and developing countries. However, the severity and magnitude of its impact are much more pronounced in low income countries at which the livelihood of the majority is dependent on agriculture.

It was found that land degradation was associated with soil degradation through exploitative cropping (Boardman, Poesen and Evans,2003). Soil quality decline is one of the main causes of land degradation and is considered to be responsible for 84% of the ever diminishing acreage.

According to Twagiramungu (2006), Land degradation specifically soil degradation is a major environmental problem in Rwanda, The degradation is particularly linked to hydrous erosion that affects a big portion of cultivated lands. It was assumed that the hydrous erosion reduces the capacity to feed 40 000 persons per year and causes annual losses of about 15 000 000 tons of soil.

According to Sileshi (2016), the vulnerability to land degradation needs to be assessed continually to take appropriate resource conservation measures. Therefore, the aim of this study was to assess the impact of land degradation on agriculture productivity in Nyabihu district through the integration of GIS and RS. More specifically, the study is targeted to map the spatial and temporal changes in agriculture land use and land cover, to assess soil erosion and landslide as factors of land degradation, as well as other factors that affect agricultural productivity.

It is against this background that the study assessed factors influencing land degradation, the level of land degradation, the impact of land degradation on crop production in Nyabihu district and the specific proposed land conservation measures.

This study will provide an understanding of influencing factors and level of land degradation in Nyabihu district and the relationship between land degradation and agriculture productivity. The study will significantly benefit farmers' policy makers and policy implementers in trying to enforce mitigation measures to cope with land degradation process.

The research is also proposed so that people can end up benefiting from the environment they are living in and later they contribute to the country economic advancement and the world as well. It will also be a great contributor to land management policies that will be implemented after this research by suggesting ways by which land can be protected so that agricultural productivity can be improved to sustain food security in Nyabihu district.

Findings from this research are expected to describe the evolution of the problem within a period of 5 years; hence, the impact of soil degradation on agricultural productivity in Nyabihu district; from year 2014 to 2018.

II. MATERIALS AND METHODS

This research dealt with different methods used in collecting, analyzing, processing and interpreting data on the impact of land degradation on agricultural productivity in Nyabihu district so as to obtain effective and efficient results. It includes the research design, data collection methods, data collection instruments, data quality control, procedure of data collection, data analysis and measurement of variables.

2.1 Study area and Case study profile

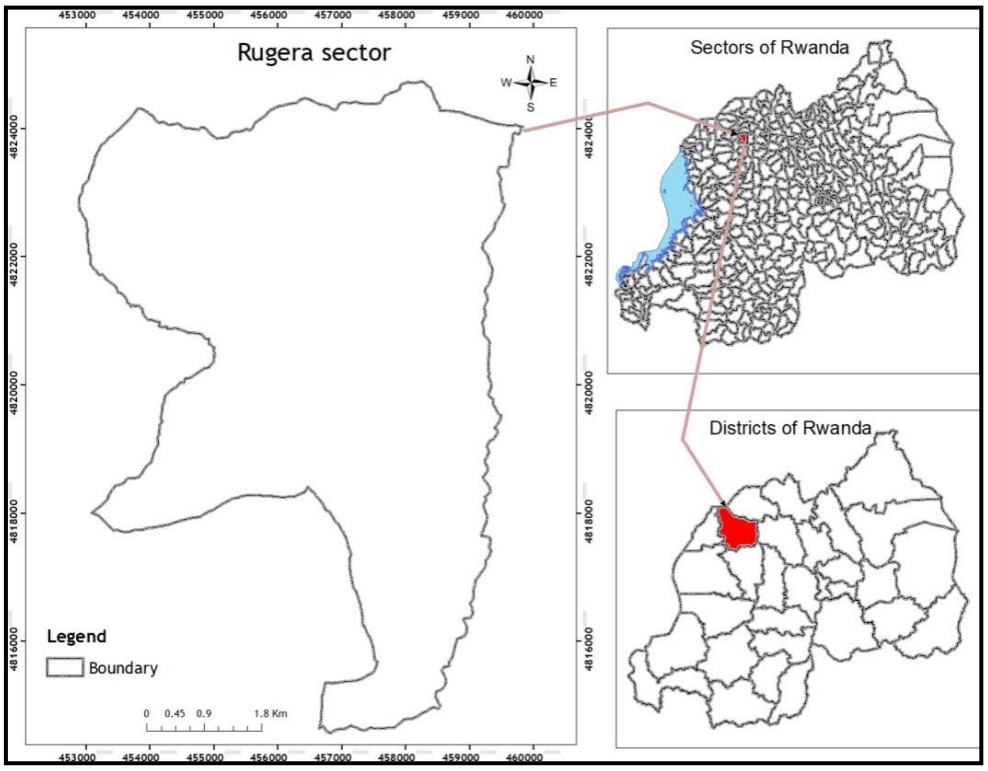

FIGURE 1: Location map of Rugera Sector, Nyabihu district from Rwanda.

Nyabihu district in general and Rugera sector in particular is characterized by heavy rainfall and low temperatures due to the effect of its elevated altitude forested land which both influences its weather patterns. The region is characterized by inceptisoils or soils of altitude, volcanic soil and alluvial soils. The soil types of the region are prone to soil erosion because of heavy rainfall; steep gradient and man's influence as well, thus land degradation.

2.2 Research design

It explains how the study is organized and implemented in details. Research design in this study, enables the conceptualization of an operational plan to undertake the various procedures and tasks necessary in the accomplishment of this study. In this study, a case study design was used with the help of GIS maps.

The case study was chosen according to the factors influencing the effects of land degradation, basing on the altitude and related factors. The effects of land degradation can be, directly or indirectly related to the geographical location of the

exposed region and the nature of the effect, according to its immediate source. GIS and RS data were acquired and processed in order to assess the factors influencing land degradation and their effects in our study area. Secondary data from past researches were consulted to discuss effects of land degradation on agricultural productivity.

2.2.1 Factors influencing land degradation

2.2.1.1 Land use and Land cover

Land cover (classified) maps were produced based on data extracted from google earth. The data were collected in the same month of January of two years of 2014 and 2017, using Smart GIS Software, the rectified image were downloaded with Geographic coordinate system, data were later projected to TM Rwanda coordinate system. With the help of Image classification tool of ArcGIS 10.4 software, the training samples were collected for each of the 3 classes of our interest. Training samples were saved as signatures which later relied on to produce classified maps. Accuracy assessments were computed from ground truthing data obtained from google earth. Using the raster to polygon tool of the same software, classified maps were converted to polygons to find its total area and the obtained values were compared to detect the change occurred in 5 years.

2.2.1.2 Slope

Slope was computed based on the DEM of 2018 downloaded from earthexplorer.usgs.gov, from 2018 DEM, the slope were calculated using Slope tool, from spatial analysis tool of ArcGIS. Raster map were converted to polygon to come up with areas of the classes of the slope.

2.2.1.3 Precipitation (P mm)

To produce a precipitation map, annually rainfall data of 2018 provided by meteo Rwanda weather stations were relied on. From ArcGIS 10.4 software, the meteo stations data with location and annual rainfall in mm were imported in software; Kriging interpolation technique from spatial analysis tools of ArcGIS 10.4 software were executed to come up with general estimation from those sample data. After all, extraction by mask tool from the same software was utilized to remain with the information of our study area.

2.2.1.4 Population density

Population density data were extracted from 2018 ESRI Rwanda Data, Data were processed in Arc GIS software and Nyabihu District population density data extracted was for the final map, and attribute table containing population density was exported in Microsoft excel for the further analysis.

2.2.2 Land degradation impact on agricultural productivity in Nyabihu district (2014-2018)

For the analysis of land degradation effects on agriculture, Irish potato production was assessed using MINAGRI data of Annual potato production (MT) from 2007 to 2017 as compiled in the study done by Emmanuel in 2018. Annual potato production from 2014 to 2017 was extracted analyzed in Microsoft Excel.

2.2.3 Land degradation Assessment

2.2.3.1 Soil loss map

Soil loss map was produced using RUSLE formula. RUSLE data of Nyabihu district were acquired from ESRI Rwanda Ltd. RUSLE stands for Revised universal soil loss equation which is computed as **A=R*K*LS*C*P**, where A stands for the annual soil loss due to erosion which is in [t/ha/year], R is the rainfall erosivity factor, K the soil erodibility factor, , LS is the topographic factor which is derived from slope length and slope gradient, C stands for the (land) cover and management factor and P which stands for the erosion control practice factor.

