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Preface

We would like to present, with great pleasure, the inaugural volume-6, Issue-3, March 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

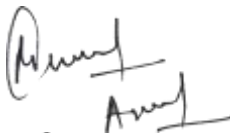
Environmental Research:

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.



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Agricultural Sciences	
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Animal Science	Agricultural Economics
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Sustainable Natural Resource Utilisation	Management of the Environment
Agricultural Management Practices	Agricultural Technology
Natural Resources	Basic Horticulture
Food System	Irrigation and water management
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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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Livestock Production	
Animal husbandry	Ranch
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Dairy Sheep	Water Buffalo
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Factors Influencing Cassava Farmers' Choices of Climate Adaptation Strategies in Rainforest Agro-Ecological Zone of Southwest, Nigeria

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Abstract— *Evidences from literature and past studies have revealed that climate change has influenced agricultural productivity leading to declining global food production. The study was to examine the effect of climate change adaptation strategies on cassava production in Southwest, Nigeria where rain forest agro-ecological zones (AEZ) was chosen for the study. The study used multi-stage sampling procedures, with the aid of well-structured questionnaire, to select 150 cassava producers. Data analysis was done using descriptive statistics and multinomial logit model. From the study, it was revealed that cassava farmers in the study area were relatively young, fairly educated, mostly married, well experienced, adequately aware of climate change, but operated on a small scale. Factors influencing the choice of these climate adaptation strategies were; sex, age, farm income, years spent in school, labour availability, amount of credit obtained intensity of temperature. It is therefore recommended that government should provide adequate extension services with knowledgeable and skilled extension agents who are equipped with climate useful information, thereby making the farmers aware about the available adaptation strategies to climate change and the benefits inherent in them; farmers, via extension agents, should be encouraged to use improved varieties of cassava as adaptation strategy in order to achieve increased output and multiple planting dates should be embraced by the cassava farmers.*

Keywords— Cassava farmers, climate adaptation strategies, multinomial logit.

I. INTRODUCTION

Climate change manifests itself through increasing variation in the weather, including temperature, precipitation, and wind. Scientific research confirmed climate change is occurring and expected to aggravate in coming decades (IPCC, 2014). Since 1950, the number of warm days and nights has increased, and it is projected that the length, frequency, and intensity of heat waves will increase on most of the land (Field *et al.,* 2012). As a result of climate change the pattern, timing and intensity of the precipitation has also altered. The number of heavy precipitation events has increased but with strong regional variations (Field *et al.,* 2012). Rise in temperature and changes in precipitation are changing water availability and other stresses for crops with effects on crop yield, income, and poverty.

Climate change poses threats to food security because of its impact on the agricultural system. Agricultural production in most Sub-Saharan African Countries (Nigeria inclusive) is dependent on weather. Climate change has a direct influence on the productivity of physical production factors such as soil's moisture and soil fertility and this affects farming output. Evidences from literature and past studies have revealed that the recent climate change has influenced agricultural productivity leading to declining global food production (Kurukulasuriya and Mendelsohn, 2006; (International Institute for Sustainable Development) (IISD), 2007; Lobell *et al.,* 2008). A negative and unfavourable climate change could engender adverse climatic conditions like drought, flooding that would result into food shortage and food insecurity like is being experienced in countries like Somalia, Sudan and other countries within the borders of the arid zones. Nigeria is not left out of this environmental quagmire. During the flooding in the southern part of the country in 2013, for example, several hundreds of thousands of farmland/crops were destroyed. Extreme and adverse environmental conditions can also trigger price increases and food import to augment local production. Extreme weather events can damage or destroy transport and distribution infrastructure and affect other non-agricultural parts of the food system adversely (Felix *et al.,* 2018).

It is then less difficult to believe that agricultural productivity under the prevailing climate change situation in most developing countries will be very low. Consequently, the low crop yield will lead to unavoidable shocks to the already fragile economies in African countries. Food prices are expected to rise, worsening the food insecurity and poor nutritional health conditions in the continent. The impact of climate change on food production, prices and food security depends on regional climate change, biological effects of increasing atmospheric carbon dioxide, changes in floods, droughts and other extreme events, existing agricultural systems, adaptive capacity, changes in population, economic growth and technological

innovation (Pittock, 2005). A clear example is the drought and food crisis situation that has been ravaging the horn of Africa (particularly Somalia, Northern Kenya, Ethiopia, Djibouti and Eritrea) since the second quarter of 2011 which has claimed many human lives, led to the death of millions of animals and livestock and has predisposed millions of people to health and nutritional challenges (Solomon and Leslie, 2015).

Large-scale farmers are more likely to adapt to climate change because they have more capital and resources (Hassan and Nhemachena, 2008; Aymone, 2009). Productive resources such as capital, land and labor serve as important factors for coping with and adapting to climate change. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources) at the disposal of farming households (Hassan and Nhemachena, 2008). The study focused on climate change adaptation strategies of cassava production where socio-economic variables and factors determining cassava farmers' choice of climate adaptation strategies were assessed for this study.

II. MATERIALS AND METHODS

2.1 Study Area

This research work was carried out in Southwest, Nigeria. The Southwest region is mainly a Yoruba speaking area, though there are different dialects within the same State. It consists of six States; Ekiti, Ondo, Osun, Oyo, Ogun and Lagos. The study area lies between longitudes $2^0\ 3^1$ and $6^0\ 00^1$ East of the Greenwich meridian and latitudes $6^0\ 2^1$ and $8^0\ 37^1$ North of the equator with a total land area of 77,818 km^2 and a population of 27,581,992 (NPC, 2006), with 2018 projected population estimate of 39,742,334 based on annual percentage population growth of 2.619% as reported by NPC, 2016.

The study area (Southwest, Nigeria) is bounded in the East by Edo and Delta States, in the North by Kwara and Kogi States, in the West by Republic of Benin and in the South by the Gulf of Guinea. The climate of South west Nigeria is tropical in nature. The weather condition varies between two distinct seasons in Nigeria; the rainy season (March - October) and the dry season (November - February). The dry season is characterized by the harmattan dust; cold dry winds from the northern deserts blow into the southern region. The temperature ranges between 21^0C and 34^0C, while the annual rainfall ranges between 1500mm and 3000mm (Falade, 2016). There is high temperature during the dry season with heavy rainfall during the rainy season (November to March). The wet season is associated with Southwest monsoon wind from Atlantic Ocean while the dry season is associated with the Northeast trade wind from Sahara desert (Otitoju and Enete, 2014).

The vegetation in Southwest Nigeria is made up of fresh water swamp and mangrove forest, the lowland in the forest stretches inland to Ogun and parts of Ondo State while secondary forest is towards the Northern boundary where derived and southern savannah exist (Faleyimu *et al.*, 2009). There are good soils favorable to agricultural production in the study area. Occupations common among the people of Southwest Nigeria include: farming, hunting, fishing, produce buying, sports, butchering and meat selling, crafts and trading. Agriculture provides income and employment for about 75% of the populace and they produce both food and cash crops. The food crops in this area are; rice, yam, cassava, maize, cocoyam and cowpea while the cash crops are; cocoa, oil palm, kolanut, plantain, banana, cashew, citrus and timber (Sakiru, 2013).

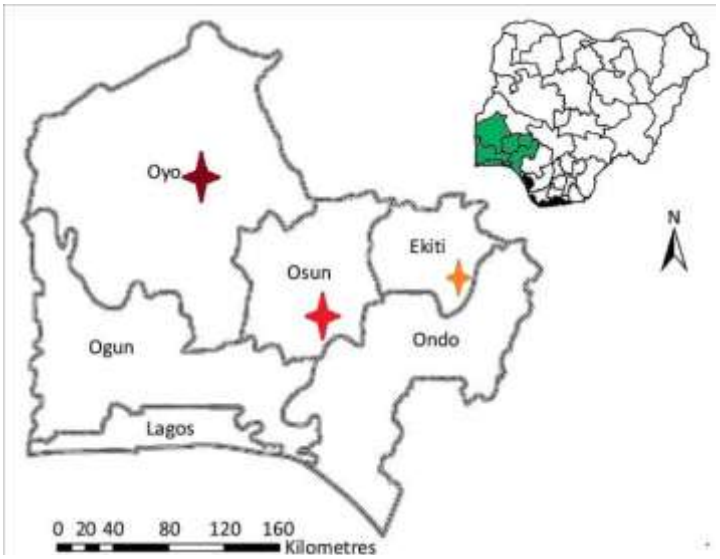

FIGURE 2: Map of Southwest, Nigeria showing the study area
Source: https://t2.gstatic.com/images

2.2 Sampling Procedure and Sample Size

A multi-stage sampling procedure was used in the selection of location and respondents for the study. At the first stage, three States; Ekiti, Osun and Oyo were randomly selected. The second stage involved purposive selection of one Local Government Area (LGA) of rainforest Agricultural Ecological Zones (AEZ) from each State based on the volume of cassava output. In Ekiti State, Emure LGA was selected because it is the highest cassava producing LGA in rain forest AEZ in the State (Ekiti State Ministry of Agriculture and Rural Development). Also, Atakunmosa East LGA was purposively selected as rain forest zones in Osun State based on their level of involvement in cassava production (Osun State Ministry of Agriculture and Food Security) while Ibarapa East LGA was chosen as rain forest AEZ in Oyo State based on their output level in cassava production in the State (Oyo State Ministry of Agriculture, Natural Resources and Rural Development). In totality, six (3) LGAs were chosen for the study. The third stage involved purposive selection of three communities from each LGA chosen based on their level of involvement in cassava production. In all, the study made use of eighteen (9) communities. Based on the population of the communities selected for this study, simple random sampling procedure was used to select between 15 to 20 respondents per community, indicating that equal number of respondents were not chosen from each community, but a total of 50 respondents per LGA remained consistent. In all, a total of 150 respondents were interviewed for the study.

2.3 Data Sources and Collection

Primary data were collected from 150 cassava farmers with the aid of a well-structured questionnaire, personal interview and Focus Group Discussion (FGD) sessions. The data comprised of socio-economic characteristics of the cassava farmers such as age, educational level, gender etc. and determinants of choice of adaptation strategies.

2.4 Method of Data Analysis

Descriptive statistical analysis was used to describe socio-economic variables of the respondents while multinomial logit model was used to determine cassava farmers' choice of climate adaptation strategies in the study area.

2.4.1 Multinomial Logit Model (MNL)

The determinants of cassava farmers' choices of adaptation strategies was analyzed using Multinomial Logit Model. Base on the finding of (Aenro *et al.*, 2015), the household decision of whether or not to undertake adaptation strategies for climate change is considered under the general framework of utility or profit maximization. For the purpose of this study, the six most commonly practiced climate change adaptation strategies were selected.

a. Use of improved varieties
b. Multiple planting dates
c. Increasing farm size
d. Mulching
e. Farm plots fragmentation
f. Crop diversification

Note: crop diversification was chosen as a reference point.
For climate change adaptation options, if a farmer decides to use option *j*, then it follows that the perceived utility or benefit from option *j* is greater than the utility from other options (say, *k*) depicted as:

$$U_{ij} = (\beta_j' X_i + \varepsilon_j) > U_{ik} = (\beta_k' X_i + \varepsilon_k), j \neq k \quad (1)$$

Where;

U_{Ij} and U_{ik} are the perceived utility by farmer i of adaptation options j and k respectively; i.e. Cassava output (kg)

X_i = Vector of explanatory variables which influence the choice of the adaptation option.

These are itemized below:

X_1 = Sex (Male =1, Female =0)

X_2 = Age (Years)

X_3 = Marital status (Married = 1, otherwise = 0)

X_4 = Educational level (Years of schooling)

X_5 = Livestock holding (Yes = 1, Otherwise =0)

X_6 = Farm income (₦)

X_7 = Farming experience (Years)

X_8 = Household size (number)

X_9 = Non-farm income (₦)

X_{10} = Frequency of extension contact (Number)

X_{11} = Access to climate change information (Yes = 1, Otherwise =0)

X_{12} = Amount of credit obtained (₦)

X_{13} = Farm size (Hectares)

X_{14} = Labour availability (Yes = 1, Otherwise =0)

X_{15} = Access to inputs (Yes = 1, Otherwise =0)

X_{16} = Fertility of the soil as perceived by the farmer (Fertile =1, otherwise= 0)

X_{17} = Temperature (Increased = 1, reduced =0)

X_{18} = Rainfall (Increased = 1, reduced =0)

X_{19} = Agro-ecological zones (Rain forest =1, guinea savanna = 0)

β_j andβ_k = Parameters to be estimated,

ε_j andε_k = Error terms.

III. RESULTS AND DISCUSSION

3.1 Socio-economic characteristics of the respondents

Table 1 revealed the distribution of cassava farmers in both AEZs based on their relevant socio-economic characteristics. The result showed that 78.67 and 21.30 percent of the respondents sampled in rain forest AEZ were found to be males and females respectively, 84.67 and 15.33 percent of the respondents from savannah were males and females respectively. This is in agreement with Otitoju and Enete (2014) who noted males are more involved in cassava production in Benue State. The result further reported 54 and 48 years as the mean age of cassava farmers in rain forest and savannah AEZs respectively, implying that cassava farmers in the study area were ageing. The cassava farmers in the study area were fairly educated as 41.7 and 26.7 percent of them acquired secondary education; this is expected to help the farmers in resource allocation in order to optimize productivity. The mean farm size cultivated in the entire study area as revealed by the pooled data was 1.6 hectares of land. This implies that these cassava farmers were still operating on small scale and this will have a tendency to reduce the production of cassava in the study areas. This is in consonance with Osanyinlusi and Adenegan (2018) who noted half of the farmers (50.0%) cultivated between 1-3 hectares of land for cassava production in Ekiti State. The finding revealed that the farmers had started farming when they were young. The mean years of farming experience was 10.6 years, which showed that the cassava farmers are experienced. This is expected to boost their production as they are familiar with the practices involved in cassava production and they would be able to mitigate against the loss or challenges they face as a result of climate change in the course of production, as it is often said 'experience is the best teacher. From the result, it was clearly reported that majority (72%) of the rainforest cassava farmers indicated that they were aware of climate change while the remaining 28% said they were not. Likewise, majority (96.7%) of the savannah cassava farmers indicated that they were aware of climate change while the remaining 3.3% said they were not. The result further showed the mean value of income generated in rain forest and savannah AEZs as ₦273,814 and ₦215,650 respectively.

TABLE 1
DISTRIBUTION OF CASSAVA FARMERS BASED ON RELEVANT SOCIO-ECONOMIC CHARACTERISTICS

Socio-economic variables	frequency	percentage	frequency	percentage
Sex				
Female	32	21.3	23	15.33
Male	118	78.67	127	84.67
Age				
≤30	5	3.3	15	10
31-40	22	14.7	20	13.3
41-50	41	27.3	58	38.7
51-60	61	40.7	40	26.7
>60	21	14	17	11.3
Level of education				
No primary education	18	12	40	26.7
Primary education	63	42	72	48
Secondary education	42	28	30	20
Tertiary education	27	18	8	5.3
Farm size				
≤2.0	85	66.7	104	69.3
2.1-5.0	54	36	41	27.3
>5.0	11	7.3	5	3.4
Farming experience				
5-Jan	33	22	27	18
10-Jun	47	31.3	42	28
15-Nov	58	38.7	20	13.3
>15	12	8	61	40.7
Awareness of climate change				
Aware	108	72	145	96.7
Not aware	42	28	5	3.3
Cassava income				
≤100,000	17	11.3	30	20
101,000-200,000	29	19.3	38	25.3
201,000-300,000	46	30.7	40	26.7
301,000-400,000	32	21.4	27	18
401,000-500,000	17	11.3	11	7.3
>500,000	9	6	4	2.7

Source: Computed from field survey data, 2018

3.2 Determinants of cassava farmers' choices of adaptation strategies to climate change

A multinomial logit MNL model was used to estimate the determinants of farmers' choices of adaptation practices to reduce the effect of climate change in rain forest AEZ in the study area. In this analysis, "crop diversification" was used as base category and the estimated coefficients compared with the base category. The likelihood ratio statistics indicated by the Chi-square test were found to be significant ($P < 0.01$) as indicated in Table 2, suggesting the model had a good fit. The use of the MNL model specification was found to be appropriate, and the model has been used previously by different studies to estimate the determinants of climate change adaptation options by farmers (Deressa *et al.*, 2009; Enete *et al.*, 2014 and

Negarsh, 2011, Abrham *et al.*, 2017).The problem of multicolinearity among the explanatory variables was tested using variance inflection factor and Contingency Coefficient for continuous and dummy explanatory variables, respectively. In both cases, no problem of multicolinearity was detected. Hence, the parameter estimates of the MNL model were used to provide the direction of the effect of the independent variables on the dependent (response) variable, whereas estimates represent neither the actual magnitude of change nor the probabilities (Table 2).

The result in Table 2 showed that being a male headed household, in rain forest AEZ, increased the likelihood of using improved varieties and increasing farm size as adaptation strategies at 5% and 1% significance levels compared to the base category. From the result, it was revealed that male-headed households had better opportunities to practice adaptation measures than the female-headed households. This finding is similar to a study by Deressa *et al.*, 2011 done in another part of Ethiopia that analyzed farmers' choices of climate change adaptation methods, which showed that male headed households could be more likely to have access to technologies and climate change information than female-headed households. As a result, they were in a better position to practice diverse adaptation strategies than the female-headed ones (Demetriades and Esplen, 2010).

The age of the household heads, in the rain forest AEZ, had positively influenced the decision to practice some of the adaptation strategies and negatively in the case of others. In this regard, age is positively related with the decision to use improved varieties, and it was statistically significant at 1%. Also, a positive relationship existed between age and multiple planting dates, indicating that as the farmers are ageing, they keep practicing multiple planting dates as adaptation strategy. This might be attributed to the experience and mastery they had had in cassava production in order to mitigate the climate change adversities. Contrarily, an inverse relationship existed among age, increasing farm size, mulching and farm plot fragmentation, implying that as the farmers got older, their farm size kept reducing, mulching of their cassava plots was reducing and farm plot fragmentation was becoming non-appealing. This might be caused by drudgery involved in all agronomic management practices in cassava production. Therefore, the strength to perform actively on the farm might not be there again bearing in mind the labour unavailability and rural-urban drift among the youths.

The coefficient of marital status was positively and significantly correlated to the probability of the households choosing the use of improved varieties at 1%. Also, the remaining four adaptation strategies were positively related to marital status, implying that households' heads who were married had higher tendency of adopting climate change adaptation strategies. This could be attributed to the fact that they had larger household size and dependents that they provide for their basic necessities i.e. feeding, clothing and education. Therefore, practicing different adaptation strategies to ensure food security was a task that needed to be done. The result conformed to the findings of Ajak *et al.*, 2018 who concluded that married and not aged households' heads were more knowledgeable about climate variability, suggesting that unmarried households' heads could have smaller household size which could mean less family labour for crop production practices and less engagement in adaptation strategy against climate change.