The study of soil loss estimation conducted in 2018 by ESRI Rwanda Ltd leading expert company in geospatial technologies covered the whole district, extraction by mask tool of spatial analyst tool of ArcGIS 10.4 software was applied to remain with the study area. Using the raster to polygon tool from conversion tools of the software mentioned above, we obtained the polygons and merged the similar one to find total areas in ha of the 5 classes that comprise the map.

2.2.3.2 Landslide

ESRI Rwanda Ltd Shape-files of landslide assessment data that covers the whole district were processed using Clip tool from Arc GIS analysis tool were utilized to remain with Rugera sector shape-files, later a field was added on attributed table to computed area for each class of the 5 classes that comprise the map.

2.2.4 Land degradation restoration, mitigation and conservation measures

2.2.4.1 Land degradation conservation measures map

ESRI Rwanda Ltd provided shape-files of proposed matrix of conservation measures from water for growth Rwanda, the data generally were for Nyabihu district. Rugera sector was extracted using extract by mask tool from Arc GIS spatial analyst tool and converted in polygons. The similar polygons were merged together to find total area for each class.

Classes extracted from map were associated with Water for Growth, (2018) report on Catchment Restoration Opportunity Mapping for Rwanda. Each identified class was associated with it proposed conservation measures using conservation measures from Water for Growth Rwanda.

2.2.4.2 Agronomic measures

Literature review on practical tools on soil and water conservation measures of REMA (2010) were used to propose land degradation agronomic conservation measures.

III. RESULTS AND DISCUSSIONS

This aimed to discuss the results of the findings and interpret data gathered in the study; the findings are based on the objectives of the study. The first section discusses the factors influencing land degradation in Nyabihu district, case study of Rugera sector. The second section discusses the impact of land degradation on agricultural productivity in Nyabihu District, finally the third section covered the assessment from crop production referring to the productivity from (2014-2018) of Irish potatoes.

3.1 Factors influencing Land degradation

3.1.1 Land Use & land cover Change

Referring to the case of Rugera sector where a land use & land cover have been altered from 2014-2017, analysis of land use & land cover change was performed referring to 3 types of land use that are Agricultural land, Forest and Built up area. The aim of the land use change detection was to analyze land use alteration that lead and influence land degradation of the area and investigating the changes in land use / land cover is very essential to take appropriate management actions.

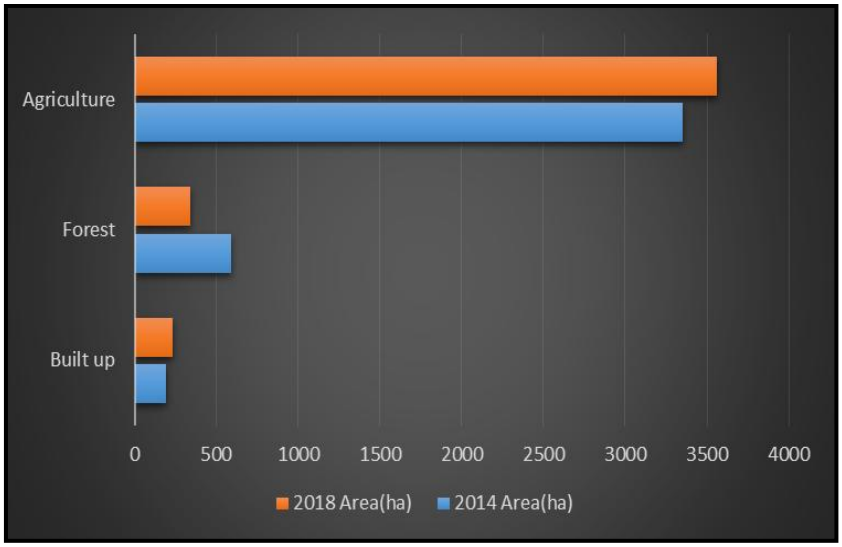

FIGURE 2: Land use & Land cover change trend.

The figures land cover &land use (2014) and land cover &land use (2017) reveal that in 2014 agriculture land increased from (81%) to (86.2%) of the total area. Area covered with forest decreased from (14.3%) to (8.2%) and built up increased from (4.6%) to (5.7%).

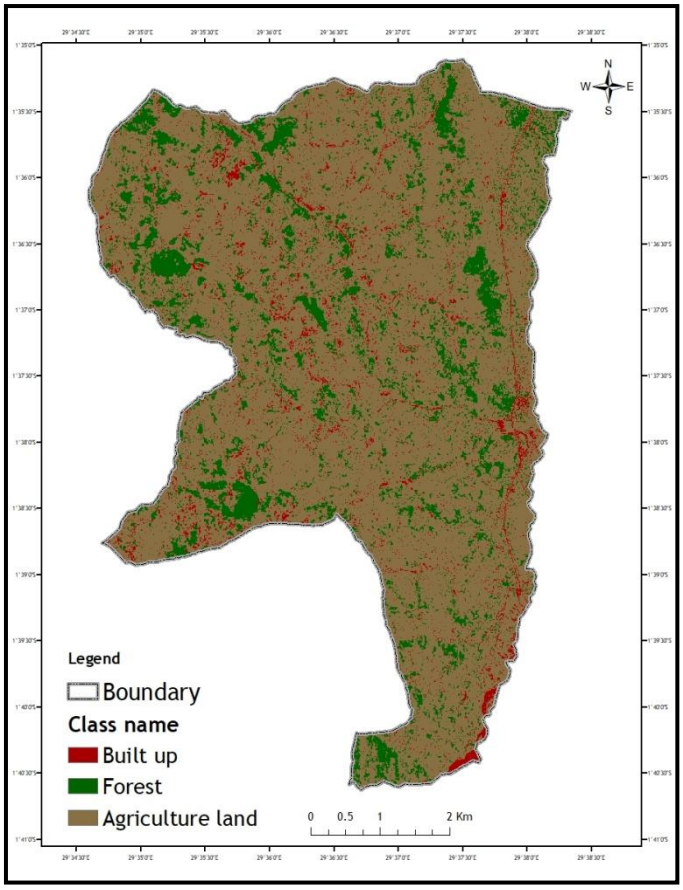

FIGURE 3: Land cover 2014
Source: Author' design

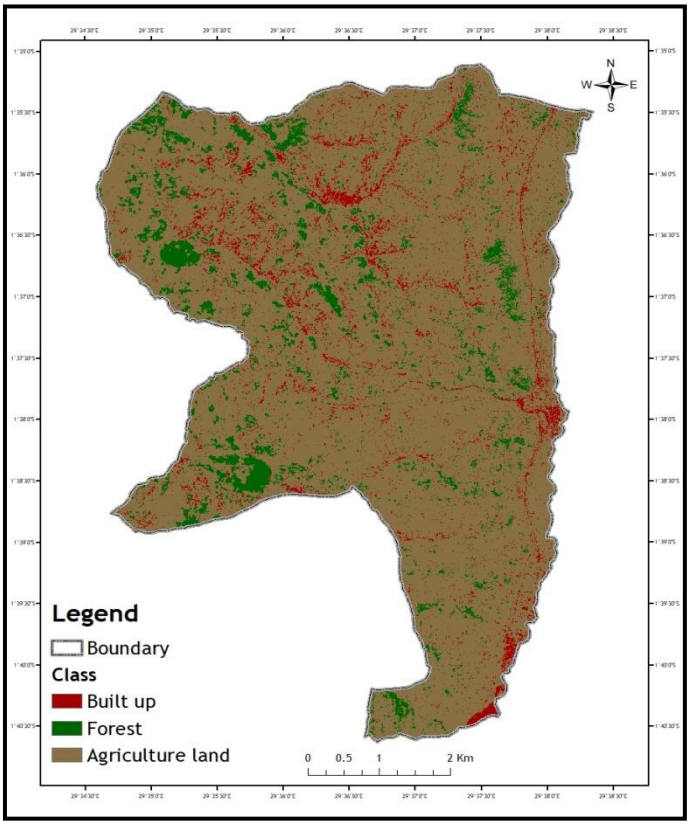

FIGURE 4: Land cover 2017
Source: Author' design

Considering the above land cover maps 2014 and 2017 land was degraded by alteration of the landscape through increasing of the area of agriculture land and built up area, and also the area occupied by forest has been reduced. The land use & land cover change have impact on agricultural productivity because the alteration land use influences the degradation of organic matter in soil. In addition, sparse forests have been reduced considerably caused the exposure of soil erosion and cause land degradation through soil degradation.