Years spent in school was found to be statistically significant (5%) and positively correlated with the use of improved varieties. This implies that being educated avails the farmers the access to improved varieties through information from radio, internet, television, Agricultural Development Projects (ADP) and interactions with friends. Also, multiple planting dates and mulching were positively correlated with the number of years spent in school while an inverse relationship existed between farm plots fragmentation as well as increasing farm size and years spent in school. Increasing the farm size does not always amount to increased output or income, but having a manageable size of farm does. Practicing farm plots fragmentation might not bring about efficiency in utilization of productive resources. This result agrees with the study of Kansiime, 2014 who observed that practicing farm plots fragmentation and increasing farm size is labour intensive and tedious, and this might be the reason why highly educated households would avoid using them than their less educated counterparts because education also broadens alternative income earning opportunities.

Livestock ownership positively influenced the cassava farmers' decision to practice the use of improved varieties because earnings or income from livestock enterprise(s) can be invested on improved varieties of cassava stem. Contrarily, all other adaptation practices (multiple planting dates, increasing farm size, mulching and farm plots fragmentation) had negative relationship with livestock ownership. This can be attributed to the fact that all the available adaptation practices are time consuming and tedious, and combining livestock rearing with practicing of those adaptation measures might appear difficult, bearing in mind that they had alternative source of income (livestock). This study conformed to the findings of Kurukulasuriya and Mendelsohn, 2008 who inferred that livestock ownership was found to be negatively correlated with multiple planting dates and other agronomic activities.

Use of improved varieties and increasing farm size were positive and statistically significant with farm income of households heads at 1 and 5% respectively. Also, multiple planting dates and mulching were positively related with farm income. Having huge output, which would translate to high income, would influence the farmers' decision to always plant improved varieties of cassava stem, and at the same time expand their farm size because there would be money to hire labour for agronomic activities. Contrarily, a negative interaction existed between farm income and farm plots fragmentation, implying that the higher the farm income, the lesser the practice of farm plot fragmentation as an adaptation strategy. The reason for this was that farmers with higher output preferred to acquire a large expanse of land in a particular location to ensure concentration and efficient allocation of resources rather than moving from one farm location to the other. This result is consistent with a study by Negarsh, 2011 which found that income had a positive relationship with changes in planting date and use of crop diversification.

Only the coefficient of use of improved varieties was found to be positively correlated and statistically significant at 10% with non-farm income. This is because having other sources of income might make improved varieties of cassava stem affordable to them. The result further revealed that all other four adaptation options (multiple planting dates, increasing farm size, mulching and farm plot fragmentation were inversely correlated with non-farm income. The reason for this was that they (cassava farmers) always found it difficult to sacrifice their time on practicing these adaptation options because most of them (adaptation practices) consume time, and the farmers needed to look for money from other sources asides farming in order to attend to their pressing needs. It was further revealed that increasing farm size was found to be positively correlated and statistically significant (10%) with labour availability, implying that labour availability was paramount in influencing the decision of the farmers to increase their farm size. In the same vein, the remaining four adaptation strategies were found to be positively correlated with labour availability, meaning that the more labour availability in the study area, the higher the cassava farmers practice these adaptation measures.

Farming experience had both positive and negative effects on some climate change adaptation strategies. It helped to stimulate response to the negative effects of climate change on agriculture. From the result, it was revealed that multiple planting dates was positively correlated and statistically significant at 1%. Also, farming experience was positively correlated with the use of improved varieties and mulching, indicating that more experienced farmers are assumed to have better knowledge about weather information and its implication on agricultural practices. On the other hand, increasing farm size and farm plots fragmentation were found to be negatively related with farming experience. This implies that the cassava farmers in the study area, based on their wealth of experience, concluded that increasing farm size and farm plots fragmentation did not necessarily amount to increased output, but concentrating the farm on a particular location, efficient allocation and intensification productive resources would bring about improved output. This result is consistent with the findings of Bazezew *et al.*, 2013 who observed that farmers chose adaptation practices based on their experience.

The coefficient of household size was positively correlated and statistically significant ($p < 0.05$) with increasing farm size, meaning that the larger the household size, the more the farm size cultivated for cassava production. This reason for this is that having larger household size would avail them family labour, thereby giving them the opportunity to increase their farm size. The result revealed further that the use of improved varieties, mulching and farm plots fragmentation were also positively related with household size, indicating that as the household size increases, the probability of practicing these adaptation options also increases. An inverse relationship existed between household size and the practice of multiple planting dates as adaptation strategy, meaning as the household size kept increasing, the probability of practicing multiple planting dates was diminishing. This could happen to household that is dominated by students. They were only available for farming activities during the weekends and holidays, and these are not enough times to assist the household heads in practicing multiple planting dates as an adaptation strategy. The result is in line with the findings of Kurukulasuriya and Mendelsohn, 2008 and Gbetibouo, 2009 who observed that larger family size and a larger number of productive household members increased agricultural production because it was associated with labor-intensive agricultural practices. Thus, household size has a significant association with some of the adaptation categories.

Farm size was positively correlated and statistically significant at 5% with the practice of increasing farm size, implying that household heads with larger farm size had a greater probability to increase their farm size. On the other hand, farm size was inversely related and statistically significant at 10% with farm plot fragmentation, indicating that the larger the farm size, the lesser the practice of farm plots fragmentation. This is because farmers with large farm size, concentrated on a particular location, can hardly think of having another farm elsewhere. The result further revealed that practicing of the use of improved varieties and mulching were inversely correlated with farm size while multiple planting dates co-moved with farm size.

All the coefficients of adaptation practices were negatively correlated with the amount of credit obtained, meaning that as the amount of credit obtained increased, the probability of practicing these adaptation measures reduced. This could be attributable to the fact that this credit, if truly obtained, was not spent on the purpose it was sourced for. Diverting this credit on payment of children's school fees and other pressing social needs had negative effect on practicing adaptation strategies. Access to climate information is an important variable that affects adaptation options. The results showed that as expected, access to climate information had impacted adaptation to climate change. Those (farmers) who had access to weather information had a higher probability of implementing climate change adaptation strategies such as use of improved varieties, multiple planting dates, increasing farm size, mulching and farm plots fragmentation which were all positively correlated with access to climate information. Access to climate information was statistically significant at 5% with the practice of multiple planting dates as an adaptation strategy. That is, cassava farmers who had better access to weather information (i.e., seasonal or mid-term forecasting) made better informed adaptation decision. This study is similar to the findings of Melka *et al.*, 2015.

Access to extension was positively and significantly (5%) related with the use of improved varieties, implying that the more the cassava farmers received the extension agents, the better the willingness to embrace improved varieties. It is the responsibility of extension agents to introduce these improved varieties to the farmers and made them realized the benefits inherent in adopting them. All the adaptation practices under this study, except farm plots fragmentation, had positive interaction with access to climate information, implying that access to extension services increases the probability of adopting different adaptation practices. Result of this study agrees with the findings of Abrham, 2017. Coefficients of increasing farm size and farm plots fragmentation were positive and statistically significant at 1% and 10% with access to inputs respectively. This indicated that the more the cassava farmers had access to inputs the higher the probability of practicing increasing farm size and farm plots fragmentation. Also, the result showed further that the use of improved varieties and multiple planting dates moved in the same direction with access to inputs while mulching was inversely correlated. It is evident from the result that seamless access to farm inputs stimulates practice of diverse adaptation strategies.

Different effects of rainfall on the practice of adaptation strategies were revealed in the result. Multiple planting dates and increasing farm size were positively and statistically significant at 5% with rainfall, implying that, with increased rainfall, cassava farmers in the study area were encouraged to expand their farm size and practiced multiple planting dates. From the result, it was evident that increased rainfall prevented the farmers from embracing the use of improved varieties, mulching and farm plots fragmentation. This is because, with increased rainfall, there was no need for improved varieties like drought resistant and early maturing varieties. Also, mulching of the cassava plots is not necessary since required volume of rainfall is guaranteed.

Likewise rainfall, mixed effects of temperature on practice of adaptation strategies were made known in the result. Practicing the use of improved varieties, multiple planting dates and mulching were statistically significant at 5%, 10% and 5% respectively. While positive relationship existed between increased temperature and the use of improved varieties and mulching, multiple planting dates, increasing farm size and farm plots fragmentation moved in negative direction with temperature. This implies that with increased temperature, farmers were ready to embrace improved varieties of cassava stems, which could withstand the adversity of climate change, as their adaptation strategy. Also, mulching was widely used among the cassava farmers as adaptation strategy to mitigate the harsh effect of extremely high temperature on the cassava production while increased temperature adversely affected the practice of multiple planting dates, increasing farm size and farm plots fragmentation.

The result further showed an inverse, but statistically significant (5%), relationship between soil fertility and increasing farm size, implying that as the fertility of the soil increases, the cassava farmers reduced their farm size or maintained the normal farm size being cultivated. The reason for this is that increasing their farm size beyond what they could manage would bring about efforts in futility since a manageable farm size would still achieve maximum output. In the same vein, the use of improve varieties and farm plots fragmentation were found to be negatively correlated with soil fertility, implying that the more the soil was reported to be fertile, the lesser the practice of the use of improved varieties and farm plots fragmentation, as adaptation options, would be embraced. This is because the farmers believed that any variety of cassava, either local or foreign species, would flourish on fertile soil. On the other hand, multiple planting dates and mulching were positively correlated with soil fertility, implying that improved soil fertility encouraged the practice of multiple planting dates and mulching as adaptation strategies.

TABLE 2

PARAMETER ESTIMATES OF THE MULTINOMIAL LOGIT MODEL FOR CLIMATE CHANGE ADAPTATION DECISIONS

Explanatory variables	Use of improved varieties	Multiple planting dates	Increasing farm size	Mulching	Farm plot frag.
	Coefficients	**Coefficients**	**Coefficients**	**Coefficients**	**Coefficients**
Sex	0.047*** (0.001)	0.067 (0.114)	0.1156** (0.043)	0.314 (0.134)	0.413 (0.971)
Age	0.051** (0.021)	0.411 (0.162)	-0.332** (0.041)	-0.213 (0.174)	-0.376 (0.142)
Marital status	0.226** (0.031)	0.417 (0.231)	0.412* (0.072)	0.521 (0.443)	0.094* (0.081)
Years spent in school	0.071*** (0.003)	0.068 (0.731)	-0.095 (0.535)	0.629 (0.174)	-0.051 (0.412)
Livestock holding	0.992 (0.423)	-0.777 (0.427)	-0.006478	-0.500 (0.606)	-0.211 (0.843)
Farm income	0.163*** (0.000)	0.216 (0.604)	0.475** (0.041)	0.175 (0.410)	-0.236 (0.450)
Non-farm income	0.078* (0.091)	-0.416 (0.722)	-0.021** (0.022)	-0.812 (0.762)	-0.612 (0.139)
Labour availability	0.241 (0.691)	0.086 (0.316)	0.029** (0.039)	0.062 (0.385)	0.541 (0189)
Farming experience	0.056 (0.140)	0.035 (0.014)	-0.612 (0.261)	0.041*** (0.644)	-0.497 (0.358)
Household size	0.118 (0.155)	-0.019 (0.211)	0.014* (0.090)	0.063 (0.494)	0.161 (0.477)
Farm size	-0.367 (0.171)	0.028 (0.159)	0.607** (0.040)	-0.660 (0.170)	-0.659** (0.017)
Amount of credit obtained	0.061*** (0.001)	-0.375 (0.181)	0.061** (0.042)	-0.891 (0.146)	-0.344 (0.103)
Access to climate info.	0.270 (0.148)	0.581** (0.042)	0.445 (0.699)	0.415** (0.031)	-0.132 (0.878))
Extent of extension contact	0.333** (0.011)	0.032 (0.713)	0.058 (0.304)	0.481** (0.045)	-0.611 (0.312)
Access to inputs	0.206 (0.201)	0.230 (0.509)	0.192*** (0.000)	-0.431 (0.619)	0.621* (0.067)
Rainfall	-0.176 (0.113)	0.144 (0.533)	0.213** (0.047)	-0.096*** (0.001)	-0.073 (0.619)
Temperature	0.028** (0.000)	-0.625 (0.429)	0.849 (0.772)	0.313*** (0.002)	-0.703 (0.307)
Soil fertility	-0.553 (0.481)	0.260 (0.443)	-0.319** (0.031)	-0.190 (0.316)	-0.446 (0.503)
Base category: Crop diversification					
Number of observation	150				
Log likelihood	690.815				
Prob> Chi^2	0				
Pseudo R-square	0.237				
LR Chi^2	171.451				

Source: Computed from Field Survey Data, 2018

****, **, *** stand for level of significance at 10%, 5%, and 1%, respectively.***

Note: Figures in parentheses are p-values, frag. = fragmentation

3.3 Marginal Effects of Choice of Climate Change Adaptation Strategies Used among Cassava Farming Households

Table 3 revealed the marginal effects on the choice of climate change adaptation strategies among cassava farmers in rain forest AEZ in southwest, Nigeria. From the result, it was shown that as the age of the household head increased by a year, the probability of the households practicing the use of improved varieties increased by 12.7% and those practicing multiple planting increased by 7.5%. Contrarily, a unit increase in age of the household head resulted in 3.5%, 4.9% and 8.3% decrease in the probability to practice increasing farm size, mulching and farm plot fragmentation as climate change adaptation strategies respectively. The result further revealed that a unit increase in number of married households' heads increased the probability of practicing the use of improved varieties by 4.2%, multiple planting dates by 1.6%, increasing farm size by 2.1%, mulching by 1.2% and farm plot fragmentation by 5.1%. The result conformed to the findings of Ajak *et al.,* 2018 who concluded that married and not aged households' heads were more knowledgeable about climate variability, suggesting that unmarried households' heads could have smaller household size which could mean less family labour for crop production practices and less engagement in adaptation strategy against climate change.

Regarding the years spent in school, a unit increase in number of years spent in acquiring education would lead to 13.9%, 7.4%, 1.6% increase in the probability of choosing and using improved varieties of cassava stem, multiple planting dates and mulching respectively. This is because educated farmers are expected to adopt new technologies based on their awareness of the potential benefits from the proposed climate change adaptation measures. Contrarily, it brought about decrease in the probability of increasing farm size and farm plots fragmentation by 1.2% and 6.4% respectively. Owning livestock would lead to 2.1% increase in the probability of choosing and using improved varieties of cassava stem as adaptation strategy. On the other way round, a unit increase in the number of households' heads rearing livestock would bring about 4.3%, 8.8%, 2.9% and 16.8% decrease in the probability of practicing multiple planting dates, increasing farm size , mulching and farm plots fragmentation respectively. This study conformed to the findings of Kurukulasuriya and Mendelsohn, 2008 who inferred that livestock ownership was found to be negatively correlated with multiple planting dates and other agronomic activities.

From the result, it was revealed that a unit increase in household farm income increased the likelihood to practice the use of improved varieties, multiple planting dates, increasing farm size and mulching by 16.3%, 2.2%, 4.7% and 1.7% respectively. This result is consistent with a study by Negash, 2011 which found that income had a positive relationship with changes in planting date and use of crop diversification. Also, a unit increase in non-farm income would increase the likelihood to practice the use of improved varieties by 7.8% while it would reduce the likelihood to practice multiple planting dates by 4.2%, increasing farm size (2.1%), mulching (8.1%) and farm plots fragmentation by 6.1%.The result further showed that a unit increase in labour availability would increase the likelihood to practice the use of improved varieties, multiple planting dates, increasing farm size, mulching and farm plots fragmentation by 6.1%, 9.7%, 12.8%, 2.7% and 12.7% respectively. From the result, it was evident that labour availability (hired and family labour) was very essential in using adaptation practices. On the same vein, a unit increase in farming experience would increase the probability to practice the use of improved varieties by 13.4%, multiple planting by 5.6%, and mulching by 2.2% while it would reduce the likelihood to practice increasing farm size by 6.2% and farm plots fragmentation by 0.6%. This result is consistent with the findings of Bazezew *et al.,* 2013 who observed that farmers chose adaptation practices based on their experience.

The result showed that a unit increase in household size increased the likelihood to practice the use of improved varieties by 1.3%, multiple planting dates by 9.1%, mulching by 1.9% and farm plots fragmentation by 1.8% and reduced the likelihood of practicing multiple planting dates by 4.5%. The result is in line with the findings of Kurukulasuriya and Mendelsohn, 2008 and Gbetibouo, 2009 who observed that larger family size and a larger number of productive household members increased agricultural production because it was associated with labor-intensive agricultural practices. Thus, household size has a significant association with some of the adaptation categories. Regarding the farm size, the result of marginal effects revealed that a unit increase in farm size reduced the likelihood to practice the use of improved varieties by 2.4%, mulching by 0.7% and farm plots fragmentation by 15.8% while it increased the practice of multiple planting dates by 2.9% and increasing farm size by 6.2%. As it was further revealed from the result of marginal effect, a unit increase in the amount of credit obtained reduced the probability of practicing the use of improved varieties by 3.2%, multiple planting dates by 1.6%, increasing farm size by 2.1%, mulching by 1.1% and farm plots fragmentation by 8.7%. Being well informed about weather variability increased the likelihood of practicing the use of improved varieties by 5.5%, multiple planting dates by 9.6%, increasing farm size by 1.9%, mulching by 6.8% and farm plots fragmentation by 8.3%. This study is similar to the findings of Melka *et al.,* 2015.