3.1.2 Cultivated sloping land

Referring to Abdallah (2016), slope factor contribute more to of land degradation through erosion, taking into consideration of our study area that has cultivated steep slope, land degradation through soil erosion is aggravated in less protected area of our study.

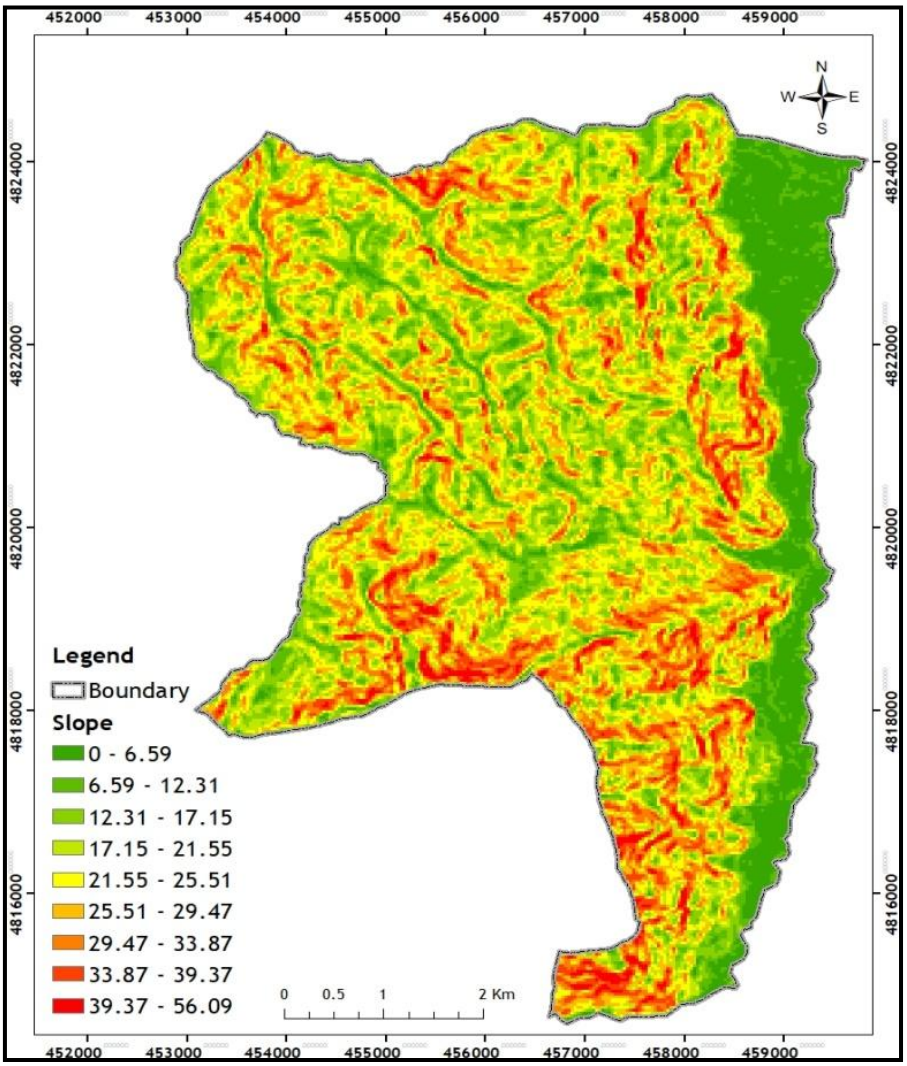

FIGURE 5: Slope map
Source: Adapted from CROM DSS data (2018)

Cultivation on steeper slopes, particularly above 30% is not recommended because it increases the vulnerability to land degradation (Sileshi, 2016). In Rwanda about 90% of the cropland is located on slopes of 5%–55%, and the soil erosion rate increased exponentially with the slope of the cropland (Karamage, Zhang, Ndayisaba, Shao, & Kayiranga, 2016). Considering our study area a big part of slope is ranging between (33%-56%) which expose the area to land degradation through soil erosion.

3.1.3 High amount of precipitation

Rainfall amount is among factors that influence land degradation, rain move soil directly, if the rain falls with sufficient intensity and the raindrop hit bare soil and breakdown soil aggregates, disperse the aggregate material. (Abdallah, 2016).

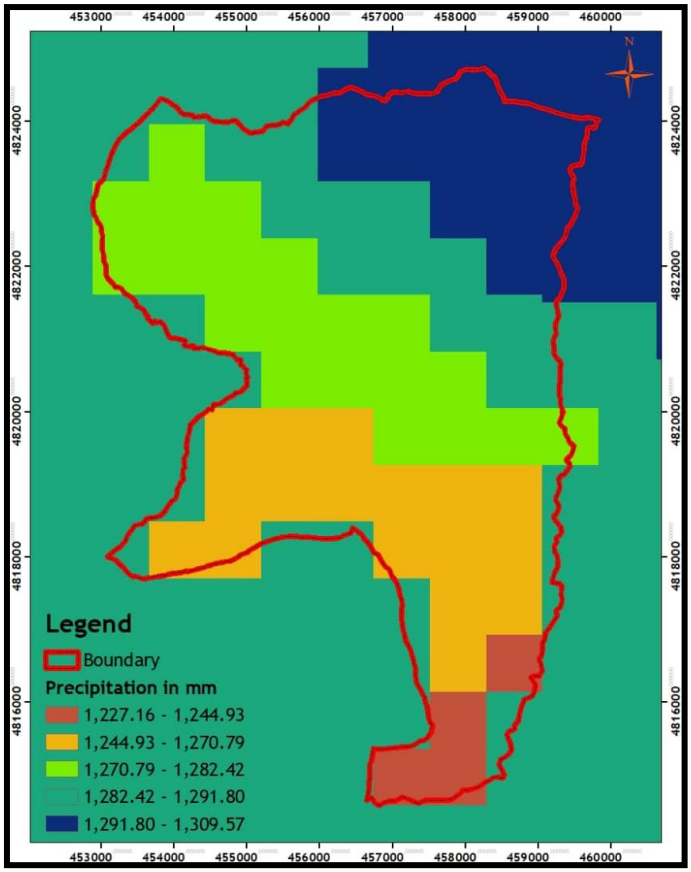

FIGURE 6: Precipitation
Source: Meteo-Rwanda (2018)

The amount of precipitation in Rugera Sector is ranging between (1227mm-1309 mm), while according to (Karamage et al., 2016), in Rwanda the average rainfall intensity is 1156 mm per year. This high amount of rainfall has impact on exposed soil and most of the time causes land degradation through soil erosion and landslide.

3.1.4 Population density

Referring to The National Institute of Statistics of Rwanda (NISR) data of 2012, the population density shows that our study area is among the 6th highest density per square km with about 589 people per km^2. A high-density rural population in our study area causes the overexploitation of agriculture land even in high sloped area ranging between (33%-56%).

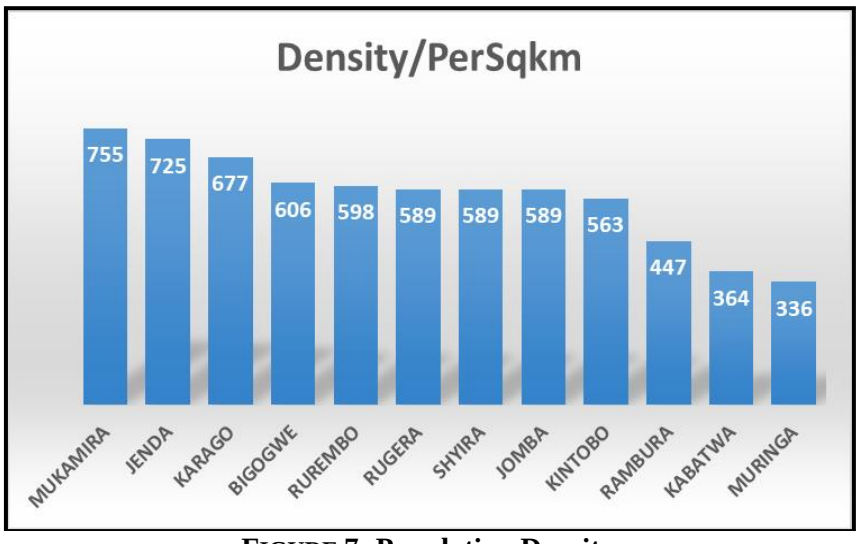

FIGURE 7: Population Density
Source: CGIS data (2012)

As stated by (Drechsel, Gyiele, Kunze, & Cofie, 2001), FAO estimates the actual supporting capacity of land ranges from 10 to 500 people/km−2, this shows that Rugera sector has exceeded the actual supporting capacity. The pressure of people on agricultural land increases cultivation of marginal soils and excessive exploitation of agricultural land will cause soon or later a severe degradation.