TABLE 3
MARGINAL EFFECTS FROM (MNL) DETERMINANTS OF CHOICE OF CLIMATE CHANGE ADAPTATION STRATEGIES USED AMONG CASSAVA FARMING HOUSEHOLDS

Explanatory variables	Use of improved varieties	Multiple planting dates	Increasing farm size	Mulching	Farm plot frag.
	Coefficients	Coefficients	Coefficients	Coefficients	Coefficients
Sex	0.086*** (0.000)	0.097 (0.167)	0.061* (0.074)	-0.011 (0.815)	0.066 (0.782)
Age	0.127*** (0.005)	0.075 (0.145)	-0.00322	-0.049 (0.270)	-0.083 (0.314)
Marital status	0.042* (0.062)	0.016 (0.268)	0.021 (0.233)	0.012 (0.566)	0.051 (0.310)
Years spent in school	0.139** (0.038)	0.170 (0.189)	-0.015 (0.667)	0.021 (0.245)	-0.012 (0.250)
Livestock holding	0.054 (0.437)	-0.098 (0.277)	-0.008832	-0.067 (0.513)	-0.275 (0.367)
Farm income	0.324** (0.034)	0.145 (0.176)	0.165** (0.042)	0.010 (0.315)	0.062 (0.386)
Non- farm income	0.015 (0.357)	-0.423 (0.233)	-0.125 (0.334)	-0.114 (0.081)	-0.012848
Labour availability	0.185** (0.035)	0.087 (0.555)	0.157* (0.096)	0.054 (0.873)	0.145 (0.534)
Farming experience	0.198 (0.400)	0.156*** (0.029)	-0.069 (0.314)	0.056(0.498)	-0.156 (0.675)
Household size	0.124 (0.451)	-0.045 (0.464)	0.133** (0.041)	0.068 (0.377)	0.098 (0.438)
Farm size	-0.235 (0.387)	0.140 (0.256)	0.099** (0.014)	-0.080 (0.721)	-0.04482
Amount of credit obtained	-0.216 (0.222)	-0.239 (0.165)	-0.007546	-0.033 (0.615)	-0.186 (0.342)
Access to climate info.	0.189 (0.225)	0.198** (0.022)	0.076 (0.156)	0.071 (0.815)	0.098 (0.316)
Extent of extension contact	0.356** (0.032)	0.098 (0.166)	0.113 (0.867)	0.027 (0.309)	-0.010 (0.400)
Access to farm inputs	0.247 (0.233)	0.134 (0.161)	0.146** (0.044)	-0.009 (0.254)	0.091* (0.074)
Rainfall	-0.011 (0.266)	0.067** (0.050)	0.136** (0.045)	-0.145 (0.587)	-0.247 (0.417)
Temperature	0.089 ** (0.038)	-0.00702	-0.097 (0.186)	0.197** (0.039)	-0.093 (0.653)
Soil fertility	-0.031 (0.609)	0.051 (0.344)	0.068** (0.019)	-0.048 (0.289)	-0.312 (0.672)

Source: Computed from Field Survey Data, 2018
****, **, *** stand for level of significance at 10%, 5%, and 1%, respectively.***
Note: Figures in parentheses are p-values, frag. = fragmentation

Having access to extension packages increased the likelihood of practicing the use of improved varieties by 32%, multiple planting dates by 24%, increasing farm size by 1.5%, mulching by 12% and farm plots fragmentation by 8.3%. Also, the result showed that a unit increase in access to inputs increased the likelihood of practicing the use of improved varieties by 3.6%, multiple planting dates by 2.4%, increasing farm size by 9.1% and farm plots fragmentation by 7.5% while it reduced adoption of mulching by 0.4%. It is evident from the result that seamless access to farm inputs stimulates practice of diverse adaptation strategies. The result further revealed that a unit increase in the volume of rainfall would increase the probability of multiple planting dates by 6.8% and increasing farm size by 9.7%. Contrarily, a unit increase in rainfall decreased the practice to use improved varieties by 3.3%, mulching by 13.6% and farm plots fragmentation by 22.9%. Unlike rainfall, a unit increase in temperature brought about increase in probability of practicing the use of improved varieties of cassava stems and mulching by 6.6% and 17.2% respectively. The result showed further that a unit increase in temperature reduced the likelihood of practicing multiple planting dates by 8.8%, increasing farm size by 6.1% and farm plots fragmentation by 6.7%. From the result, it was made clear that a unit increase in soil fertility resulted in likelihood to practice multiple planting dates by 4.9% and increasing farm size by 4.1%. The result further revealed that a unit increase in soil fertility reduced the probability of practicing the use of improved varieties by 2.1%, mulching by 0.8% and farm plots fragmentation by 2.4%.

IV. CONCLUSION AND RECOMMENDATIONS

Mixed effects of socio-economic and climatic variables were observed on choice of adaptation practices in the study area. It was concluded that sex, age, marital status, years spent in school, farm income, amount of credit received and temperature greatly influenced the decision of cassava farmers to choose adaptation strategies in rain forest AEZ. It is therefore recommended that government should provide adequate extension services with knowledgeable and skilled extension agents who are equipped with climate useful information, thereby making the farmers aware about the available adaptation strategies to climate change and the benefits inherent in them; farmers, via extension agents, should be encouraged to use improved varieties of cassava as adaptation strategy in order to achieve increased output and multiple planting dates should be embraced by the cassava farmers.

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Use of Crop Ranking Technique for Quantitative Evaluation of Landuse in Ahmednagar District in 1960-61 and 2010-11

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Abstract— *The net sown area, current fallows and land under tree crops and groves are included in agricultural land use. Use of land is an important factor for planning process because of the finite nature of land resource. Ahmednagar district in Maharashtra covered an area of about 17 lakh hectare comprising nearly 73.52percent area under net sown area in 1971-1972. Area under forest decreased slightly, area not available for cultivation decreased by 0.52 percent, other uncultivated area increased by 0.38 percent, while fallow land decreased by 0.92 percent during that period. Among the talukas, overall volume of change is greater in Nagar, Sangamner, Shrirampur and Newasa tahsils probably due to dynamic conditions existing there.*

Keywords— Land Utilization, Fallow land, Net Sown Area.

I. INTRODUCTION

Agriculture is very important occupation in most of the Indian states. Agricultural scientists, economists, geographers and many others are engaged in the study of agriculture. Utilization requires proper planning for being limited resource. For agriculture, land is a very important resource. For its large area size, and physical and socio-cultural diversities, Ahmednagar has different types of land uses. Agriculture is predominant economic activity in Ahmednagar, engaging nearly three-fifths of its working population. Though the share of agricultural sector in gross domestic product has considerably declined to about one-fourth yet the importance of agriculture as employment provider to workforce especially in the countryside is very high. Obviously, agriculture forms the hub of Indian economy as a large number of industries are also heavily dependent on agriculture for supply of raw materials. Agriculture involves not only crops rising but also animal ranching and fishing. Here an attempt has been made to study the land use pattern in Ahmednagar district from 1960-61 to 2010-11.

II. DATA SOURCE & METHODOLOGY

Secondary data has been used from Socio-Economic Reviews and District Statistical Abstracts of Ahmednagar District from 1961 to 2011. The data have been collected for various crops for the year 1960-61 and 2010-11 in both kharif and rabbi crops from taluka headquarter office, Ahmednagar District Gazetteer, Socio-Economic Abstract of Ahmednagar District and Census Handbook of Ahmednagar District are sources of data for this study. It is supplemented by numerous spot-inquiries. The areas of crop have converted into percentage (to net sown area) which is later on, used for ranking of crops to identify the relative strength of individual crop.

2.1 Objectives

- To know the availability of land in Ahmednagar and its different uses.
- To present area wise efficiency of the crops grown in the taluka by ranking and analysis the factors responsible for this rank distribution.

2.2 Study Area

Ahmednagar district in western Maharashtra region of Maharashtra state is an economically and agriculturally developed area. In 1961-62, there were thirteen tahsils in Ahmednagar district. The District 'Ahmednagar' is located middle part of the bank of Godavari and Mula river. This lays between 18°02′North 19°09'north to 73°09′East 75°05′East longitude with an area of 1701836 hectors of land and in thirteen tahsils as per 1971-72 District gazetteers. It has an average elevation of 549 metres (1,801 ft) from mean sea level Physiography, rainfall, soil, temperature, and drainage influences on agricultural land use pattern in this district. Rainfall varies between 508 to 635 mms annually. The underline basalt on disintegration and decomposition brought various agents had yielded three kinds of soils viz. Deep black, deep & shallow Alluvial soils in Pravara, Mula and Seena river basins. These rivers are main irrigation source of middle district areas. The rainfall is mainly due to rain shadow area in term of amount of rainfall average receives 571.5 mms in western and middle part of district but southern part of district six talukas are totally drought prown area. Therefore these areas are mostly hilly and unirrigated. The

variation in amount of rainfall & type of soil exerts influence on the Land use pattern of the study region in 1960-61 to 2010-11.

The crops growth and cultivation are closely related to environmental condition, use of high yielding varieties seeds, improved and efficient instrument, new irrigation technique, applications of chemical fertilizers and pesticides. The hectare under individual crop gives comparative efficiency and realistic picture of crop landuse in the analysis of crop ranking of the study region. The ranks of crops and their combination provide spatial variation in the distribution patterns. In this respect the study of crop combination and diversification manifests the present agricultural scenario.

2.3 Crop Ranking

TABLE 1
CROPS RANKING (1960-61)

Sr. No.	Crops	Crops Ranks and Number of Talukas							
		I	II	III	IV	V	VI	VII	VIII
1	Jawar	11	01	--	--	--	--	01	--
2	Bajara	01	07	01	02	01	01	--	--
3	Fodder Crops	01	--	--	02	03	01	05	01
4	Pulses	--	03	03	04	01	02	--	--
5	Oilseeds	--	01	07	01	04	--	--	--
6	Sugarcane	--	01	01	01	--	--	01	03
7	Cotton	--	--	01	01	--	02	03	04
8	Wheat	--	--	--	01	04	07	01	--
9	Rice	--	--	--	01	--	--	--	--
10	Vegetables	--	--	--	--	--	--	01	04
11	Condiments & Spices	--	--	--	--	--	--	01	01
Total Talukas		**13**	**5**	**12**	**13**	**4**	**9**	**2**	**5**

(Compiled by the Researcher)

TABLE 2
CROPS RANKING (2010-11)

Sr. No.	Crops	Crops Ranks and Number of Talukas							
		I	II	III	IV	V	VI	VII	VIII
1	Jawar	05	01	01	--	--	01	01	01
2	Bajara	04	06	01	--	01	--	01	--
3	Oilseeds	02	01	--	03	01	--	01	01
4	Cotton	01	01	01	--	01	02	--	01
5	Fodder Crops	01	--	--	--	--	01	04	03
6	Sugarcane	01	01	01	02	--	02	02	03
7	Wheat	--	01	05	--	05	01	--	--
8	Pulses	--	01	03	01	04	03	02	--
9	Rice	--	01	--	--	--	--	--	--
10	Vegetables	--	01	01	03	02	03	--	--
11	Condiments & Spices	--	--	01	--	--	--	--	--
12	Fruits	--	--	--	02	--	01	02	03
13	Maize	--	--	--	01	--	--	01	02
Total Talukas		**14**	**5**	**2**	**3**	**2**	**1**	**3**	**5**

(Compiled by the Researcher)

The ranking attained for thirteen crops in 1960-61 and 2010-11 for thirteen main crops in the district to recognize the comparative value of individual crop in cropping pattern. The first eight ranking crops have been recognize and mapped (Map 1 to Map 8). The ranking of crops and number of talukas have been shown in Table 1 and 2.

2.3.1 First Ranking

Map 1.A and B have shown the first ranking crops in the district. Three crops were respectively Jawar, Bajra and Fodder crops in 1960-61 and six crops respectively jawar, bajra, oilseeds, cotton, fodder crops and sugarcane in 2010-11 are recognize occupied first rank. In the district Jawar was the major crop stands as first rank and found to have largest coverage in the district from 1960-61 to 2010-11. The auspice environment in the district was beneficial for growing jawar on light black soils. In 1960-61, jawar was covered on 642779 hectares (88.46%) in eleven talukas, respectively, Kopargaon, Rahata, Shrirampur, Newasa, Shevgaon, Pathardi, Nagar, Rahuri, Parner, Shrigonda, Karjat and Jamkhed while in 2010-11 Jawar had covered on 287331 hectares (54.50%) in the five talukas, viz. Nagar, Parner, Shrigonda, Karjat and Jamkhed in the district. It observed 33.96 percent area decreased within the study period.

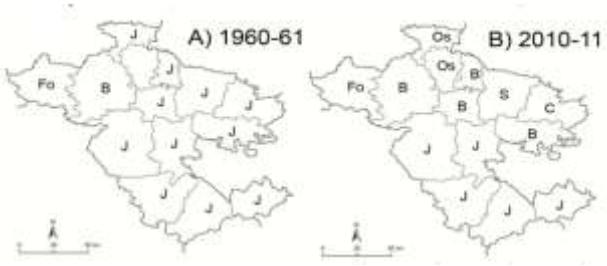
Bajara was identified as the second major crop in 1960-61 in the area under study. Bajara was the major crop grown in Sangamner taluka of the district (Map 1.A) and covered 57564 hectares (7.92%). While bajara identified as the second major crop in 2010-11 in the area under study. Bajara had grown in four talukas respectively Sangamner, Rahuri, Pathardi and Shrirampur and confined to the middle part of the district (Map 1.B) covered 104425 hectares (19.81%). The other crops were growing like jawar and bajara were not growing on the slopping land. Fodder crops were as major crop in Akole taluka. A Fodder crops was hold first rank on 26289 hectares (3.62%) at Akole taluka in 1960-61. Oilseeds hold first rank on 31321 hectares (5.94%) in 2010-11 at Kopargaon and Rahata talukas. The preference of farmers of this talukas leads to cultivation of oilseeds (Map 1.A&B). Then Sugarcane holds first rank on 47140 hectares (8.94%) at Newasa taluka while fodder crops rank first on 42621 hectares (8.08%) at Akole taluka in the district. While Cotton holds first rank on 14330 hectares (2.72%) at Shevgaon taluka (Map 1.B).

2.3.2 Second Ranking

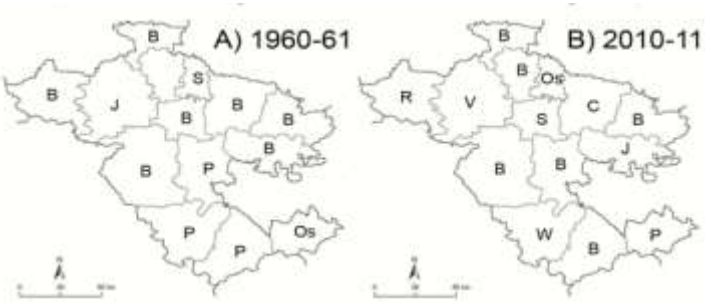
The second ranking crops were relatively more than those of first ranking. Map 2.A & B reveals five crops respectively Bajara, Pulses, Jawar, Sugarcane and Oilseeds in 1960-61 and nine crops in 2010-11 ranked second. These nine crops are Bajara, Cotton, Pulses, Jawar, Sugarcane, Vegetables, Rice, Wheat and Oilseeds. In 1960-61 Bajara was dominant in the district and holds the second rank in seven talukas viz. Rahuri, Newasa, Shevgaon, Pathardi, Parner, Akole and Kopargaon of Ahmednagar district. It covered 144059 hectares area in the district (Map 2.A) and associated with the land and climatic conditions of these talukas which was very favourable for bajara cultivation. While in 2010-11 Bajara was dominant in the district and holds the second rank in six talukas respectively Kopargaon, Rahata, Shevgaon, Nagar, Parner and Karjat and occupied wide spread in size in Ahmednagar District. It covered 135172 hectares (51.26%) area in the district (Map 2.B). The land and climatic conditions of those talukas were very favourable for vegetable cultivation.

In 1960-61 (Map 2.A) Pulses ranked second in three talukas viz. Nagar, Karjat and Shrigonda covered 31937 hectares (14.24%) in the district (Map 2.A). The relative intensity of concentration of pulses was in Shrigonda, Nagar and Karjat talukas. While Jawar rank second in Sangamner talukas covered 26362 hectares (11.75%) in the district (Map 2.A). Sugarcane and Oilseeds also identified as second ranked crops in the district. Sugarcane occupied 13348 hectares (5.95%) in Shrirampur taluka while Oilseeds occupied 8611 hectares (3.84%) in Jamkhed taluka (Map 2.A).

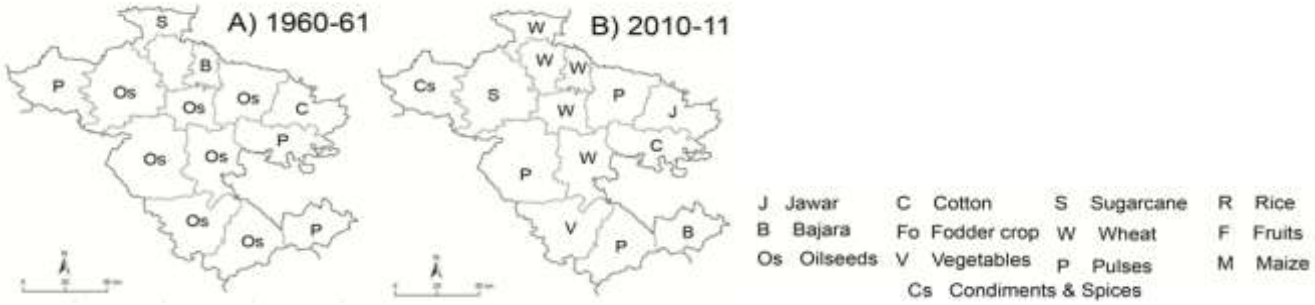
In 2010-11 (Map 2.B) Cotton ranked second in Newasa taluka covered 28006 hectares (10.62%) in the district (Map 2.B). Pulses stand second in Jamkhed taluka covered 25149 hectares (9.54%) in the district (Map 2.B). Jawar ranked second in Pathardi taluka covered 23137 hectares (8.77%) in eastern part of the district. These taluka were associated with low rainfall in the district as it appears to hardly crop to grow. Sugarcane ranked second in Rahuri taluka covered 15285 hectares (5.80% in the district. Vegetable ranked second in Sangamner taluka covered 10358 hectares (3.93%) in the district. Rice ranked second in Akole taluka covered 9810 hectares (3.72%) in western part of the district. These taluka are associated with high rainfall in the district as it appears to hardly crop to grow. Wheat and Oilseeds also identified as second ranked crops in the district. Wheat occupied 9635 hectares (3.65%) in Shrigonda taluka while Oilseeds occupied 7127 hectares (2.70%) in Shrirampur taluka (Map 2.B).



MAP 1: Ahmednagar District First Ranking Crop



MAP 2: Ahmednagar District Second Ranking Crop



MAP 3: Ahmednagar District Second Ranking Crop

2.3.3 Third Ranking

It is evident from Map 3 that the third ranking crops were widely spread in their areal distribution pattern. The ranking crops were Oilseeds, Pulses, Bajara, Sugarcane and Cotton in 1960-61 and eight in numbers in 2010-11. These eight crops were Wheat, Pulses, Jawar, Bajara, Cotton, Sugarcane, Vegetables and Condiments and Spices. It has seen from Map 3.A & B that oilseeds occupied first position covered 64825 hectares (52.37%) in seven talukas respectively Nagar, Rahuri, Newasa, Sangamner, Parner, Shrigonda and Karjat in 1960-61 while in 2010-11 wheat occupied 39460 hectares (42.59%) in five talukas respectively Kopargaon, Rahata, Shrirampur, Nagar and Rahuri hold third rank in Ahmednagar district while Pulses occupied 23584 hectares (19.5%) in Akole, Pathardi and Jamkhed talukas. Bajara, Sugarcane and Cotton hold third rank in the district (1960-61) and observed each in one taluka. Sugarcane occupied 12552 hectares (10.14%) in Kopargaon taluka, Bajara occupied 11454 hectares (9.25%) in Shrirampur taluka, while Cotton occupied 11369 hectares (9.18%) in Shevgaon taluka in the Ahmednagar District (Map 3.A).

Pulses hold third rank in the district and observed in three taluka (2010-11) occupied 18923 hectares (20.42%) in Newasa, Parner and Karjat talukas. Sugarcane, Bajara, Condiments and Spices, Jawar, Cotton and Vegetables stands as third ranking crops each in one taluka. Sugarcane occupied 9282 hectares (10.02%) in Sangamner, Bajara occupied 6195 hectares (6.69%) in Jamkhed, Condiments & Spices occupied 6087 hectares (6.57%) in Akole taluka, Jawar occupied 5670 hectares (6.12%) in Shevgaon taluka while Cotton occupied 4590 hectares (4.95%) in Pathardi taluka and Vegetables occupied 2446 hectares (2.64%) in Shrigonda taluka in the district (Map 3.B).

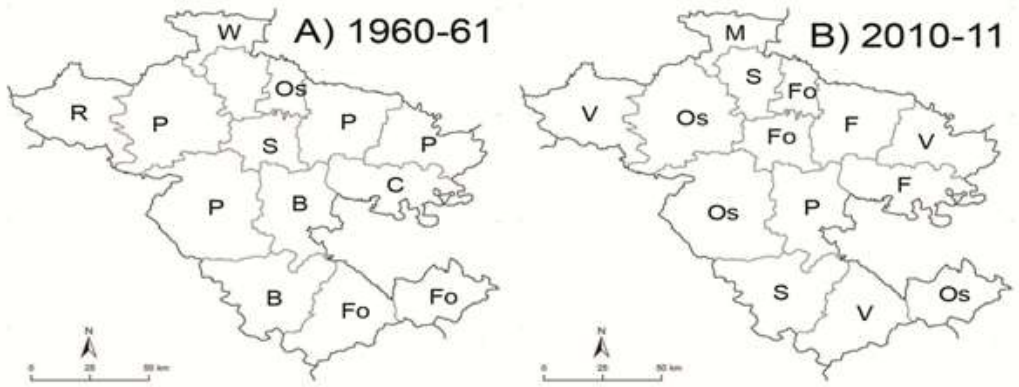
2.3.4 Fourth Ranking

Fourth ranking crops were presented a much varied distribution both were space and the number of crops involved (Map 4.A & B). There were eight crops, viz. Pulses, Bajara, Fodder crops, Oilseeds, Sugarcane, Cotton, wheat and Rice in 1960-61and seven crops respectively Oilseeds, Vegetables, Sugarcane, Fruits, Fodder crops, Pulses and Maize in 2010-11. Pulses hold largest covered (i.e. 39.54 percent in 1960-61) among fourth ranking crops in Ahmednagar District. It was cultivated in Newasa, Shevgaon, Parner and Sangamner in 1960-61and it covered 35254 hectares (39.54%).

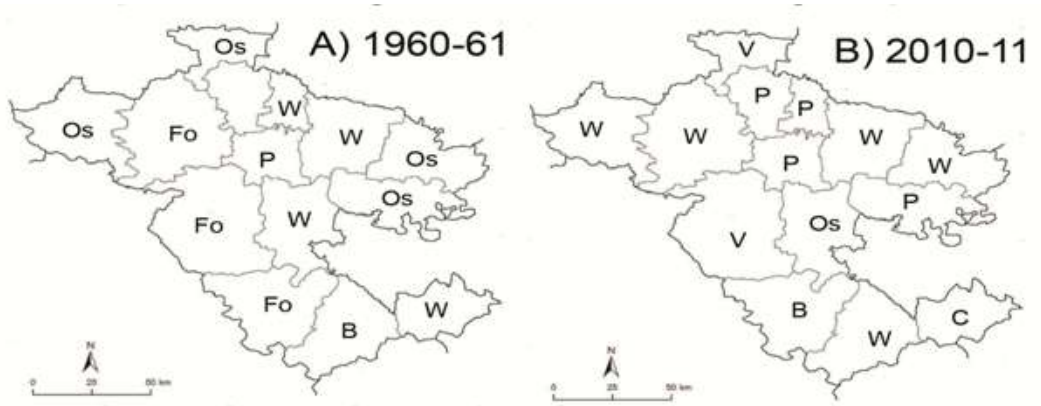
While in 2010-11 Oilseeds and Vegetables cultivated in three talukas Viz. oilseeds occupied Sangamner, Parner and Jamkhed talukas covered 15733 hectares (29.38%) and vegetables occupied Akole, Shevgaon and Karjat talukas covered 10663 hectares (19.91%). Bajara and Fodder crops hold fourth rank in the district (1960-61) and observed each in two-two talukas. Bajara occupied 13864 hectares (15.55%) in Nagar and Shrigonda talukas while Fodder crops occupied 8967 hectares (10.06%) in Karjat and Jamkhed talukas. Wheat, Rice, Oilseeds, Cotton and Sugarcane hold fourth rank in the district (1960-61) and observed each in one- one taluka. Wheat occupied 8667 hectares (9.69%) in Kopargaon taluka, Rice

occupied 8052 hectares (9.03%) in Akole taluka, Oilseeds occupied 4834 hectares (5.42%) in Shrirampur taluka, Cotton occupied 4806 hectares (5.39%) in Pathardi taluka, while Sugarcane occupied 4743 hectares (5.32%) in Rahuri taluka in Ahmednagar district, (Map 4.A & B).

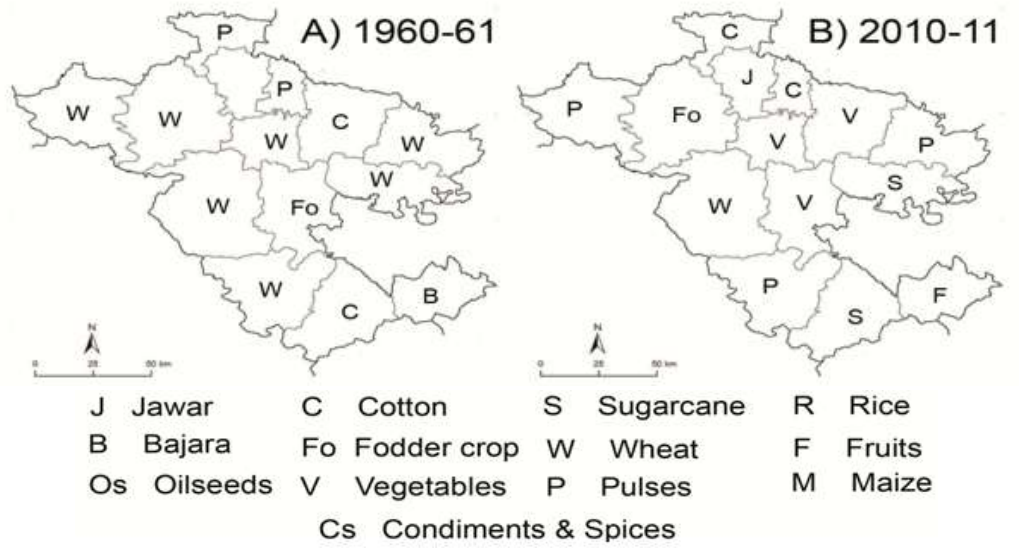
Fodder crops, Fruits and Sugarcane hold fourth rank in the district and observed each in two talukas (2010-11). Fodder crop occupied 6867 hectares (12.82%) in Shrirampur and Rahuri talukas. Fruits occupied 6396 hectares (11.94%) in Newasa and Pathardi taluka while Sugarcane occupied 5713 hectares (10.67%) in Rahata and Shrigonda talukas. Maize and Pulses are grown in one taluka each, Maize occupied 6185 hectares (11.55%) in Kopargaon taluka While Pluses occupied 1989 hectares (3.71%) in Nagar taluka (Map 4.B).



MAP 4: Ahmednagar District Fourth Ranking Crop



MAP 5: Ahmednagar District Fifth Ranking Crop



MAP 6: Ahmednagar District Sixth Ranking Crop

2.3.5 Fifth Ranking

The numbers of crops in fifth rank were five in 1960-61 and six in 2010-11 and were spread throughout the district. The crop distributional pattern in this ranking was more fragmented and diversified (Map 5.A & B). An oilseed holds largest covered (38.58 percent in 1960-61) among fifth ranking crops in Ahmednagar District. It was cultivated in Shevgaon, Pathardi, Akole and Kopargaon talukas and area covered 22681 hectares (38.58%). Wheat also cultivated in four talukas (Nagar, Jamkhed, Shrirampur and Newasa) in the area 18249 hectares (31.04%). Fodder crop hold fourth rank in the district and observed in two talukas (1960-61). Fodder crops occupied 10207 hectares (17.36%) in Sangamner, Parner and Shrigonda talukas. Pulses and Bajara were grow in one taluka each, Pulses occupied 4147 hectares (7.05%) in Rahuri taluka while Bajara occupied 3507 hectares (5.97%) in Karjat taluka. (Map 5.A).

The increased crops were six in number (2010-11) that include Wheat, Pulses, Vegetable, Bajara, Cotton and Oilseeds. Wheat was dominant crop in the district. Wheat covered 15081 hectares (35.08%) comprising five talukas, respectively Akole, Sangamner, Newasa, Shevgaon and Karjat. Pulses covered 10746 hectares (24.99%) comprising four talukas respectively, Rahata, Shrirampur, Pathardi and Rahuri (Map 5.B). Vegetable also cultivated in two talukas (Kopargaon and Parner) in the area covered 11623 hectares (27.03%). Bajara, Cotton and Oilseeds stand as fifth ranking crops each in one taluka. Bajara occupied 2325 hectares (5.41%) in Shrigonda taluka, Cotton occupied 1782 hectares (4.14%) in Jamkhed taluka and Oilseeds occupied 1436 hectares (3.34%) in Nagar taluka in Ahmednagar District (Map 5.B).

2.3.6 Sixth Ranking

There were five crops which emerge in sixth rank in 1960-61while seven crops in sixth rank in 2010-11 in the district. In 1960- 61the crops were Wheat, Pulses, Cotton, Bajara and Fodder crops. Sixth rank crops indicate diversity in number and crop distribution in the area under study.

Among the five crops, Wheat hold largest coverage (53.94 percent in 1960-61) among fifth ranking crops in Ahmednagar District. It is cultivated in seven talukas (Rahuri, Shevgaon, Pathardi, Shrigonda, Parner, Akole and Sangamner) in the area covered 21869 hectares (53.94%). Pulses and Cotton are cultivated in two talukas each. Pulses covered 7552 hectares (18.63%) in Shrirampur and Kopargaon talukas while Cotton covered 6180 hectares (15.24%) in Newasa and Karjat talukas. Fodder crops and Bajra cultivated in one taluka under each crop. Fodder crops covered 3015 hectares (7.44%) in Nagar taluka while Bajara covered 1928 hectares (4.76%) in Jamkhed taluka in Ahmednagar District (Map 6.A).

There were seven crops which emerged in sixth rank in the district. In 2010-11 the crops were Vegetables, Pulses, Cotton, Sugarcane, Fodder Crops, Wheat, Jawar and Fruits. Sixth rank crops indicate diversity in number and crop distribution in the area under study. Among the seven crops, Vegetable and Pulses are dominant crops in the district. Vegetables covered 6003 hectares (17.90%) comprising three talukas, respectively Newasa, Nagar and Rahuri talukas. Pulses covered 5559 hectares (16.57%) comprising three talukas respectively Akole, Shevgaon and Shrigonda. Cotton and Sugarcane are cultivated in two talukas each. Cotton covered 8222 hectares (24.51%) in Shrirampur and Kopargaon talukas while Sugarcane covered 2237 hectares (6.67%) in Pathardi and Karjat talukas. Fodder crops, Wheat, Jawar and Fruits cultivated in one taluka under each crop. Fodder crops covered 3851 hectares (11.48%) in Sangamner taluka, Wheat covered 3800 hectares (11.33%) in Parner taluka, Jawar covered 2467 hectares (7.36%) in Rahata taluka while Fruits covered 1400 hectare (4.17%) in Jamkhed taluka in Ahmednagar District (Map 6.B).

2.3.7 Seventh Ranking

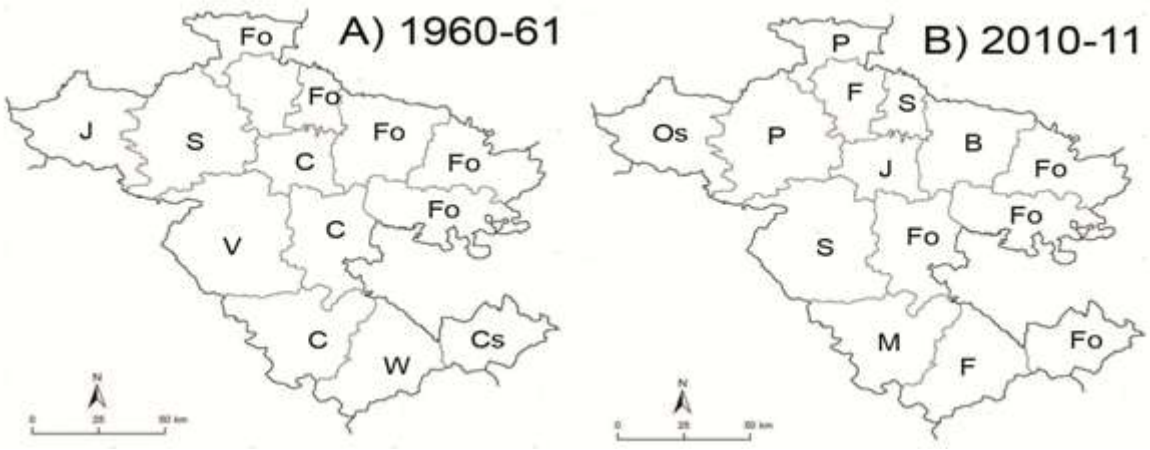
In 1960-61 the numbers of crops in seventh rank were seven and were spread throughout the district. The crop distributional pattern in this ranking was more diversified. Those crops were Fodder crops, Cotton, Vegetables, Sugarcane, Wheat, Jawar and Condiments & Spices. Among the seven crops Fodder crops was principal crops found in five talukas. Fodder crops covered 10377 hectares (46.25%). The largest coverage of fodder crops found in the talukas respectively Shrirampur, Newasa, Shevgaon, Pathardi and Kopargaon talukas. Cotton was cultivated in three talukas respectively Nagar, Rahuri and Shrigonda covered 5557 hectares (24.77%) in the district. Vegetable, Sugarcane, Wheat, Jawar and Condiments & Spices were cultivated in one taluka each. vegetables covered 1667 hectares (7.43%) in Parner taluka, Sugarcane covered 1668 hectares (7.43%) in Sangamner taluka, Wheat covered 1468 hectares (6.54%) in Karjat taluka, Jawar covered 1215 hectares (5.42%) in Akole taluka while Condiments & Spices covered 485 hectares (2.16%) in Jamkhed taluka of Ahmednagar District (Map 7.A).

The numbers of crops in seventh rank were eight (2010-11) and were spread throughout the district. The crop distributional pattern in this ranking was more diversified. Those crops were Fodder crops, Sugarcane, Pulses, Fruits, Jawar, Bajara,

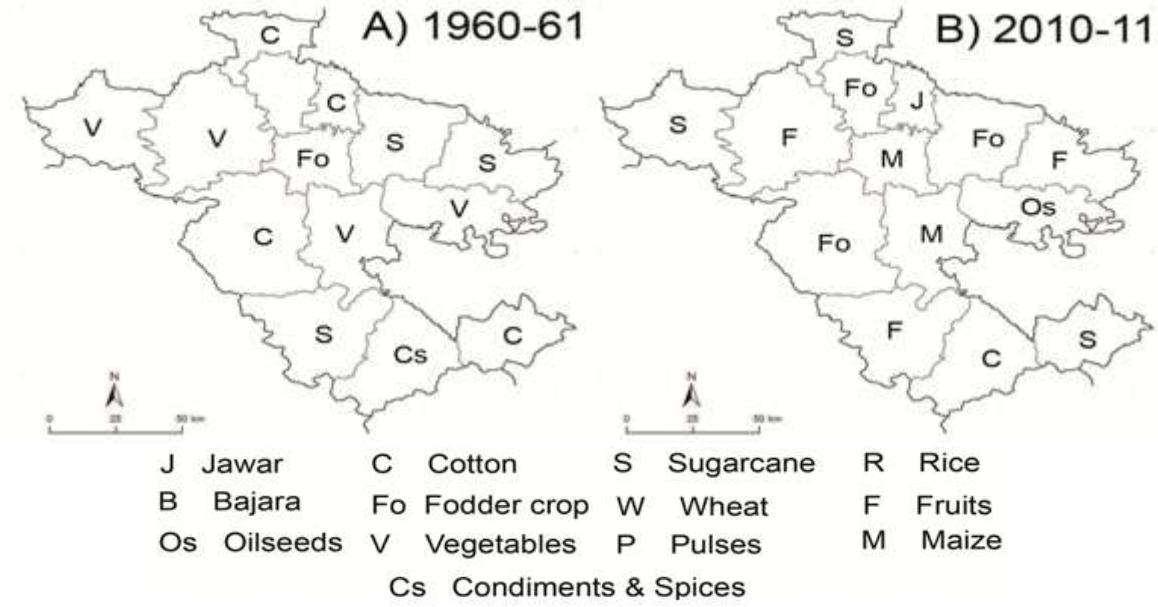
Oilseeds and Maize. Among the eight crops fodder crops was found largest coverage on 2348 hectares (10.61%). The largest coverage of fodder crops was found in the talukas respectively Shevgaon, Pathardi, Nagar and Jamkhed. Pulses, Sugarcane and Fruits were cultivated in two talukas each. Pulses covered 7234 hectares (32.69%) in Sangamner and Kopargaon talukas, Sugarcane covered 3598 hectares (16.26%) in Shrirampur and Parner talukas while Fruits covered 2831 hectares (12.79%) in Rahata and Karjat talukas. Oilseeds, Bajara, Jawar and Maize were cultivated in one taluka under each crop. Oilseeds covered 2020 hectares (9.13%) in Akole taluka, Bajara covered 1705 hectares (7.71%) in Newasa taluka, Jawar covered 1315 hectares (5.94%) in Rahuri taluka while Maize covered 1075 hectares (4.86%) in Shrigonda taluka of Ahmednagar District (Map 7.B).