3.2 The impact of land degradation on agricultural productivity in Nyabihu district

The increase for demand for crop land to maintain food production is leading to agriculture in unsuitable area and cause soil erosion due to the inappropriate crop management. Land use and land cover change (2014-2017), related to increasing population and expansion of agriculture on steep slopes and unsustainable land management were the main cause of agricultural productivity decline in the area. The impact of land degradation on agriculture productivity will be explained using Nyabihu district Irish potato production trend.

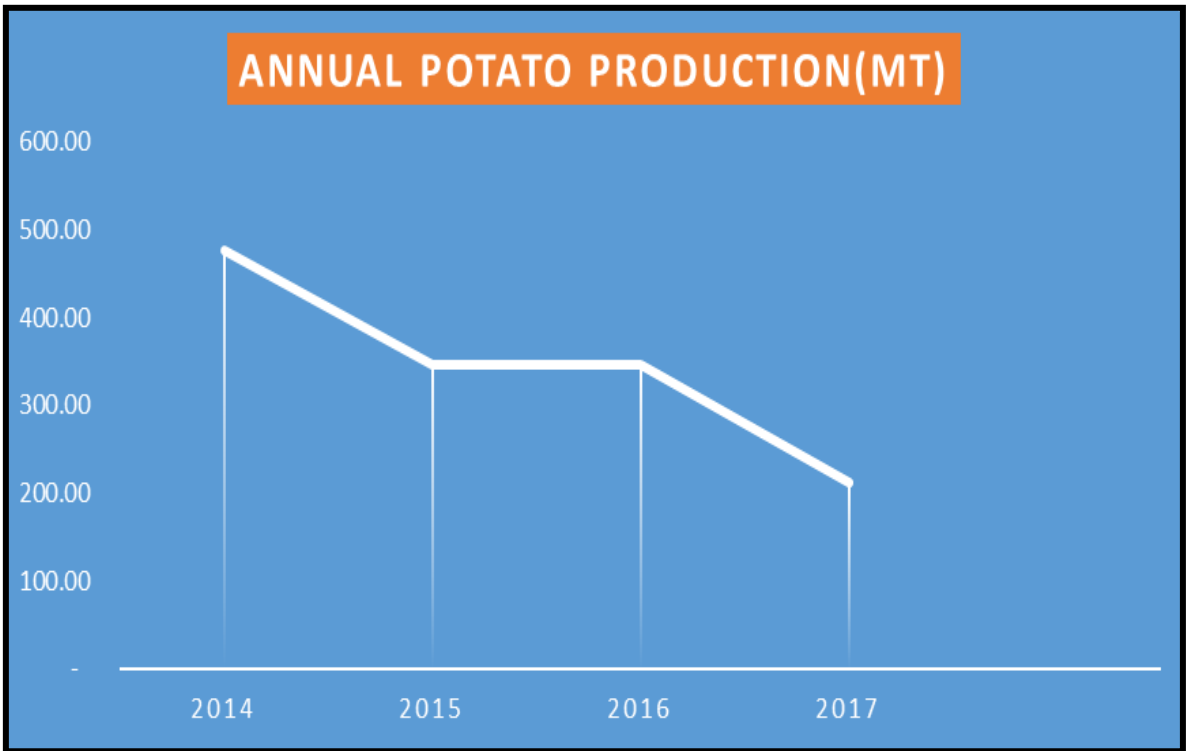

FIGURE 8: Annual irish potato production
Source:(Emmanuel, 2018)

Although according to Emmanuel (2018), the decline of annual Irish potato production was associated with factors such as pests and diseases, lack organic manure, mineral fertilizers, quality of seed, timely planting and inter-annual temperature variability. However land degradation is another influencing factor that can't be overlooked as it was identified in Rugera sector, where there are factors influencing land degradation such as land use and land cover change (2014-2017), cultivated sloping land, high amount of precipitation and high population density.

3.3 Land degradation vulnerability assessment.

The assessment of soil physical degradation is essential for the planning of land degradation restoration. GIS spatial modeling tools are efficient tools that may help decision makers to take the necessary actions to protect the most area exposed to land degradation (Ahmed Harb Rabia, 2012). Therefore this assessment will help Nyabihu district in planning of different activities to mitigate land degradation in the study area.

3.3.1 Soil erosion vulnerability

According to Kumar & Pani (2013), soil's physical degradation affects crop growth and yield by decreasing root depth, water availability and nutrient reserves. Hence, the soil erosion vulnerability assessment is a critical activity to be adopted by planners in order to reduce effects of soil degradation on agriculture productivity.

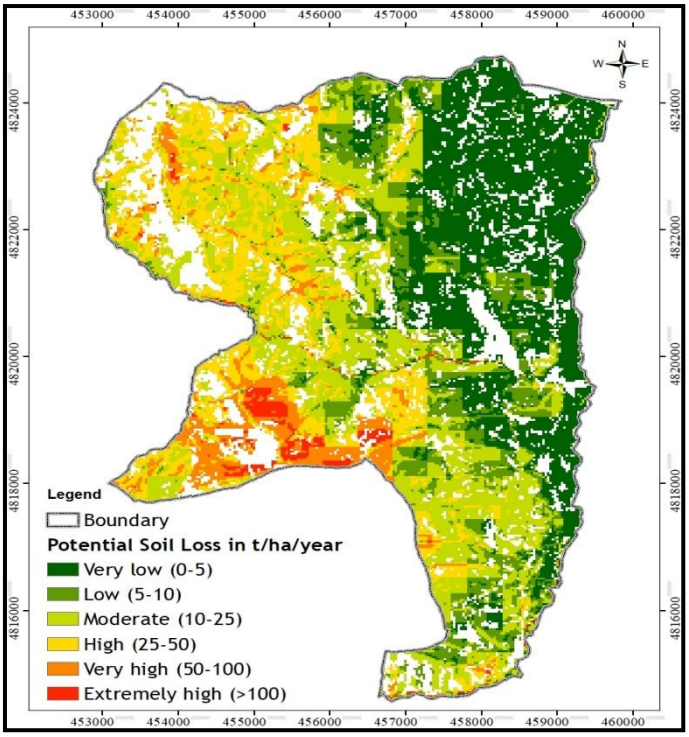

FIGURE 9: Risk to Soil Loss

Source: Adapted from CROM DSS data (2018)

Five factors (slope, land cover, rainfall, soil depth and geology) have been used to determine areas exposed to soil erosion. The soil erosion vulnerability was assessed in our study area and the vulnerability erosion maps were classified into six categories. The soil loss rate was estimated in (t ha $^{-1}$ y^{-1}) where (0-5) is considered as the area with very low soil erosion loss and (>100) is the area with high soil erosion. The soil erosion vulnerability assessment of our study area will be a contribution in soil degradation mitigation and choosing conservation measures to be adopted.

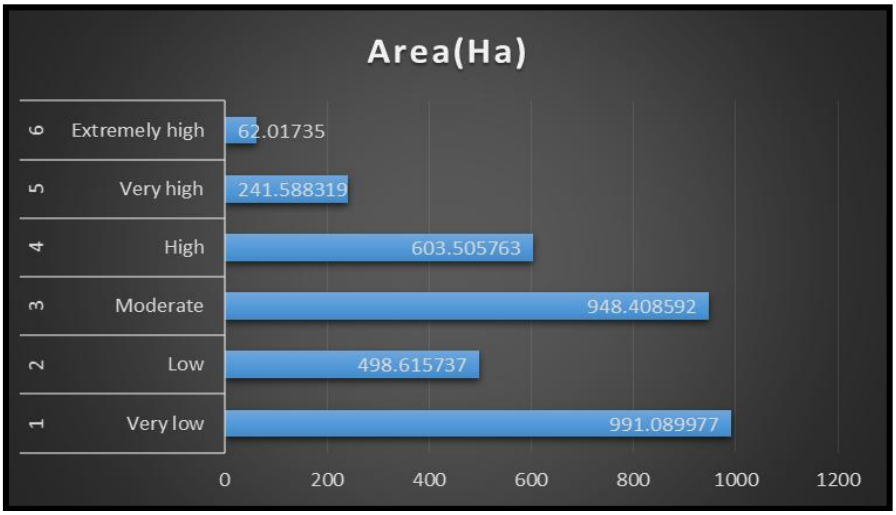

FIGURE 10: Status of Area exposed to soil erosion

According to the figure (10) about 62 ha are exposed to extremely high soil loss, 241 ha are exposed to moderate, high and extremely high soil loss and 1855ha are exposed to high soil loss. In total 2396 ha of the area are most exposed to the soil loss and need more attention for restoration and conservation measures.