2.3.8 Eighth Ranking

In 1960-61 there were five crops which emerge as eighth in rank in Ahmednagar District. The crops were Cotton, Vegetables, Sugarcane, fodder crops and Condiments and Spices. Eight rank crops indicate diversity in number and crop distribution in the area under study. Among the five crops Cotton and Vegetables were the principal crops found largest coverage in the district. Cotton coverage on 3762 hectares (32.43%) and found in four talukas respectively Shrirampur, Kopargaon, Parner and Jamkhed. Vegetables covered 3208 hectares (27.65%) and found in four talukas respectively Sangamner, Pathardi, Nagar and Akole. Sugarcane covered on 2070 hectares (17.84%) and found in three talukas viz, Newasa, Shevgaon and Shrigonda. Fodder crops and Condiments and spices cultivated in one talukas under each crop. Fodder crops covered 2036 hectares (17.55%) in Rahuri taluka, Condiments and Spices covered 525 hectares (4.53%) in Karjat taluka in Ahmednagar District (Map 8.A).



MAP 7: Ahmednagar District Seventh Ranking Crop



MAP 8: Ahmednagar District Eighth Ranking Crop

There were seven crops (in 2010-11) which emerged as eighth in rank in Ahmednagar District. The crops were Sugarcane, Fodder crops, Fruits, Maize, Jawar, Cotton and Oilseeds. Eight rank crops indicate diversity in number and crop distribution in the area under study. Among the seven crops Sugarcane, Fodder crops and Fruits were the principal crops found larges coverage in the district. Sugarcane covered 5734 hectares (29.70%) and found in three talukas respectively Akole, Kopargaon and Jamkhed talukas, Fodder crops coverage on 4834 hectares (25.04%) and found in three talukas respectively Rahata, Newasa and Parner talukas While Fruits occupied 4607 hectares (23.86%) in three talukas respectively Sangamner, Shevgaon and Shrigonda talukas. Maize was cultivated in two talukas viz. Nagar and Rahuri covered 1382 hectares (7.16%). Jawar, Cotton and Oilseeds cultivated in each crop one taluka. Jawar covered 2099 hectares (10.87%) in Shrirampur taluka while Cotton covered 398 hectares (2.06%) in Karjat taluka and Oilseeds covered 254 hectares (1.32%) in Pathardi taluka in Ahmednagar District (Map 8.B).

III. CONCLUSION

- The ranking of crops denotes the relative strength of individual crops. Jawar ranks as the first ranking crop in 11 talukas respectively, Kopargaon, Rahata, Shrirampur, Newasa, Shevgaon, Pathardi, Nagar, Rahuri, Parner, Shrigonda, Karjat and Jamkhed (85% to total talukas) and consequently occupies an outstandingly predominant position in 642779 hectares in 1960-61.
- In 2010-11 Jawar had covered on 287331 hectares (54.50%) in the five talukas, viz. Nagar, Parner, Shrigonda, Karjat and Jamkhed in the district.
- Bajara stands second in rank in six tahsils (43 % to total tahsils) and wheat stand third in rank in five tahsils. Other crops namely sugarcane, pulses, oilseeds, fodder crop, cotton, vegetables, fruits, maize and rice have low percentage than that of Jawar, Bajara and Wheat.
- The third ranking crops were Oilseeds, Pulses, Bajara, Sugarcane and Cotton in 1960-61.
- Pulses hold third rank in the district and observed in three taluka (2010-11) occupied 18923 hectares (20.42%) in Newasa, Parner and Karjat talukas. Sugarcane, Bajara, Condiments and Spices, Jawar, Cotton and Vegetables stands as third ranking crops each in one taluka.
- The fourth ranking crops were Pulses, Bajara, Fodder crops, Oilseeds, Sugarcane, Cotton, wheat and Rice in 1960-61and seven crops respectively Oilseeds, Vegetables, Sugarcane, Fruits, Fodder crops, Pulses and Maize in 2010-11.Fodder crops, Fruits and Sugarcane hold fourth rank in the district and observed each in two talukas (2010-11).
- The numbers of crops in fifth rank were five in 1960-61 respectively, Wheat, Fodder Crop, Pulses, Bajara and Oil Seeds and six in 2010-11 respectively, Wheat, Pulses, Vegetable, Bajara, Cotton and Oilseeds. Wheat was dominant crop in the district. Wheat covered 15081 hectares (35.08%)
- There were five crops which emerge in sixth rank in 1960-61while seven crops in sixth rank in 2010-11 in the district. In 1960- 61the crops were Wheat, Pulses, Cotton, Bajara and Fodder crops. There were seven crops which emerged in sixth rank in the district. In 2010-11 the crops were Vegetables, Pulses, Cotton, Sugarcane, Fodder Crops, Wheat, Jawar and Fruits.
- The crop distributional pattern in seventh ranking was more diversified. Those crops were Fodder crops, Cotton, Vegetables, Sugarcane, Wheat, Jawar and Condiments & Spices. Among the seven crops Fodder crops was principal crops found in five talukas. Fodder crops covered 10377 hectares (46.25%).
- The numbers of crops in seventh rank were eight (2010-11). Those crops were Fodder crops, Sugarcane, Pulses, Fruits, Jawar, Bajara, Oilseeds and Maize. Among the eight crops fodder crops was found largest coverage on 2348 hectares (10.61%).
- In 1960-61 there were five crops which emerge as eighth in rank in Ahmednagar District. The crops were Cotton, Vegetables, Sugarcane, fodder crops and Condiments and Spices. Among the five crops Cotton and Vegetables were the principal crops found largest coverage in the district. Cotton coverage on 3762 hectares (32.43%) and found in four talukas respectively Shrirampur, Kopargaon, Parner and Jamkhed.
- There were seven crops (in 2010-11) which emerged as eighth in rank in Ahmednagar District. The crops were Sugarcane, Fodder crops, Fruits, Maize, Jawar, Cotton and Oilseeds. Eight rank crops indicate diversity in number and crop distribution in the area under study. Among the seven crops Sugarcane, Fodder crops and Fruits were the principal crops found larges coverage in the district.

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Physico-Chemical and Bacteriological Analysis of Waste water from Hospital "Case of Centre University Teaching Hospital of Kigali"

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***Abstract*—** *Hospitals produce relatively huge amount of wastewater containing pathogenic microorganisms, toxic, laboratory and pharmaceuticals residuals, disinfectants, biodegradable, polluters and radioactive contaminants that are potentially threats to population health and the components of environment when they are discharged without proper treatment.*

The purpose of the study was the assessment of water quality effluent from CHUK wastewater treatment plant (CHUK WWTP) by analyzing physico-chemical and bacteriological parameters. Sampling has been take place at different points and time better understanding of how hospital unit operations affect the effluent quality. A sum of twelve (12) samples were collected in three (3) trials at four (4) different points in Nyarugenge, Gitega and at the border with Kimisagara sector especially Mpazi stream where CHUKWWTP's effluents are discharged. Samples collection, conservation, preparation and measurement took place at university of Rwanda-college of science and technology (CST) laboratory.

The obtained results at WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent were Cu (0.06, 0.07, 0.05 and 0.07mg/l); Fe (0.13, 0.037, 0.037 and 0.034mg/l); Pb (0.021, 0.024, 0.024, and 0.027mg/l); Hg (0.0015, 0.003, 0.003 and 0.004 mg/l) respectively. pH (7.25, 812,7.74 and 7.4); COD (215.5, 122.4, ,145.5 and 187.2mg/l); BOD5 (29.3, 30.85, 29.4 and 27.3 mg/l); TN (3.29, 2.97,3.2 and 3.46 mg/l); TP (1.05, 0.91, 0.92 and1.05mg/l); NH_4^+(7.46, 8.5,7.5and 8.8 mg/l); TSS (77, 56.5,62.8 and 69.1mg/l); fecal (282, 263,270, and 273 CFU/ml) and TC (233, 213, 224 and 210 CFU/ml). These parameters are prescribed within the reference limits of Rwanda Standard Board (RSB) and World Health Organization (WHO) standards, thus they have no negative side impact and effects on the receiving environments and their components.

***Keywords*— hospital wastewater, physico-chemical, bacteriological -analysis.**

I. INTRODUCTION

Wastewater can be defined as any water, whose quality has affected or being abused by anthropogenic influence (petrovic, 2010). These are liquidious waste released from domestic homes, industries, hospitals, agricultural and commercial sectors (barchelo, 2010). Most of the liquid wastes from hospital are categorized as non-regulated "emerging pollutants (EPA, 2016). According to Amouiei, Barcelo and Petrovic2010: the exposure to hospital wastewater released without adequate treatment in surrounding environment and its components results to adverse effects on the biological balance of aquatic ecosystems, causing imbalance at different trophic levels possibly related to the action of toxic and genotoxic agents and indirectly lead to eutrophication on water bodies surface.

The quality, nature and risk assessment of released effluents are described by its flow, sources of generation, physico-chemical and microbiological characteristics (Galletti ,2010). Addition to this findings of miscellaneous research done on hospital effluent show that effluent discharged from hospitals usually contains certain harmful pollutants such as: pathogenic microbes and bacteria, residues of medicine, laboratory chemicals, pharmaceuticals residues, biodegradable organic materials, carcinogenic metals, and radiation emitting wastes which are danger to the life of the living organisms and environment (Verlicchi ,2010; Kanama,2018).

Hospital effluents are released into water bodies (streams, rivers and lakes) through sewer and cause the deviation from baseline situation of the received environment which is negatively affecting the ecological balance and life if they left with its pathological, radioactive, product of pharmacy, chemical and infectious components lead to diseases, cancer epidemics, skin diseases and contaminate air, water and land holder components (kumar, 2007)

According to (Verlicchi,2015) effluent discharge from hospitals wastewater treatment with low capacities of pollutants removal create high demand for oxygen like BOD, COD in receiving water bodies and deviate the aesthetic value of aquatic ecosystems while research finding of Carraro,2016 state that: some hospital treatment facilities for liquid wastes (HWWTP) are not properly managed and slightly show low removal capacities for common parameters including BOD5, COD, TSS, heavy metals (mercury and lead), coliforms ,total nutrients (total nitrogen, phosphorus and ammonium).

At the beginning of 1928, University teaching hospitals of Kigali (CHUK)located in Kigali City, Nyarugenge district, Nyarugenge Sector, in its daily activities requires large volume of water, the reason why more wastewaters are generated and use sewer passing through Nyarugenge, Gitega Sectors and meet with Mpazi stream passing through Kimisagara sector and this lead CHUK to be a particular example of hospital discharging effluents into surrounding environment. However, there is no known study done on CHUK hospital effluent and small effluents data exist in Rwanda on hospital effluents characteristics (Aurelian, Sylvie, 2013).

Currently, the statistics data from ministry of health show that the number of patients cared by CHUK hospital have increased at 45% in 10yesars ago while its treatment plant has not expanded and replaced. This cause to higher need of large volume of water and release to much wastewater which can surpass the existing capacity of treatment facilities leading to discharge of effluents which are not matching with required standards of receiving environment and aquatic ecosystems. The population of above stated sectors use Mpazi stream as source of water in their daily activities like watering, washing and cleaning while the quality, physicochemical and bacteriological composition of Mpazi stream water after mixing with the effluent from CHUK water treatment plant are not well already known.

According to water Aid report of 2013, department of water and sanitation report of 2017, Rwanda loses RWF32 billion annually due to poor sanitation and It's approximated that 7,200 Rwandans including 6,100 children under 5, die each year from poor sanitation related diseases, nearly 90% of which is directly attributed to poor water, sanitation and hygiene.

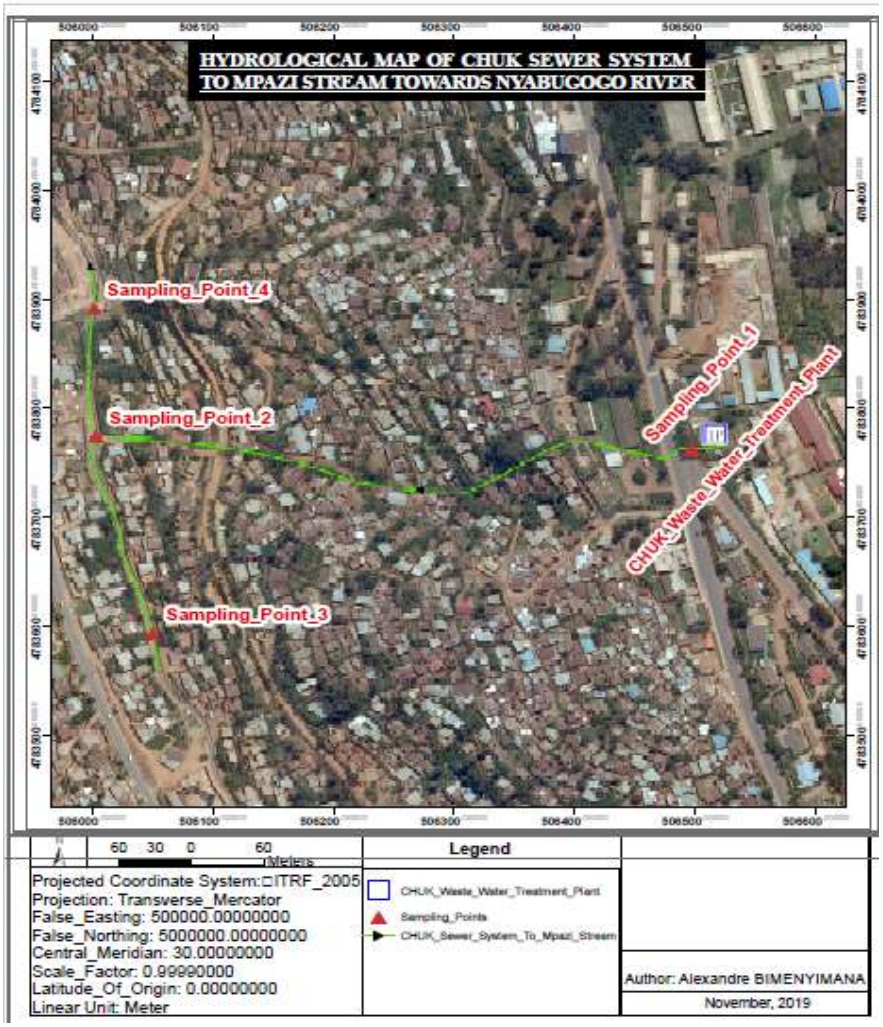
Several research studies have done by analyzing the quality and composition municipal wastewater 'effluents but there is big gap about analyzing hospital wastewater 'effluents in Rwanda Where some parameters like mercury(Hg), Lead (Pb) and other heavy metals were left aside and Kigali city is a part of the above issues.

The aim of the research study was to assess the quality of the effluent from Centre university teaching hospital of Kigali wastewater treatment plant (CHUKWWTP) by analyzing the physical, chemical and bacteriological parameters and this overcame the gaps appeared on analysis of effluents generated from hospitals in Rwanda and showed the current data of CHUK hospital effluent discharged , and increase the safety of receiving environment, the report is supposed to be used by the ministry of health, water and environment regulating agencies and CHUK hospital to improve the quality of their effluents through regular maintenance of its WWTP.

II. MATERIALS AND METHODS

2.1 Description of case study area

CHUK, the Centre University teaching hospital of Kigali is located in the Centre of Kigali city, District of NYARUGENGE, Sector of NYARUGENGE. It is among the main referral public health institution of the country. It was built in 1918. That time, it was functioning as a health Centre, later 1965 especially from April1994 to 1996; CHUK has served as a health Centre, a district hospital and referral hospital according to MINISANTE report 2013. It is located near Serena hotel, Kigali exhibition, Rwanda meteorology and school of EPA. The effluents from CHUK are discharged into MPAZI stream through sewer system after treatment.



MAP 1: Map of Chuk sewer System

2.2 Wastewater sampling

2.2.1 Sample Collection and sample conservation

a. sampling equipment

Isothermal cooling boxes, stoppers for pipetting and BOD bottles, were used during sampling while P^H meter and thermometer were used for situ measurement.

b. Sample Collection and sample conservation

CHUK hospital effluents samples were collected at 4 points of sampling, at outlet of CHUK wastewater treatment plant in NYARUGENGE sector at the point where MPAZI stream meets with CHUK WWTP effluents, the third sample at Mpazi stream and the last at Mpazi stream after mixing with CHUK effluents. Twelve (12) Wastewater samples were taken within three (3) weeks at 4 different points stated above at 6pm to help the understanding of how hospital unit operations affect the effluent quality, each round of 4 samples were taken s week per week at the same time. Effluent Samples were collected using one litter plastic bottle for each. Plastic bottles were thorough washed and rinsed before use. Dissolved oxygen (DO) and biological oxygen demand (BOD5) samples have been collected in one litter plastic bottles with stoppers and Winkler solution were used to fix the available oxygen at site and keep them in a closed cooling box to avoid cross contamination, thereafter at UR-CST laboratory, pH and temperature measurements were done in situ. Samples are conserved via keeping in refrigerator at 4◦C in laboratory, blanks and reagents were prepared according to the designated protocol of analysis.