3.3.2 Landslide vulnerability

Landslide vulnerability identification on agricultural may be significant for land use planning (Kroh, 2017). For the conservation of the most vulnerable areas susceptible to the landslide phenomenon, a landslide vulnerability assessment map was produced for the study area. The map is classified into five classes.

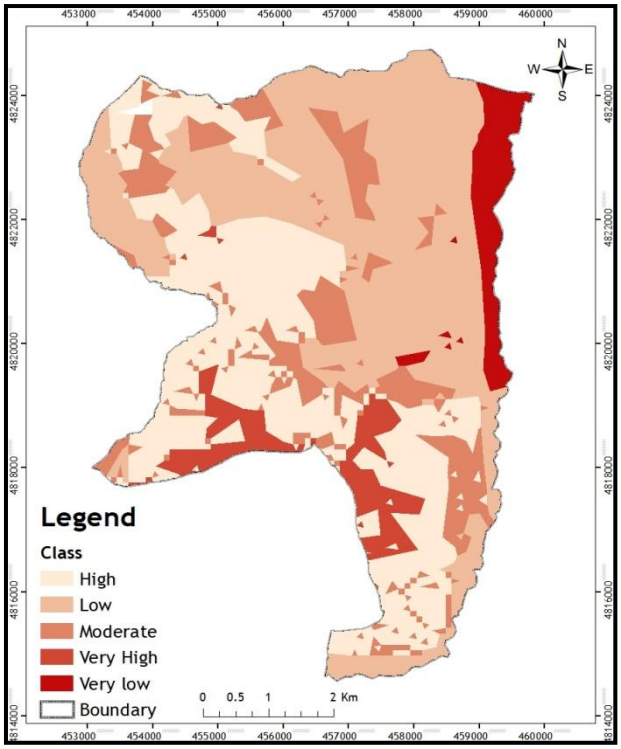

FIGURE 11: Landslide risk map
Source: Adapted from CROM DSS data (2018)

Landslide risk assessment is important in land degradation vulnerability assessment, because it helps in setting up need for restoration and conservation measures of land degradation. The identification of area exposed to landslide is also crucial while planning for restoration.

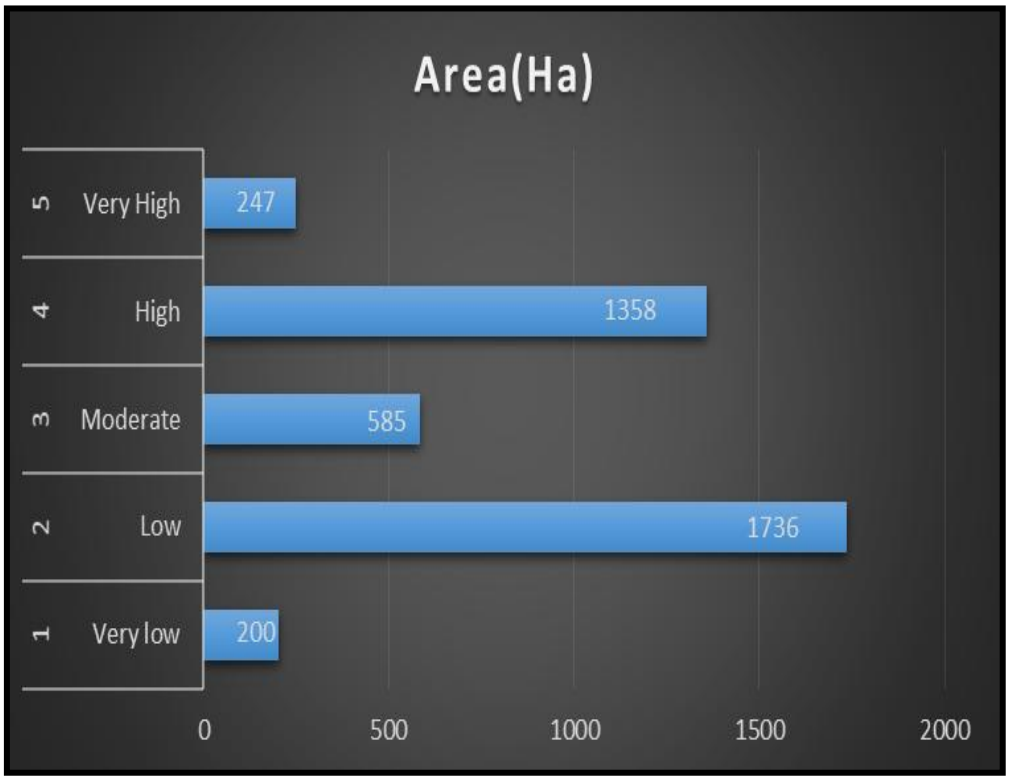

FIGURE 12: Status of Area exposed to Landslide

Considering the assessment of area exposed to landslide (Figure 12), about 2190 ha is exposed to moderate, high and very high landslide area and need restoration and conservation measures as soon as possible.

3.4 Land degradation restoration, mitigation and conservation measures

This section provides some proposed specific technical guidance for the land conservation measures. The measures proposed in this section were adopted from (REMA, 2010) and Water for growth Rwanda matrix.

3.4.1 Agronomic measures

Agronomic measures includes include mulching, crop management and agroforestry. These measures use the effect of surface covers to reduce splash erosion the splash, decreasing the velocity of runoff, and hence reducing the amount of soil loss. It combines agricultural and forestry technologies to create more diverse, productive, profitable, healthy and sustainable land-use systems.

3.4.2 Water for growth Rwanda control matrix

Based on two main factors (slope and soil depth) a matrix was developed with proposed options of restoration. The matrix including classes was adapted from a previously developed conservation matrix under Land Husbandry, Water Harvesting and Hillside Irrigation Project (LWH project). From each of identified class, options of measures have been proposed.