TABLE 1

LABORATORY MEASUREMENT AND ANALYSIS OF PHYSICAL CHEMICAL AND BACTERIOLOGICAL PARAMETER

Physico-chemical parameters	Equipment	Reagents	Methods
BOD5	incubator	CaCl2, FeCl3, MgSO4 and buffer (the buffer acts as nutrient for bacteria)	The sample is filled in an airtight and incubation at specific temperature for 5days. The dissolved oxygen (DO) content of the sample is determines before and after five days of incubation at 20°C where the starch as reagent were used as food for bacteria to grow which were contributed to the decomposition of the matter (Heberer,2012) .DO and BOD_5 were calculated with the following formula: **CALCULATIONS** The determination of BOD in mg/L was done as follow: BOD, mg/L = [(Initial DO - Final DO) x 300]/mL sample or $DO = V*M*8*(\frac{1000}{Vb-2})$ V: Volume of $Na_2S_2O_3$ M: Concentration of $Na_2S_2O_3$ Vb: Volume of blank solution $BOD_5 = (DO-Sv)*(\frac{Vb}{C})$ DO: Dissolved oxygen at starting $Sv = V*M*8*(\frac{1000}{Vb-2})$: Dissolved oxygen after 5days C: volume of incubated sample
COD	Spectrophotometer at 814nm (DR5000)	mercuric sulfate, silver sulfate, sulfuric acid and chromic acid	The organic compound present in effluents was oxidized completely by strong oxidizing agent of potassium dichromate ($K_2CR_2O_7$) in the presence of sulfuric acid (H_2SO_4), silver sulfate ($AgSO_4$) to produce CO_2 and H_2O. The amount of oxidizing agent used ($K_2Cr_2O_7$) in the medium of sulfuric acid and the excess potassium dichromate ($K_2Cr_2O_7$) will was being determined by titration against ferrous ammonium sulfate, and ferroin after adjusting spectrophotometer (DR5000) at wavelength of 814nm
TSS	Gravimetric and filtration Methods using membrane filters	-	-place effluents sample in oven to evaporate the moisture content leaving the solids. Measure dissolved solids, recuperated solids on filter is dried and weighed. -calculate the suspended solids weigh by subtracting dissolved from total solids (Krishna,2015).
Total phosphorus	Spectrophotometer at 650nm (DR5000)	Buffer, BaCl2, Na2SO4 and potassium persulphate	-well mixed Samples were digested in autoclave for 2hours at 121^{0}C with potassium persulphate to convert all phosphorus to orthophosphate. The orthophosphate was then being analyzed using the ascorbic method and adjust the spectrophotometer (DR5000) at wavelength of 650nm
Total Nitrogen	Spectrophotometer at 420nm (DR5000)	Buffer, BaCl2, Na2SO4 potassium persulphate	Well mixed samples were digested in autoclave for 45 min at 110^{0}C with potassium persulphate to convert all Nitrogenous form to nitrate. Nitrate was then being analyzed using the cadmium reduction method and adjusts the spectrophotometer (DR5000) at wavelength of 420nm before measurements (Kure, 2012).
ammonium	Spectrophotometer at 540 nm (DR5000)	$ZnSO_4$, NaOH,NH4Cl-EDTA and Cadmium regents	-Using filters, transfer sample in a beaker mix with zinc sulfate solution and add NaOH solution the alkalinity. Thereafter add ammonium chloride- EDTA solution with cadmium reagents - Allow 10 minutes for color development within 2 hours pull the sample into sample cell and put to a spectrophotometer, measure the absorbance at 540 nm against a reagent blank. (EPA,1975).
Copper (Cu), Iron (Fe),	Spectrophotometer at 270 nm (DR5000)		After digestion, Set the operating parameters of the instrument and a connected chart recorder. and connect the mercury vapor generation accessory to the instrument. Transfer, by graduated cylinder, 50 ml of the standard to the reaction vessel of the accessory, and add 3 ml of 100 g/l stannous chloride solution. Immediately insert the bung assembly in the reaction vessel and stir the solution vigorously with the magnetic stirrer for 90 seconds. Simultaneously turnoff the stirrer and turn on the air supply to the vessel. Record every absorbance obtained as peak height on the chart recorder. Extract the normality of mercury in each sample by reference by matching the height of peaks with its corresponding concentration

Lead(Pb) and Mercury(Hg)	Inductively Coupled Plasma Emission (Schimadzu,ICPE9000)	stannous chloride	➢ Set the operating parameters of the instrument and a connected chart recorder. and connect the mercury vapour generation accessory to the instrument. Transfer, by graduated cylinder, 50 ml of the standard to the reaction vessel of the accessory, and add 3 ml of 100 g/l stannous chloride solution. ➢ For lead "Aspirate the standard and sample solutions" ➢ Immediately insert the bung assembly in the reaction vessel and stir the solution vigorously with the magnetic stirrer for 90 seconds. Simultaneously turnoff the stirrer and turn on the air supply to the vessel. Record every absorbance obtained as peak height on the chart recorder. ➢ Extract the normality of mercury in each sample by reference by matching the height of peaks with its corresponding concentration
Bacteriological	**Equipment**	**reagents**	**Methods**
Total coliform	incubator	Lactose Broth with bacteriological agar as media and nutrient	Total coliforms were detected by placing the media of Lactose Broth with bacteriological agar to Petri plate. The serial dilution of samples was done for each petri plate, the petri plate of total coliforms were incubated at 37 o C for 24 h and fecal coliforms at 44 o C for 24h. The typical colonies were counted after incubation (Michalke, 2008). The coliforms were calculated using the following formulae. $\mathbf{NCT} = \frac{\varepsilon TC * 100}{d}$, $\mathbf{NCF} = \frac{\varepsilon FC * 100}{d}$ Where N: number of colonies d: type of serial dilution/ml FC: Fecal coliform TC: Total coliform NCF: Number of colonies of fecal coliform NCT: Number of colonies of total coliform
Fecal coliform	incubator	Lactose Broth with bacteriological agar as media and nutrient	

III. RESULTS AND DISCUSSIONS

TABLE 2
THE AVERAGED VALUES OF ALL PHYSICO-CHEMICAL PARAMETERS STUDIED

Parameter / Site	P^H	T (^{0}C)	TSS(mg/l)	EC(Us/cm)	TP(mg/l)	TN(mg/l)	NH_4^+(mg/l)	Cu(mg/l)	Fe(mg/l)	Pb(mg/l)	Hg(mg/l)	BOD(mg/l)	COD(mg/l)
At WWTP Outlet	7.25	26.4	77.0	442.5	1.05	3.29	7.86	0.06	0.13	0.021	0.0015	29.3	215.25
At point of meeting with MPAZI stream	8.12	26.8	56.5	350	0.91	2.97	8.5	0.07	0.037	0.024	0.003	30.85	122.4
Mpazi Stream	7.74	26.9	62.8	394.7	0.92	3.2	7.9	0.05	0.037	0.024	0.003	29.8	145.5
Mixture of Mpazi stream and CHUK effluent	7.4	26.5	69.1	419.7	1.05	3.46	8.5	0.07	0.034	0.027	0.004	27.3	187.2
WHO standard	5-9	-	100	-	6	10	9	3.5	3	0.035	0.006	34	60

3.1 pH Value

The acidity or basicity of wastewater always disrupt and damages the wastewater collection and treatment facilities and disturb the designed treatment processes (Onesios, 2009). The range of pH value at WWTP outlet, point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent were 7.25, 812,7.74 and 7.4 respectively and and it is suitable from the viewpoint of wastewater treatment processes comparable to WHO limit standards (WHO, 2009).

3.2 Total suspended solids

One among of the common parameters used in defining effluents is TSS as illustrated in Fig. (3), the total suspended solids (TSS) concentration of the CHUK outlet, point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent were77, 56.5, 62.8 and 69.1mg/l respectively.

The decrease of value of TSS from sampling point 1 to sampling point 2 showed a contribution of environmental treatment that worked properly to remove total suspended solids. The increment from sampling point 2 to to Mpazi stream showed that the quality of CHUK effluent is differ from the quality of Mpazi stream caused by the other discharge from nearby Mpazi and anthropogenic activities carried around stream system, but these results are prescribed WHO limit (100mg/l) (WHO, 2009).

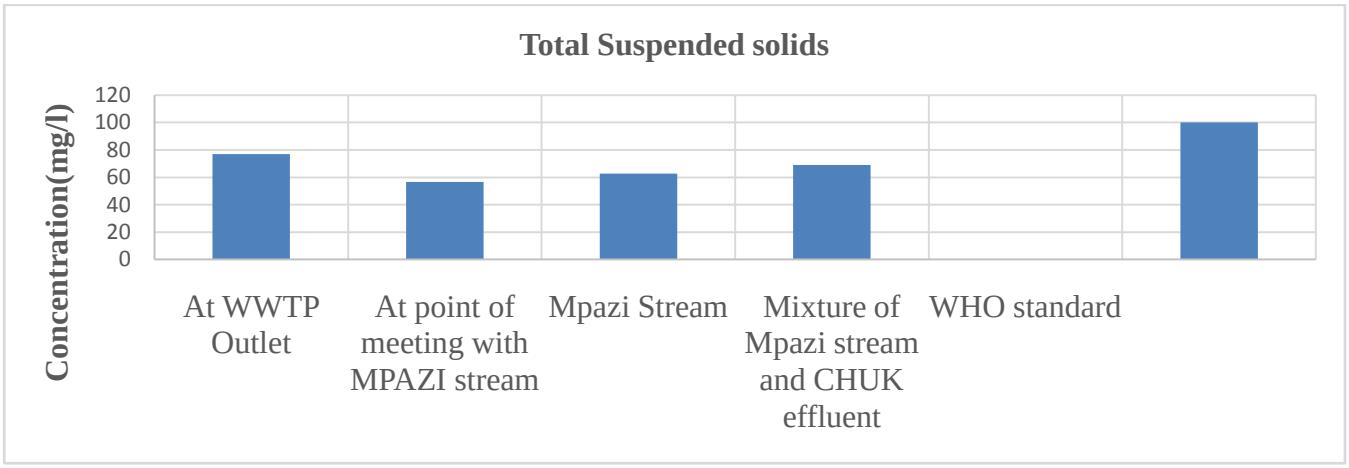


FIGURE 1: Total suspended solid variations at all sites

3.3 The total phosphorous, total nitrogen and ammonium

The total phosphorous, total nitrogen and Ammonium are the major indicator of nutrients load to any receiving environment, the higher concentration lead to rapid growth of plants on water surface and cause the depletion of oxygen, this condition endangers the aquatic organisms. The Fig (4) shows averages concentration results of total phosphorous, total nitrogen and ammonium measured WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent. Total phosphorous was 1.05, 0.91, 0.92 and1.05mg/l, total nitrogen was 3.29, 2.97,3.2 and 3.46 mg/l respectively while ammonium was 7.46, 8.5,7.5and 8.8 mg/l respectively.

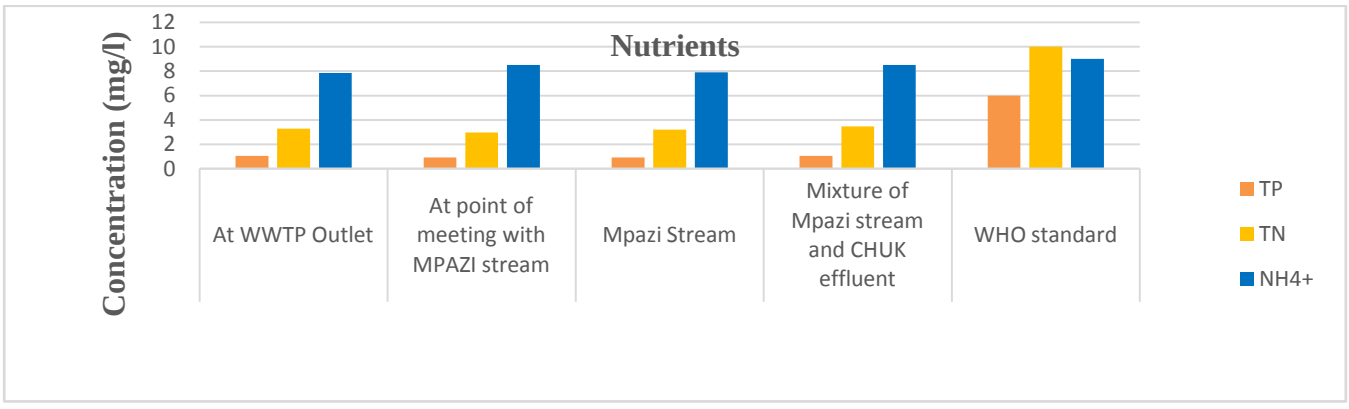


FIGURE 2: The total phosphorous, total nitrogen and ammonium variations in all point of sampling

The variability of these results for nitrogen, phosphorous and ammonium for point1 to point 4 of sampling show that the quality of CHUK effluents are different from quality of Mpazi stream while they are complying with recommended standard of WHO (6-10mg/l) respectively (WHO, 2009) and showed highly performance of CHUK WWTP spite of that the quality effluent from CHUK is affected by other surroundings.

3.4 Heavy metals

Copper, Iron, Lead and Mercury was the heavy metals investigated in the study. The average concentration of Copper was WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent was 0.06, 0.07, 0.05 and 0.07mg/l, Iron was 0.13, 0.037, 0.037 and 0.034mg/l, Lead was 0.021, 0.024, 0.024, and 0.027mg/l while Mercury was 0.0015, 0.003, 0.003 and 0.004 mg/l respectively. The capacity of CHUK WWTP to remove heavy metals in its wastewater before release effluent is enough as the average levels of these metals in hospital wastewater were within permissible levels of WHO (3.5, 3, 0.035 and 0.006 mg/L).

3.5 Chemical oxygen demand and Biological oxygen demand

BOD5 and COD parameters are widely used to characterize the organic content of wastewater (Puangrat, 2010). Figure (7) demonstrated the average concentrations of BOD5 and COD obtained from WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluent. The results BOD5 were 29.3, 30.85, 29.4 and 27.3 mg/l respectively while COD were 215.5, 122.4, 145.5 and 187.2mg/l respectively. The biodegradability of organic compounds BOD5/ COD ratio in the study was 0.13, 0.25, 0.20 and 0.15 which reported the speed and completeness of their degradations by microorganisms and described the potential impact on the WWTP efficiency.

The ratio 0.5-0.6 of BOD5 / COD is the threshold value to study the biodegradability of organic compounds hospital effluents (Seiss, 2001). Therefore, the organic content of CHUK effluent had high biodegradability and ratio obtained was very desirable from the viewpoint of treatment process and promotes the efficiency of WWTP.

3.6 Bacteriological parameters

TABLE 3
RESULTS OF BACTERIOLOGICAL PARAMETERS

Location / Parameter With Unit (cfu/mL))	At WWTP Outlet				At point of meeting with MPAZI stream				Mpazi Stream				Mixture of Mpazi stream and CHUK effluent			
	S1	S2	S3	Ave rage	S1	S2	S3	Ave rage	S1	S2	S3	Ave rage	S1	S2	S3	Average
Total coliform	227	231	241	233	211	220	207	213	221	241	211	224	211	210	208	210
Fecal coliform	297	280	269	282	287	258	243	263	287	260	272	270	297	268	253	273

Wastewater of treating patients with enteric diseases is a particular problem during outbreaks of diarrhea disease so the microbial quality of hospital effluents is very critical (Pauwels, 2006). Therefore, some bacteriological indicators are used to reflect the occurrence of pollution accompanying pathogens such as FC and TC that are the most world-wide approach to detect contamination of water resources.

Figure (5) illustrated the average number of TC and FC in CHUK hospital effluents which were obtained to be 233, 213, 224 and 210 CFU/ml for total coliform and 282, 263,270, and 273 CFU/ml for Fecal coliforms respectively, that was comparable to the standards WHO (400*10^2, 1000*10^2) (WHO, 2009). The performance of CHUKWWTP was justified by the greater reduction of coliforms from WWTP outlet, at point of meeting with Mpazi stream, Mpazi stream and mixture of Mpazi stream with CHUK effluents while environmental treatment was justified by the reduction of coliforms from effluent to Mpazi stream. This showed that there were no negative effects on receiving environment and their components

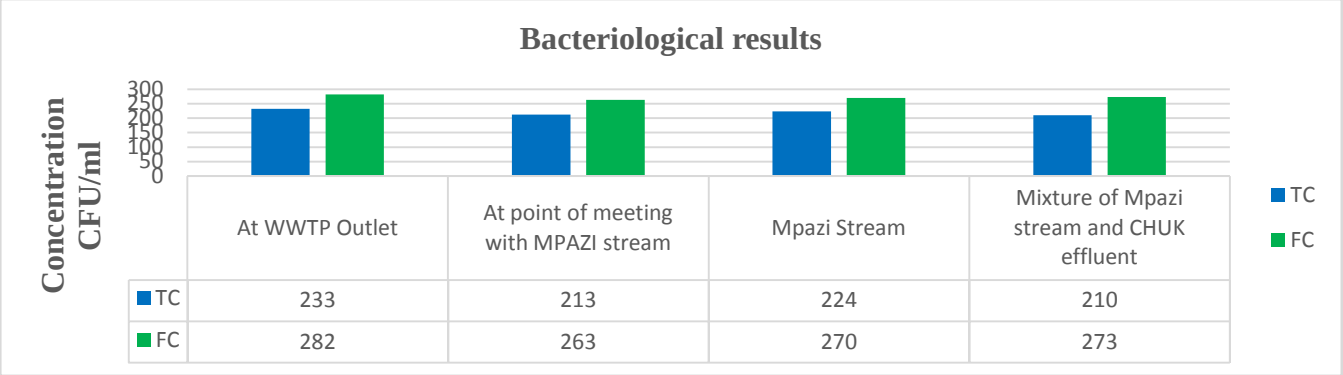


FIGURE 3: Variations of biological parameters cfu/1ml for both total and fecal coliforms at all point of sampling

Findings on hospital physical chemical and bacteriological available in effluents vary from one area to another, Outside Rwanda, miscellaneous research studies have been done on hospital effluents in different side of the world such as Ethiopia, France, India, Nigeria, Iran, Morocco, Indonesia and Korea. Research findings showed that BOD values are most varying from 242 mg/L to 632 mg/L and COD value varies from 616 mg/L to 1388.75 mg/Metals classified as (Lead, Copper Mercury) concentrations were also found in hospital effluents [1-17, 36,] (UN water, 2012).

In Rwanda –Kigali city, the research findings done obtained by Alice U, Ming Y, Nestor U, Donath N, Narcisse N (2017) on Liquid Wastes Treatment and Disposal in Rwanda show that TSS mg/l was≤ 720, pH≤8, Total Nitrogen mg/l ≤36, Ammonium mg/l ≤10, Total phosphorus ≤8.9, lead mercury, and iron was≤03,4.6,0.1mg/l respectively, Temperature variation of treated water compare to ambient temperature of water ≤3, BOD5 mg/l ≤70, COD mg/l ≤500 total and fecal Coli forms number/100ml ≤400 and they are all exceeding the recommended standards of discharge .

Thus for CHUK effluents it is not the case of the area stated above as all parameters studied are prescribed with the limit of standards.

IV. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The physico-chemical and bacteriological parameters analyzed from CHUK WWTP effluents discharged in Mpazistream towards Nyabugogo River were measured, analyzed, interpreted in the research study. After data analysis and compared with the WHO standard, the effluents result of Cu, Fe, Pb,Hg, COD, BOD5, and TSS, total nitrogen, phosphorous ,ammonium and microbiological concentrations were all meet the limit of standard recommended WHO and RSB and have no negative effects on the receiving environment. The decrease in concentration for all parameters from initial point (point one) of sampling to Mpazi stream justified the performance and effectiveness CHUK WWTP with environmental treatment while the increment from effluent to Mpazi stream are suspected to be originated from other discharge of nearby institutions and anthropogenic activities carried around sewer system.

As stated in the hypothesis, the pollution was supposed to be evaluated based on comparison of effluents results with the standard, therefore comparison shows that as all results of CHUK effluent are prescribed within the limit of WHO and local standard from Rwanda standard board, thus CHUK Hospital is not polluting the environment and its component at all.

5.2 Recommendations

After evaluating the quality effluents from CHUK WWTP and those received by Mpazi stream the following recommendations should be noted, act on that and take into account.

- CHUK should measure the effluents released from their wastewater treatment plant week per week because the results of the research are based on the samples taken weekly and show high variability.
- CHUK should offer trainings to their employees about cleaner production while ensuring maintenance of WWTP by regular replacing the oldest deteriorated equipment, this will reduce the volume wastewater generated and cut treatment cost.

- Interested parties should sensitize the people located in NYARUGENGE, GITEGA, and KIMISAGARA sectors that using Mpazi stream as source of water for drinking and washing is not allowed and forbidden.
- Rwanda environmental, health regulatory agencies should do surprise consultancy and inspections provide the reports to ensure that the obtained results are reliable and consistent.
- Discharge standards must be based on current scientific data.
- It supposed to be an obligation for the industries to have laboratories which can be used to prove whether their discharge are proportional to those required standards.
- The penalties should be increased to the extent of being a preventive mechanism.
- The technology about treatment of liquid wastes should be specific and the monitoring system should be improved in different institutions
- The polluter pay principle and cleaner mechanism should be applied in order to minimize the quantity of waste generated.
- More research should be done periodically in different season to support and update the current results.
- The last one, fences must be constructed nearby CHUK sewer system to avoid accident as it is crosscutting habitant area in Gitega sector.

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Determination of the Carcass Characteristics of Breeding Pigs in Côte D'ivoire

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Abstract— *The purpose of this study is to determine the characteristics of the carcass of pigs reared in the south of Côte d'Ivoire. The work involved 320 pigs from pig farms in the district of Abidjan and around Abidjan, and a few pig farms in the provinces of Côte d'Ivoire. The animals are left on fasting in the SIVAC slaughterhouse park on the eve of slaughter. On the day of slaughter, the animals are weighed on the ground and after slaughter; the pigs are gutted, split before the carcass weight is determined. The lean meat content of the carcasses is determined by the manual method, using the grading slider ZweiPunkt (ZP), and then the carcasses are classified according to the EUROP grid. The study reveals that the pigs slaughtered at the SIVAC slaughterhouse have an average live weight of 89.1 ± 13.6 kg. The average carcass weight is 66.5 ± 11.2 kg and the average carcass efficiency is 74.71 ± 4.5 %. Most pig's carcasses are in class E where the estimated lean meat content is greater than or equal to 55%. Female pigs are predominantly less fatty than castrated male pigs, with estimated lean meat content greater than or equal to 55 %. These results confirm that the pigs reared in Côte d'Ivoire are less fat and partially meet the nutritional needs of the population.*

Keywords— pigs, lean meat, carcass, Côte d'Ivoire.

I. INTRODUCTION

Côte d'Ivoire has significant agricultural potential for ensuring appreciable food production for an estimated population of 23 million [1] .However, it has a significant gap between production and demand for animal protein. The food balance sheet for Côte d'Ivoire (2001-2007) shows a low availability of animal products which is 12.5 kg on average per inhabitant and per year for meat, against 35 kg on average per *capita* per year. According to [2], Côte d'Ivoire is highly dependent on imports of animal and animal products, apart from eggs. The production of meats from ruminants and poultry, alone, cannot fill the growing protein deficit, given the current and especially future constraints linked to these farms [3]. A development strategy for the pig sector can be an alternative to protein feeding problems. It can play an important role in improving the nutritional status of the population. However, the pork sector presents today many challenges, namely the acceptability of the product by society and its response to consumer requirements in terms of price, quality and safety [4]. In Côte d'Ivoire, people tend to consider pork too fatty and incompatible with good nutrition. The objective of this work is to determine the characteristics of the carcass of pigs slaughtered at the Abidjan SIVAC slaughterhouse.

II. MATERIAL AND METHODS

2.1 Material

The present work involved 320 pigs composed of 183 males and 137 females from pig farms in and around Abidjan, and from a few pig farms in the interior of Côte d'Ivoire. The age of these animals varied between 8 and 10 months, and consist of Large White, Land race, Piétrain, hybride, Duroc and Korhogo pigs. The material of the slaughterhouse consisted of an individual monitoring sheet pigs, an EXA brand mechanical scale, Roman type, weighing 300 kg to weigh cattle. A marker was used to identify live pigs, and methylene blue for the identification of pig carcasses. An electronic load cell incorporated into the rails made it possible to weigh pig carcasses. The ZweiPunkt (ZP) slide, version 2006, was used to determine the lean meat content of the carcasses for grading pigs.

2.2 Live weight and carcass weight

The study was carried out from March to May 2017, at the Société Ivoirienne d'Abattage et de Charcuterie (SIVAC), based in the halltown of Yopougon, in Abidjan. The sampling method used is the empirical, non-probabilistic method in which all breeders who come to slaughter pigs are kept. A maximum of 10 pigs were kept each day, by farmer. These animals were identified on the ground using markers, and methylene blue for carcasses. The pigs were weighed on the foot using an EXA brand mechanical balance, Roman type, with a 300 kg capacity for weighing cattle. After the slaughter of the pigs,

evisceration and slitting, the carcasses were weighed using an electronic load cell incorporated into the slaughterhouse rails.

2.3 Determination of muscle level

The carcasses are graded using the ZweiPunkt (ZP) strip (Figure 1). The grading method for pig carcasses using the ZP slider is a manual grading method based on the measurement of fat and muscle. The Muscle Piece Prediction Equation (PMR) hot, expressed in millimeters, is:

$$Y = 55.99 - 0.514\ G + 0.157\ M$$

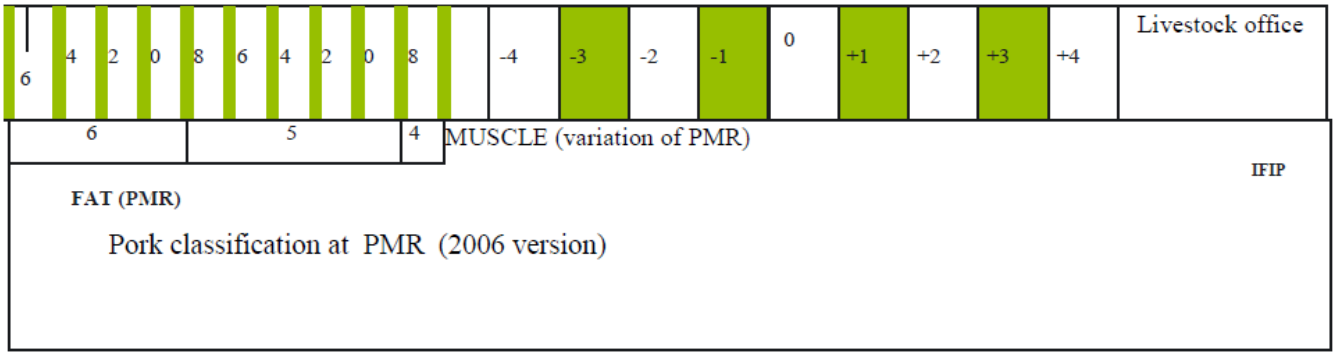


FIGURE 1: ZweiPunkt (ZP) grading strip

According to [5], the use of the slider is carried out in a sequence in several operations (Figure 2). fat is measured. The minimum fat thickness zone is immediately identified visually. The zero of the ZP strip (top left corner) is positioned on the border between the *gluteus medius* muscle and the subcutaneous fat and perpendicular to the rind and the air (Photograph 1). The highest value of the estimated lean meat content is memorized.

Measuring the minimum muscle thickness was done in several steps. The minimum thickness area of the lumbar muscle is visually identified. The zero of the slide (left top corner) is positioned on the dorsal side of the spinal canal at the minimum muscle thickness (Photograph 2). An adjustment of the strip is made so that its upper edge is in contact with the anterior end of the *gluteus medius* muscle. The variation of PMR located under the anterior end of the *gluteus medius* muscle is read. As in the case of fat measurement, the lowest value read is stored. The calculation of the PMR was done by a mental calculation by summing the value of PMR due to fat and the variation of PMR due to muscle and the marking on the carcass.

2.4 Carcass classification

The piece muscle ratio (PMR) or lean meat content obtained made it possible to classify pig carcasses according to the EUROP grid. According to [5], each letter corresponds to a class which is based on the estimated lean meat content of the carcass. The higher the lean meat content of the carcass, the less fat the pork (Table 1). Carcass yield is the ratio of carcass weight to live weight, all multiplied by 100.

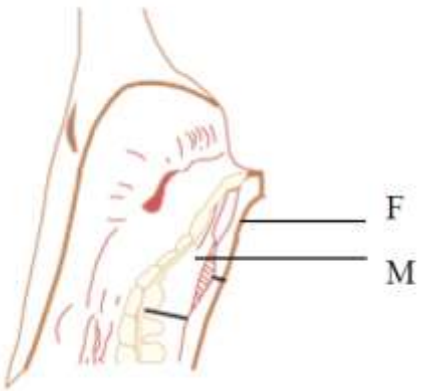
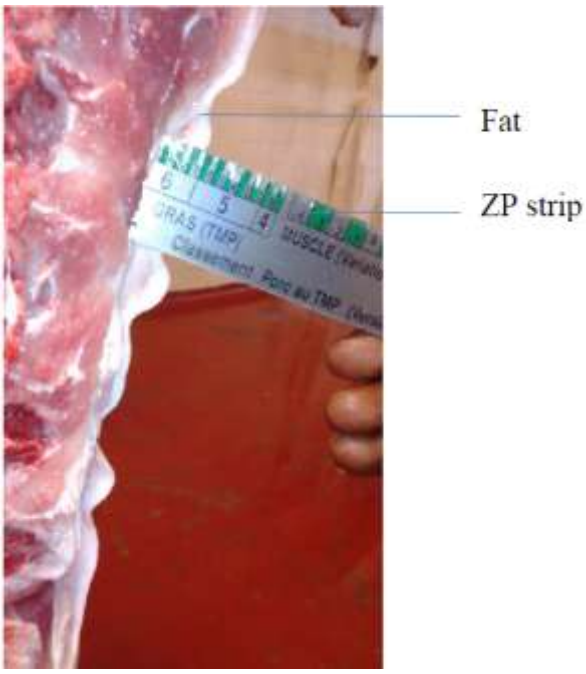
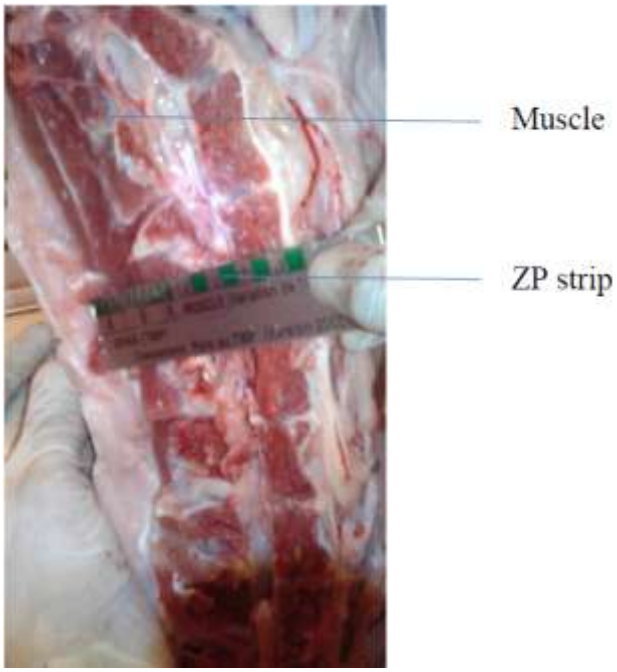


FIGURE 2: Manual method measurement sites
F: Fat; M: Muscle



PHOTOGRAPH 1: Measurement of the minimum fat thickness



PHOTOGRAPH 2: Measurement of the minimum muscle thickness

TABLE 1
EUROP GRID

Estimated lean meat content	Classes
55 and over	E
50 to less than 55	U
45 to less than 50	R
40 to less than 45	O
less than 40	P

Source: Daumas (2006)

2.5 Data processing

Data entry was carried out by Access software and data processing was carried out using Excel software and Statistical Package for the Social Sciences Personal Computer (SPSS / PC) software.

III. RESULTS

3.1 Average weight and carcass yield of slaughtered pigs

According to Table 2, pigs slaughtered at the SIVAC slaughterhouse have an average live weight of 89.1 ± 13.6 kg with an average carcass weight of 66.5 ± 11.2 kg. The lowest recorded live weight is 59 kg and the highest weight is 128 kg. The minimum carcass weight is 42 kg and the maximum is 96.4 kg. The average carcass yield of slaughtered pigs is 74.71 ± 4.5 % with a minimum of 71.19 % and a maximum of 75.31 %.

3.2 General classification of pig carcasses by estimation of lean meat content

According to Figure 3, the carcasses of pigs slaughtered at the SIVAC slaughterhouse belong to classes E, U and R of the EUROP grid. Most pig carcasses (64.69 %) are in class E where the estimated lean meat content is greater than or equal to 55 %. This class is followed by class U which includes 30.94 % of pig carcasses with lean meat content between 50 and less than 55 %. The lowest proportion of pig carcasses (4.37 %) falls to class R with estimated lean meat content between 45 and less than 50 %. There are no pig carcasses belonging to classes O and P.

TABLE 2
WEIGHT AND CARCASS YIELD OF PIGS SLAUGHTERED AT SIVAC

Criteria	Average value	Minimum value	Maximum value
Live weight (kg)	89.1 ± 13.6	59	128
Carcass weight (kg)	66.5 ± 11.2	42.0	96.4
Carcass efficiency (%)	74.71 ± 4.5	71.19	75.31

Number of pigs slaughtered: n = 320;
Carcass efficiency (%) = (Carcass weight x 100) / Live weight

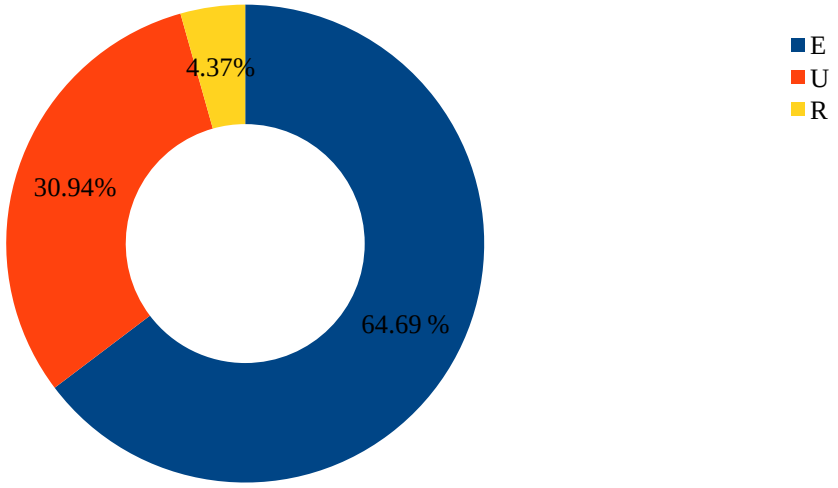


FIGURE 3: General classification of the pig carcass according to the lean meat content using the ZP slider

Number of pigs slaughtered n = 320
Class E: lean meat content estimated at 55 % and more
Class U: estimated lean meat content of 50 to less than 55 %
Class R: estimated lean meat content from 45 to less than 50 %

3.3 Sex classification of pig carcasses

According to Figure 4, the carcasses of female pigs are essentially in class E with a proportion of 49.3 %. Unlike females, castrated male pig carcasses generally belong to class R with a proportion of 78.6 %. Female pigs are therefore mostly less fat compared to castrated males.

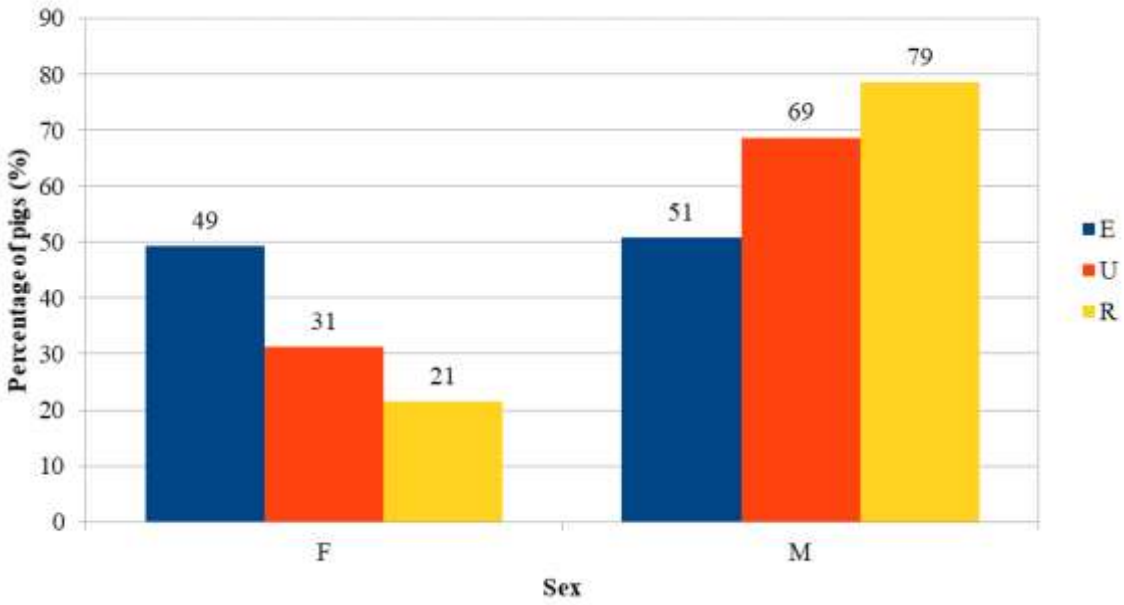


FIGURE 4: Classification of pigs by sex according to lean meat content

Number of pigs slaughtered n = 320

Class E: lean meat content estimated at 55% and more

Class U: estimated lean meat content from 50 to less than 55

Class R: estimated lean meat content from 45 to less than 50

F: Female

M: Male

IV. DISCUSSION

Pigs slaughtered at the SIVAC slaughterhouse have an average live weight of 89.1 ± 13.6 kg with an average carcass weight of 66.5 ± 11.2 kg. This average carcass weight is lower than that obtained by [6] where the average carcass weight was 84.35 kg. The average carcass yield for slaughtered pigs is 74.71 ± 4.5 % with a minimum of 71.19 % and a maximum of 75.31 %. These results are lower than those of [7] who have an average carcass yield of 80.1 ± 1.1 %

Most pig carcasses (64.69 %) are in Class E where the estimated lean meat content is greater than or equal to 55%, indicating that the majority of pigs slaughtered at SIVAC are less fat. These results are similar to those mentioned in the report of the [8] where the lean meat content of pigs varies between 60.2 % and 61.2 %. This could be explained by the fact that pig farming in Côte d'Ivoire is dominated by the semi-intensive system where animals are rationed and fed on a more or less balanced diet. The food ingredients used by pig farmers in Côte d'Ivoire are very varied. The main sources of protein used in most farms are soybean meal, fishmeal, palm kernel meal and copra meal. The dosage of feed for pigs in the southern zone has revealed levels in energy and protein identical to the standard values. These results agree with those of [9] who emphasized that among the factors of breeding influencing the quality of pork meat, diet plays a central role. The level and distribution profile of the ration (restriction then replenishment) influence the speed and composition of the weight gain (proteins / lipids) at body and tissue level, and therefore, the composition of the carcass and tissues. The sensory quality of the meat can thus be modified, in particular via the content of intramuscular lipids. These same authors indicate that the balance between the main nutrients, in particular proteins and the energy of the ration, also condition the speed and the nature of tissue deposits, which can thus affect the sensory quality of meats. Nutrition is a powerful lever for modifying the lipid profile of pig meat, the fatty acid content (polyunsaturated n-3 in particular), and their nutritional value.