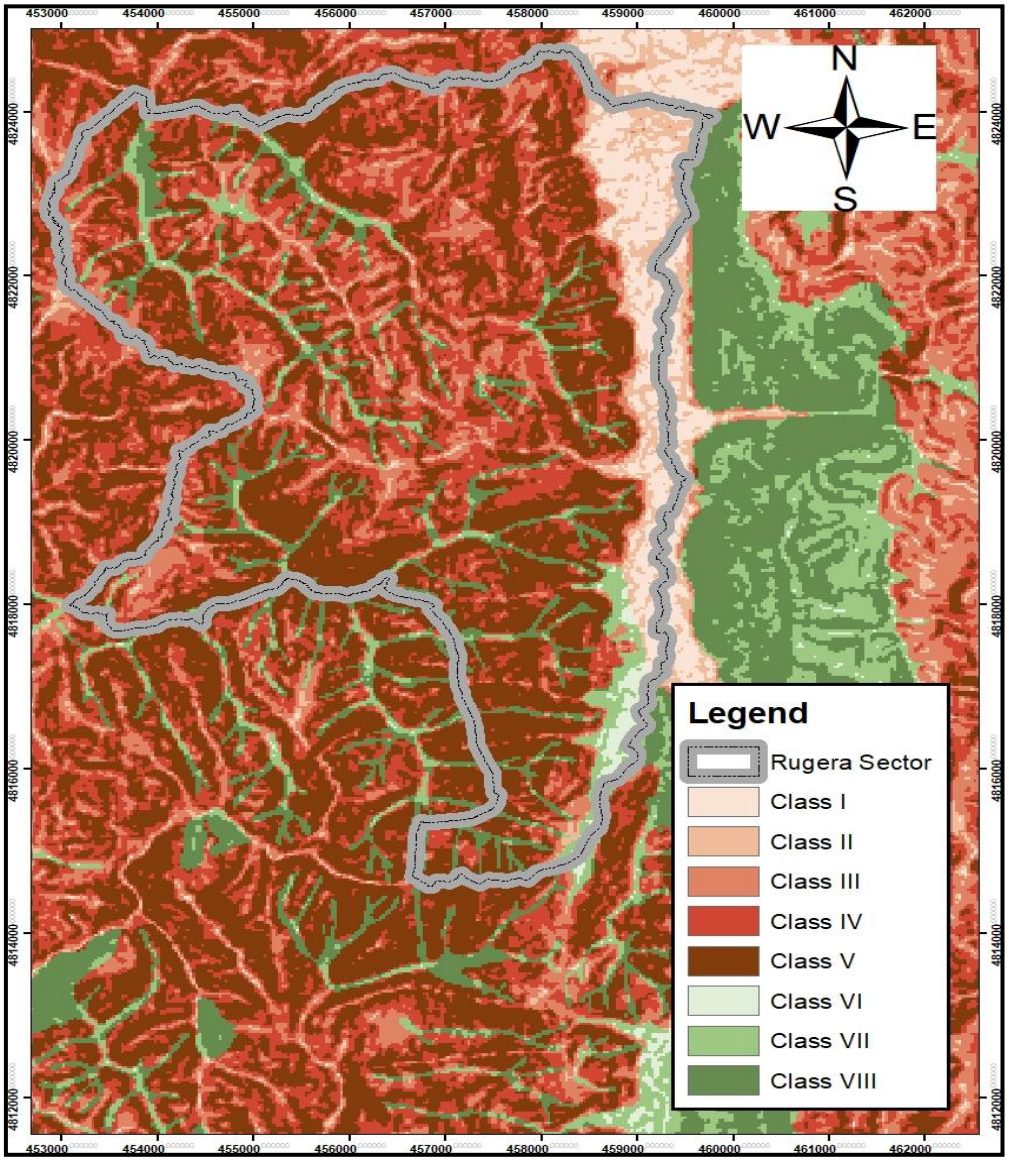

FIGURE 13: Conservation measures classification
Source: Adapted from CROM DSS data (2018)

Considering our study area we have 8 classes, for each of them, options of restoration measures have been proposed referring to proposed conservation matrix of Water for Growth Rwanda done in 2018.

TABLE 1
PROPOSED CONSERVATION MEASURES

Soil depth→ / **Land slope↓**	**1: (> 0.5m)**	**2: (≤ 0.5 m)**
1: (0-6%)	**Class I**	**Class VI**
	-Agroforestry + Contour ploughing + Alley cropping combined with grass strips	- Agroforestry + Contour ploughing + Alley cropping combined with grass strips
		- Forestation where soil depth is too limited and unsuitable for crops
		- Perennial crops, coffee, tea, banana, fruit trees
2: (6 - 16%)	**Class II**	**Class VII**
	- Progressive terraces	- Progressive terraces
	- Perennial crops, coffee, tea, banana, fruit trees	- Perennial crops, coffee, tea, banana, fruit trees
		- Forestation where soil depth is too limited and unsuitable for crops
3: (16 - 40%)	**Class III**	**Class VIII**
	- Bench terraces (or progressive) reinforced by agroforestry hedges and grass strips	- Progressive terraces / Contour bunds (4-5 m spacing between terraces) reinforced by agroforestry hedges and grass strips
	- Perennial crops, coffee, tea, banana, fruit trees	- Forestation where soil depth is too limited and unsuitable for crops
		- Perennial crops, coffee, tea, banana, fruit trees
4. (40- 60%)	**Class IV**	**Class IX**
	- Narrow cut terraces (or progressive terraces if parent material is not stable) reinforced by agroforestry hedges and grass strips	- Forestation
	- Perennial crops	
	- Forestation	
5. > 60%	**Class V**	**Class X**
	- Forestation	- Natural vegetation
	- Perennial crops	

Based on two main factors (slope and soil depth) the above table (1) is the matrix table of proposed restoration measures of land degradation in Nyabihu district, Rugera Sector. The matrix was adapted from the one developed with CROM –DSS Data from Rwanda water and Forestry Authority (RWFA) proposed options conservation of restoration.

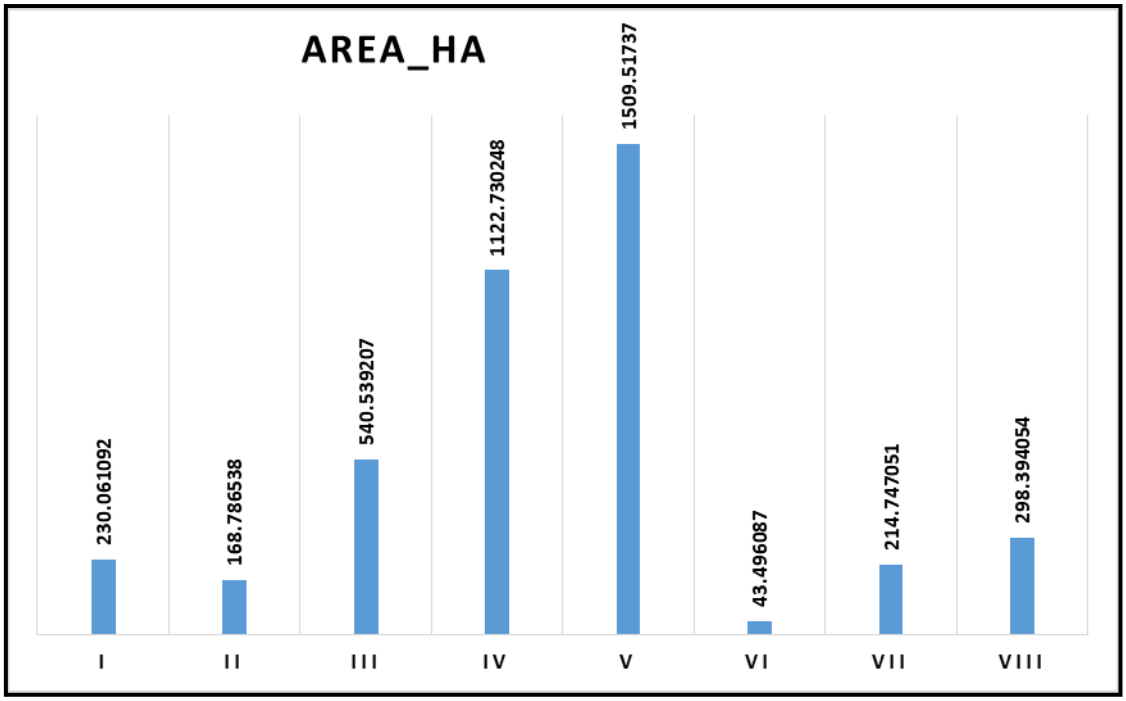

FIGURE 14: Area covered by classes

Referring to the above figure 15, a big area is covered with class five (V) with 1509.51737 Ha, followed with Class IV, III and VIII. Therefore conservation measures such as forestation of the area, planting perennial crops, narrow cut terraces or progressive terraces reinforced by agroforestry hedges and grass strips must be among the priority conservation measures of the study area.

The above table and map must be consulted by Nyabihu district, specifically Rugera sector authorities before the implementation of land conservation measures. However the implementation of most of the proposed measures are expensive (ex: Bench terrace), therefore the government should support farmers in their implementation. Concerning agronomic measures, as they are less expensive agronomist must continue the mobilization on the use of them in agriculture land.

IV. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

From the results obtained in this study, it can be concluded that in Nyabihu district, Rugera sector land degradation is influenced by biophysical and anthropogenic factors. Those factors are land cover and land use change, high amount of precipitation and high density population cultivating sloping land. Land degradation that occurred from (2014-2018) alongside with other factors such pests and diseases, lack organic manure, mineral fertilizers, Quality of seed, timely planting and Inter-annual temperature variability had impact on agriculture productivity. From 2014, 2015, 2016, 2017 and 2018 a decline in annual crop production was observed in Nyabihu district. Land degradation through soil erosion and landslide were found to be more frequent and affecting agriculture productivity in the study area. Using GIS assessment about 2190 ha were found to be exposed to moderate, high and very high landslide and needed special attention for conservation and restoration measures, while 1855ha were exposed to moderate, high and extremely high soil loss. For effective conservation measures on land degradation the study recommends the use of both combined agronomic measures and land conservation measures adapted from proposed conservation matrix under Rwanda water and Forestry Authority (RWFA).

4.2 Recommendations

Based on the findings from the study, recommendations have been formulated to cope up with the effects of Land degradation on agriculture productivity in Nyabihu district:

- We recommend Nyabihu district all sectors deep assessment of the most vulnerable areas exposed to land degradation through erosion and landslide as most frequent hazards that contribute to the agriculture land degradation.

- While selecting conservation measures for land degradation, Nyabihu district officials must consider proposed conservation matrix under Rwanda water and Forestry Authority (RWFA).
- District agronomist in collaboration with Sectors agronomists must increase awareness and follow up on the use of land conservation agronomic measures including mulching, crop management and agroforestry as it was found to be the less expansive.
- Farmers should be involved actively in the process of land management and conservation measures in order to achieve land conservation sustainability.

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Impact of an APT01 Compost on Quality Improving of the Anna Apple (Age of the Plant 8.0-8.5 Years)

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Abstract— *This study aims to analyze the effect of theAPT01compost as the soil organic matter to the apple crop production (Malus sylvestris) at harvest time (SPN).The experiment was carried out according to completely randomized factorial design with the amount of mud cake that was fermented for two weeks by APT01 as bio-catalyst. The experiment was conducted in a treeation area of 400 square meters. The amount of the APT01compost as much as 20, 30, and 40 kg per tree was applied a day after defoliation. A total of 48 apple trees aged about 8.0-8.5 years with a distance between trees 2-3 meters were randomly selected. Observations made during fruit growth took 5-6 months after giving the APT01compost at harvest (SPN).The parameters measured were the number and weight of fruit per tree. Results were analyzed variance, two-way ANOVA with interaction (α = 0.05), using Microsoft Excel. The results of variance analysis concluded that : (1) The addition of 20, 30, and 40 kg of APT01 compost per tree, shows significant differences (α = 0.05) on the amount of fruit production on SPN, (2) The addition of 30 and 40 kg of APT01 compost has an impact on increasing the quality of fruit from grade C (12-15fruits per kg) to grade AB (10-11 fruits per kg).*

Keywords— APT01; mud cake; compost; apple; fermentation.

I. INTRODUCTION

Apple treeation centers is currently located in Batu, East Java, Indonesia. The village is very fertile with society's diverse style, which is still productive agroecologicaly (soil and climate). However, the lands used to produce crops usually have a much greater erosion of land with natural vegetation. The increase of erosion is caused by the replacement of the structure of forest tree roots which bind the soil strongly with a weaker root structure of agricultural crops **[1]**.This is reinforced by the application of farming system that uses high fertilizers and chemical pesticides that is increased from year to year, both in quality and quantity, which in turn exceeds the carrying capacity of the land. As a result, the land is damaged and the production is declined**[2]**.

Such these conditions force us to constantly conserve the resources and minimize the external impact. One form of such breakthrough was the addition of organic matter such as mud cake given twice a year. Some literatures mentioned that the content of organic matter in Java agricultural land is less than 1% which is ideally should be more than 3%.The interest of public to improve soil fertility is by applying compost as an organic matter. Farming communities are encouraged to convert agricultural waste such as corn stalks and grasses used as raw material to make compost. Quality of compost produced depends on the raw materials and the treatment of the composting process **[3]**.

The organic fertilizer can be derived from agriculture waste and manure, household waste, or even from the sugar cane industry known as mud cake. Mud cake waste which is generated by the sugar mills are dirty, brownish watery, and smelly. Therefore, it needs to be composted to become organic fertilizer.

The process of composting organic materials can be accelerated by the addition of *T. viride* APT01 as bio-catalyst that could decrease the C:N and total organic carbon which was originally 26.8 and 37.6% to 14.6 and 22.7% **[4]**. This is supported by the addition of organic matter into the soil to improve the quality of physical and chemical impact on improving soil porosity, soil organic carbon and nitrogen, as well as the ability to maintain soil fertility[5].

Some minerals such as potassium and calcium presence in the soil organic matter tend to join and give rise to the production [6]. Encourage increased soil organic matter and cation exchange capacity to respond to 90% adsorption strength of the soil. Cations such as potassium and calcium will be generated during the decomposition **[7]**.

The amount of fruit during four months after defoliation (SR4) increased from 39.08% to 48.28% by the addition of compost APT as much as 10 and 20 kg per tree while the percentage of the number of fruit increases at harvest (SPN) ranging between 58.57% and 67.14%. Age tends to reinforce the fruit on the stem of the tree resulting in fruit loss reduction. The trees network systems become stronger as a result of nutrients such as K and Ca which can be absorbed by trees. These elements are presented in the compost of organic matter APT01. Potassium and calcium is in the form of positive ions that tend to be bound by the negatively charged organic matter to form compounds available to trees. K and Ca play a role in strengthening and toughen tree tissues such as flowers and fruit so it does not easily fall out[8].

Application of mud cake for apple tree should be conducted continuously, because mud cake is well known as source of organic materials and is available continuously in large quantity. Our previous research shows that the first application of mud cake composting by *Trichoderma viride* APT01 after defoliation can improve the number of fruit (58.57- 67.14%) and weight of fruit per tree (74.51-135.91%) compared to controls [8]. The addition of APT01compost as much as 20 kg was significantly able to further increase number and weight of apple (51 fruits and 4.91 kg) than other compost addition (α = 0.05). In the second period, we knew that the number and weight of apple in 10 kg compost APT01addition was similar with Bokashi compost addition (α = 0.05), but it has different amount of compost[9].Those productivity still need to be increased. So, the second application of mud cake should be conducted to get more information about the effect of mud cake composting on productivity (quantity and quality) of apple trees in apple farm area, Batu, East Java, Indonesia.

Previous research on the use of compost in apple treeations was also carried out in Himachal Pradesh, India. The addition of compost as much as 5-15 kg per tree once a year. The study concluded that the quantity and quality of apples has increased in terms of fruit size, storage time of apple fruits, and soil quality [10]. Improvement on fruit size will have an impact on increasing the value of Rupiah. It is known in the market in Batu, Indonesia, that the apple current grades are A, AA, AB and C. Grade A contains 6-7, AA 8-9, AB 10-11, and C 12-15 fruits per kg. The price of grade A > AA > AB > C [11].

II. MATERIALS AND METHODS

The experiment was carried out according to completely randomized factorial design with the amount of mud cake that was fermented for two weeks by APT01 as bio-catalyst. The experiment was conducted in a treeation area of 400 square meters. The amount of theAPT01 compost as much as 20, 30, and 40 kg per tree was applied a day after defoliation. A total of 48apple trees aged about 8.0 to 8.5 years with a distance between trees 2-3 meters randomly selected. Observations made during fruit growth 5-6 months after giving the APT01compost at harvest (SPN).The parameters measured were the number and weight of fruit per tree. Results were analyzed variance, two-way ANOVA with interaction (α = 0.05), using Microsoft Excel.

III. RESULTS AND DISCUSSION

Observation of fruit growth per period was conducted for 5-6 months from composting to harvesting (SPN). Tree observations were undertaken at a day after defoliation in February 2020 until fruit production was harvested in June 2020. The parameters observed were generative growth (total number and weight of fruit per tree) as shown in Table 1, Figure 1 and Figure 2.

TABLE 1
THE RESULT OF FRUIT PRODUCTION BY A APT01 COMPOST AT 2 WEEKS FERMENTATION

APT01Compost (kg) per tree	Number of Fruit			Weight of Fruit (kg)		
	SPN			SPN		
20	112	107	109	8.7	7.9	8.3
30	141	134	139	14.4	13.2	13.8
40	145	147	143	14.0	14.8	13.6

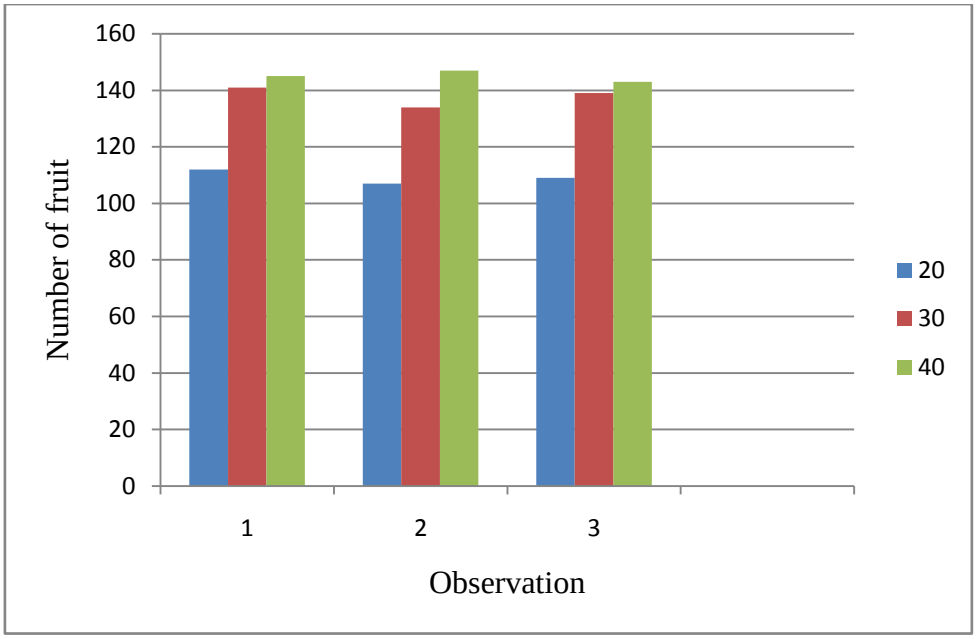

FIGURE 1: Number of fruit production

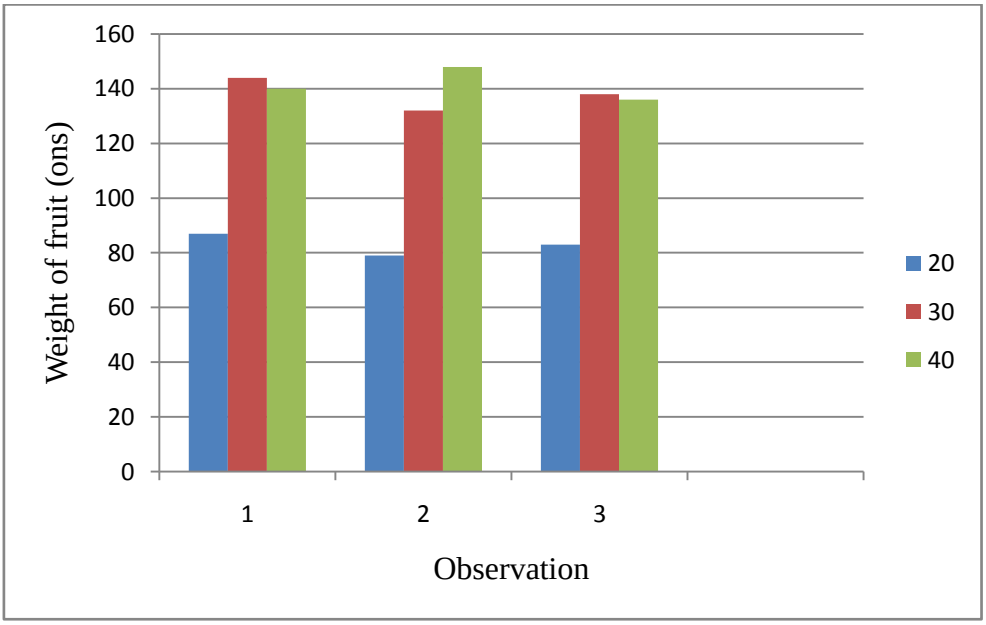

FIGURE 2: Weight of fruit production

The amount of fruit produced by the addition of APT01 compost 30 and 40 kg increases the range between 26.85 and 33.33% compared to 20 kg per tree as control. To determine the effect of addition of APT01 compost 30 and 40 kg against statistically performed using two-way anova with the following results. Hypothesis column in Table 1. show the p value less than 0.05, then the decision to accept H_1 and reject H_0. Furthermore, it appears the value of F is higher than F_{crit}. In other words, $F_{calculated} > F_{table}$. It means that there is a significant difference between the average value calculated from categories of addition of 30 and 40 kg APT01 compost. Each addition of 30 and 40 kg compost would make the difference in number and weight of fruit of apple crop production. The results of this study reinforce the research data conducted by Asio [12], that the addition of organic matter can improve soil fertility either physically, biologically or chemically.

Addition 30 and 40 kg of APT01 compost reduces the value of the original fruit to fall from 3.57% to 2.04-2.84%. The value of the fruit loss tends to decrease by increasing the APT01 compost to the soil. This is evidenced by the addition of compost as much as 20, 30, and 40 kg for each apple tree aged 8.0 to 8.5 years which have an impact on the reduction of fruit loss value. Application ofAPT01 compost directly into the soil cannot be well absorbed by tree roots. This is shown by the growing strength of the fruit stalk during 4 months of composting than during 3 months. Strength of the fruit stalk as a result

of absorption of potassium and calcium which can be absorbed by trees. Potassium and calcium in the form of positive ions tend to be bound by negatively charged organic compounds to form compounds available to trees. These elements play a role in strengthening elements of trees such as flower and fruit so it does not easily fall out [8].

At this time the apple treeation land in Batu, East Java, Indonesia has likely degraded. Land degradation in the uplands is mainly because of erosion, lack of organic matter, and loss of nutrient due to conversion of forest to agricultural land. The percentage increased in the amount of fruit as a result of the addition of organic matter such as APT01compost.The impact of land degradation resulting in yield reduction amount of fruit produced.

Observations weight of fruit per tree from various compost treatments mentioned that the addition of APT01compost can enlarge apple production. The largest increase in yield is71.08% on the addition of APT01compost as much as 30 and 40 kg per tree.

Previous research by Adebayo[13], found that the addition of compost on Okra trees were able to increase the number and weight of fruit production significantly. Similar studies had been reported by Khan and Ishaq [14], that the addition of compost made from the remains of trees and livestock manure into the soil can improve nutrient of potassium, nitrate, and phosphorus in the form available to trees. The availability of tree nutrients accelerated growth and increased sustainability in production. The addition of composted organic material has been done by previous research on apple crop varieties "Galaxy" were able to increase production more than 10% [15].

Based on previous research in period-1, the production of fruit weight per tree by the addition of APT01 compost ranging from 3.24-4.22 kg, while on period-2 of 3.97-4.91 kg/tree. The addition of APT01 compost at period-1 is able to increase production 74.51-135.91% significantly ($\alpha = 0.05$) compared with no addition of compost [8]. The addition of APT01 compost to the same treatment as period-1 for the next season (period-2) increases production 16.35-22,53% compared to the period-1. The magnitude of the increase in the percentage of period-1 nutrient expected to remain high in the soil mainly nitrogen, potassium and phosphorus in the form of unavailable become available by adding APT01 compost[11].

The number of apple trees per hectare is 1,500-1,700 trees. Composting per season of production per hectare is 30-50 tons per hectare. For apple trees that are productive (10-20 years), the amount of compost added can reach 50-60 tons per hectare per season. The addition of the compost is expected to affect the increase of flower and fruit production. The results of the research of the productivity of apple trees by the addition of APT01compost showed an increase in the number of fruits as a result of the addition of compost.

The addition of APT01compost as much as 30 and 40 kg per tree impact to increase in a weight and a number of fruit that was originally 7.9-8.7 kg (107-112 fruits) to 13.6-14.8 kg (134-147 fruits).When it made the quality grade, the average fruit produced from 12-13 to 10-11 fruits/kg, and can be categorized into Grade C to AB. The previous research by Caione[16], which states that the use of compost of mud cake of 7.5 tonnes/ha can increase the content of phosphorus in the soil, leaves, stalks and crop productivity. Improvement on fruit size will have an impact on increasing the value of rupiah. It is known in the market in Batu, Indonesia that the apple grades currently are A, AA, AB and C. Grade A contains 6-7, AA 8-9, AB 10-11 and C 12-15 fruits per kg. The price of grade A > AA > AB > C [11].The research data of Budiono[9],showed that a 20 kg APT01compost addition gave the best result to improve quality and quantity productivity of apple trees than Bokashi compost in SPN. The 20 kg APT01compostaddition suppressed the fruit loss until 13.85% and improved fruit weight until 49.11% .

IV. CONCLUSION

The results of ANOVA variance analysis concluded that: (1). The amount of fruit produced by the addition of 30 and 40 kg APT01 compost increases ranged between 26.85 and 33.33% compared to 20 kg per tree as control. It means that there was a significant difference ($\alpha = 0.05$) between the average value calculated from categories of addition of 30 and 40to 20 kg APT01compost. Each addition of 30 and 40 kg of APT01 compost those were different number and weight of apple production., (2) The addition of 30 and 40 kg of APT01 compost has an impact on increasing the quality of fruit from grade C (12-13 fruits per kg) to grade AB (10-11 fruits per kg).

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