These results are in agreement with those of [10] who showed that in the castrated, the food restriction must be important to allow a significant reduction in adiposity. The distribution of a protein-deficient diet is accompanied by an increase in the adiposity of the animal and in the content of inter and intramuscular lipids [11]. These results also agree with those obtained by [12] who indicate that pork is often considered fatty by the medical profession or consumers, due to a confusion made between the overall adiposity of the carcass and the lipid content of the lean fraction of the meat. In reality, the largest muscles in the pig are low in fat. This lipid content is 1.5 to 2 % in the longissimus of pigs, against 5 to 6 % in the equivalent muscle in cattle.

Female pigs are mostly less fat with estimated lean meat content greater than or equal to 55% compared to castrated males having estimated lean meat content between 45 % and less than 50 %. These results are consistent with those of [13] who revealed that castration has the effect of increasing food consumption in animals, decreasing nutritional efficiency and increasing the adiposity of carcasses, thus acting on the chemical composition of adipose tissue. The adipose tissues of castrated males contain more lipids and less water than those of whole males, and females to a lesser extent [14, 15, 16, 17].

V. CONCLUSION

Most pig carcasses with an average carcass yield of 74.71 ± 4.5 % are in class E where the estimated lean meat content is greater than or equal to 55 %. Compared to castrated males, female pigs are predominantly less fat with an estimated lean meat content greater than or equal to 55 % .These results confirm that pigs reared in Côte d'Ivoire are less fat and partly respond to nutritional needs of the population.

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Evaluation of the Biological Efficacy of Fungus and Bacteria Isolated from Mushroom Substrates against Pathogenic Fungi

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Abstract— *In vitro efficacy of fungus and bacteria isolated from mushroom substrates were evaluated against selected pathogens (Fusarium oxysporum, Sclerotium rolfsii, and Colletotrichum corchori). There were four fungi Aspergillus flavus, Aspergillus niger, Trichoderma harzianum, and Penicilliumsp and four bacteria Bacillus subtilis, Bacillus cereus, Pseudomonas sp. and Paenibacillus polymyxa isolated from substrate. Different biochemical and pathogenicity test were performed to confirm their species. In in-vitro dual culture method T. harzianum showed the highest inhibition in case of Fusarium oxysporum (70.26%) followed by Sclerotium rolfsii (59.94%) and Colletotrichum corchori (57.02%) whereas Penicillium sp showed the least significant result against these pathogens. To inhibit the growth of Sclerotium rolfsii and F. oxysporum. Pseudomonas spp. was significant around 72.19% and 62.62% respectively. On a comparative study among the four isolated bacteria and fungi Pseudomonas sp. and T. harzianum showed the best significant antagonistic activity against all the selected plant pathogenic fungi.*

Keywords— In vitro, isolated, mushroom substrates, dual culture, pathogenic fungi.

I. INTRODUCTION

Among the edible fungi, mushroom is a large reproductive structure, which is the most popular nutritious, delicious and medicinal vegetable around the world. Materials containing cellulose, hemicellulose and lignin (i.e., rice and wheat straw, cotton seed hulls, sawdust, waste paper, leaves, and sugarcane residue) can be used as mushroom substrates (Chang, 1989).

Remarkable various factors are responsible for lower mushroom production in Bangladesh. Among the different factors, fungal and bacterial disease and their antagonistic effect on mushroom is one of the major influential factors, which can initiate from the mushroom substrate.

Usually chemical components are not prescribed for the management of diseases because they have negative impression on the environment and human health. Antifungal agents produced by some fungus and bacteria in mushroom have shown to be beneficial to control pathogenic fungi (Chang and Kim, 2007). Some bacteria belonging to the species Pseudomonas and Bacillus have been reported to exert promoting effects on the growth of mushrooms, including *P. eryngii* (Kim *et al*., 2007). *Trichoderma harzianum* used as potential biocontrol agents against different *Fusarium* sp. (Marten *etal*., 2000; Siddiqui, 2005).

Keeping these facts in mind the study was undertaken to evaluate the biological activities of isolated bacteria and fungi against selected pathogenic fungi (*Fusarium oxysporum*, *Sclerotium rolfsii*, *Colletotrichum corchori*).

II. MATERIALS AND METHODS

The experiment was conducted at the Molecular Plant Pathology Laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University.

2.1 Collection of mushroom substrate and pathogenic fungi

Mushroom substrates mainly containing Rice and wheat straw, paper and saw dust were collected from mushroom culture centre, Savar, Bangladesh as they are available and cheap to use.

Three pathogenic fungi *Fusarium oxysporum* (the causal agent of dry rot of potato), *Sclerotium rolfsii* (the causal agent of foot and root rot of betel vine), *Colletotrichum corchori* (the causal agent of anthracnose of jute) were collected from MS Laboratory Department of Plant Pathology of Sher-e-Bangla Agricultural University. The fungi were cultured in Potato Dextrose Agar media.

2.2 Isolation of bacteria on NA media

Bacteria were isolated from mushroom substrate by dilution plate method following the technique describer by Goszczynska and Serfontein, (1998).

2.3 Biochemical Tests for bacteria

Various biochemical tests were done to confirm the bacterial species. The tests were- KOH solubility test (Suslow *et al*., 1982), catalase test (Schaad, 1988), oxidase test (Kovacs, 1956), gelatin liquefaction test (Salle, 1961), starch hydrolysis test (Cowan, 1974). Bacillus Cereus Agar Base was done to separate different species of Bacillus (Harmon (1992). Virulent colonies of *Pseudomonous* were selected on the basis of growth of bacteria on cetrimide agar medium.

2.4 Isolation of fungi on PDA media

Potato Dextrose Agar (PDA) media were prepared to isolate fungi. Dilution plate technique was carried out as described by (Dhingra and Sinclair, 1985) for isolation of mycoflora.

2.4.1 Identification of fungi

Identification was done with the help of different books, manuals and publications following the keys suggested by Barnett and Hunter (1992) Watanabe (2000) Mathur and Kongsdal (2003).

2.5 Dual culture method to evaluate the antagonistic effect of isolated bacteria and fungi against pathogenic fungi

Isolated antagonist was screened for their ability to suppress the mycelial growth of fungal *in vitro* dual culture assays on potato dextrose agar media. Each combination of pathogen and antagonist was replicated three times and plates were randomly placed in the dark chamber and incubated at 25°C for 7 days. The radial mycelial growth of pathogenic fungus towards the antagonist (T) and that on a control plate (C) were measured and the mycelial growth inhibition was calculated according to the formula (Amadioha 2004):

$$\%\ \text{inhibition of growth} = \frac{C-T}{C} * 100$$

Data collected during experiment period were tabulated and analyzed following Statistical package MSTAT-C. Treatment means were compared with Duncan's Multiple Range Test (DMRT) (Gomez, K.A. and Gomez, 1984).

III. RESULTS AND DISCUSSION

3.1 Antagonistic effect of isolated bacteria against three selected pathogenic fungi

Biological efficacy of bacteria isolated from mushroom substrate against three pathogenic fungi were studied and found significant variations in terms of percent inhibition of radial mycelial growth of pathogenic fungi (Table 1). In case of *Fusarium oxysporum* the highest inhibition observed against *Pseudomonas* spp. (62.62 %) and the lowest against *Paenibacillus polymyxa* (48.00 %). In case of *Sclerotium rolfsii* the highest inhibition observed against *Pseudomonas* spp. (72.19 %) and the lowest against *Bacillus subtilis* (20.14 %). In case of *Colletotrichum corchori* the highest inhibition observed against *Pseudomonas* spp. (48.15 %) and the lowest against *Bacillus subtilis* (20.15). In this study it has been observed that among the bacterial antagonists used against pathogenic fungi the most effective was *Pseudomonas* sp.

TABLE 1
BIOLOGICAL EFFICACY OF BACTERIA ISOLATED FROM MUSHROOM SUBSTRATE AGAINST THREE PATHOGENIC FUNGI.

Bacterial isolates	% Inhibition of mycelial growth		
	Fusarium oxysporum	*Sclerotium rolfsii*	*Colletotrichum corchori*
Bacillus subtilis	62.21 b	20.14 d	20.15 c
Bacillus cereus	54.00 c	40.18 c	38.14 b
Paenibacillus polymyxa	48.00 d	48.85 b	35.28 b
Pseudomonas sp.	62.62 a	72.19 a	48.15 a
LSD(0.50)	2.71	2.19	3.27

3.2 Antagonistic effect of isolated fungi against three selected pathogenic fungi

Biological efficacy of fungal isolated from mushroom substrates against three pathogenic fungi were studied and found significant variation in terms of percent inhibition of radial mycelial growth of pathogenic fungi. In case of *Fusarium oxysporum* the highest inhibition was observed against *T.harzianum* (70.62%) and the lowest against *Penicillium* sp (28.58%). In case of *Sclerotium rolfsii* highest inhibition observed against *T. harzianum* (59.94%) and the lowest against Penicilliumsp (20.15%). In case of *Colletotrichum corchori* highest inhibition observed against *T. harzianum* (57.02%) and the lowest against *Penicillium* sp (39.59%).

TABLE 2
BIOLOGICAL EFFICACY OF FUNGAL ISOLATED FROM MUSHROOM SUBSTRATE AGAINST THREE PATHOGENIC FUNGI.

Fungal isolates	% Inhibition of mycelial growth		
	Fusarium oxysporum	*Sclerotium rolfsii*	*Colletotrichum corchori*
Penicillium sp	28.58 d	20.15 d	39.59 c
Aspergillus flavus	32.37 c	57.67 b	42.69 c
Aspergillus niger	49.23 b	45.37 c	47.69 b
Trichoderma harzianum	70.62 a	59.94 a	57.02 a
LSD(0.50)	2.62	2.39	3.32

IV. CONCLUSION

The present study was based on the presence of bacteria and fungus on mushroom substrate and their antagonistic effect against *Fusarium oxysporum*, *Sclerotium rolfsii* and *Colletotrichum corchori*.

On a comparative study among the four isolated fungi *Trichoderma harzianum* isolated from different mushroom substrate was found effective against the selected pathogenic fungi. Thus, *Trichoderma harzianum* could be used as bio-control agent against those pathogenic fungi. Further works need to be conducted to research the method of application of *Trichoderma harzianum* against those fungi. Among the four isolated bacteria *Pseudomonas* sp. showed the best significant antagonistic activity against all the selected plant pathogenic fungi. After *Pseudomonas* sp. *Bacillus subtilis* had the most significant antagonistic activity.

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Effects of NP and Biofertilizers on Growth and Some Yield Attributes of Sunflower *Helianthus Annus* L

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Abstract— *A field experiment was carried out in the demonstration farm of Sudan University of Science and Technology, College of Agricultural Studies, Shambat, for two consecutive seasons 2014/15 and 2015/16 to determine the effects of synthetic N (urea) and P (superphosphate) fertilizers and/or microbial biofertilizers on plant height (cm), number of leaves per plant, shoot and root dry weights, head diameter and 1000 seed weight of the sunflower hybrid Shambat. Nitrogen and phosphorus were applied at 100 and 50 kg/feddan, respectively. Biofertilizers were applied as a mixture of Azospirillum Brasilense (a nitrogen fixer) and Bacillus megaterium var. phosphaticum (a phosphate solubilizer). A combination of synthetic and biofertilizers was applied in addition to the control. NP treatment gave the highest values of growth parameters in the first season followed by biofertilizers. In the second season biofertilzers then their combination produced the highest values. Head diameter and 1000 seed weight were enhanced by NP fertilizers. Significant differences in the first season were found only between NP and the combination of NP + AB in the number of leaves per plant and root dry weight, and in the second season the same treatments were significantly different only in shoot dry weight.*

Keywords— Sunflower, biofertilizer, nitrogen, phosphorus, growth.

I. INTRODUCTION

Sunflower (*Helianthus annuus*), belonging to the family *Composite*, is an important oilseed crop containing high quality edible oil. It is easy to cultivate and grown in different conditions and soils (Kaya and Kolsarici, 2011and Lopez-Valdez *et al*., 2011). It is an emerging oil producing crop in Sudan after Groundnuts and sesame. The total area under sunflower in Sudan, season 2003/2004 was 6300 ha (Zubillaga et al., 2002).

Nitrogen and Phosphorus are the two most important major essential elements for growth and development of plants. They are applied in the form of chemical fertilizers. Such fertilizers pose health hazards and microbial population disturbances in soil besides their high cost. Excessive nitrogen fertilization of sunflower not only generates that environmental risk, it may also affect the grain quality, decreasing its oil content and reduce yield through an increase of plant lodging (Scheiner *et al*., 2002). In addition, soluble phosphorus under wide range of soil conditions converts to unavailable form because of phosphorus fixation. In such a situation the biofertilizers play a major role in organic agricultural practices that aim to enhance biodiversity, biological cycles and soil biological activity so as to achieve optimal natural systems that are socially, ecologically and economically sustainable (Samman *et al*. 2008).

Since the environmental and health problems arising from chemical fertilizers usage, attention has been drawn to the application of biological fertilizers in agriculture. Biological fertilizers or biofertilizers contain useful microorganisms, which could colonize the rhizosphere and promote plant growth through increasing the supply or availability of essential nutrients to the plants (Vessey, 2003). Soil microbes play an important role in many critical ecosystem processes, including nutrient cycling and homeostasis, decomposition of organic matter, as well as promoting plant health and growth as bio-fertilization (Han *et al*., 2007). Certain strains are referred to as plant growth-promoting rhizobacteria (PGPR), which can be used as inoculant biofertilizers. These bacteria include species of Azotobacter and Azospirillum, both of which provide direct and indirect effects on plant growth and pest resistance (Kennedy *et al*., 2004). Azotobacters and Azospirillum are free-living bacteria that fix atmospheric nitrogen in cereal crops without any symbiosis and they do not need a specific host plant

(Mahrous *et al*., 2014).It is well-recognized that microbial inoculants constitute an important component of integrated nutrient management that leads to sustainable agriculture. (Akbari *et al*., 2011).

In recent years, biofertilizers have emerged as a promising component of integrating nutrient supply system in agriculture. Our whole system of agriculture depends in many important ways, on microbial activities and there appears to be a tremendous potential for making use of microorganisms in increasing crop production. Microbiological fertilizers are an important part of environment friendly sustainable agricultural practices (Bloemberg et *al*., 2000).Nowadays multi-strain biofertilizers containing microorganisms, having a definite beneficial role in supporting plant growth and developing sustainable soil fertility (Mekki and Ahmed, 2005) are receiving much attention.

Regarding the significant role of N, and P in sustainable production of oil seed crops, an experiment was conducted to study the effect of biofertilizers on growth and some yield attributes of sunflower (*Helianthus annuus*. L).

II. MATERIALS AND METHODS:

A field experiment was conducted for two consecutive seasons in the years 2014/15 and 2015/16 at the Demonstration farm of the Faculty of Agriculture- Sudan University of Science and Technology, Khartoum-Sudan (Lat. 15° 40′ N, Long.32° 32′ E).Composite soil samples were collected from 0 to 30 cm depth and analyzed for some chemical soil properties determination (pH = 7.4, EC = 0.36dSm^{-1}).

The experiment was laid out in a randomized complete block design. Soil was ploughed, harrowed, leveled and cut into 70 cm apart ridges.

Seeds of Sunflower hybrid Shambat were sown in 16 m^{2}plots and 30 cm hole spacing with three seeds/ hole that are thinned to two after plant establishment. The first sample was taken 70days after sowing, and the second after 100 days. Parameters determined were plant height (cm), number of leaves, root and shoot dry weights (g), head diameter (cm)and 1000 seed weight (g). Treatments tested were as follows: nitrogen (urea) and phosphorus (superphosphate) synthetic fertilizers (NP) at rates of 100 and 50 Kg /Feddan of N and P, respectively. Biofertilizer mixture (AB) of *Azospirillum brazilense* (nitrogen fixer) and *Bacillus megaterium* var. phosphaticum (phosphate solubilizer) as carrier based biofertilizers, the combination of synthetic NP at half dose and bio-fertilizers (NP+AB)and a control set, all in triplicate.

Urea was added alongside ridges as split two doses, one at sowing and the other at flowering. Superphosphate was as a single dose at sowing. Biofetilizer mixture was added as a seed coating after seeds had been mixed with an adhesive (12% sucrose solution), then seeds were dried in shade for15 minutes, sown and irrigated immediately.

Data of the two seasons of the experiment were statistically analyzed separately according to the analysis of variance (ANOVA) using Statistic 8.0 computer software (2008).

III. RESULTS AND DISCUSSION

In table 1 nitrogen and phosphorus fertilizers (NP) treatment have generally improved growth parameters of sunflower plants especially in the first season, followed by the biofertilizer mixture (AB). However, Keshta*et al*. (2008) reported that plant height of sunflower was significantly less under biofertilization treatment than under the control treatment.

The greatest plant heights were obtained from the AB treatment with values of 149 cm and 160 cm for the first and second samples, respectively.

The highest number of leaves per plant (38.7) was obtained with NP treatment that was significantly superior to the combination NP + AB treatment in the first sample that could explained by the direct effect of nitrogen on shoot growth and vigor.

Regarding root dry weight, significant increase was obtained from both AB and the combination NP+AB treatments (65.7, 61.1gm) over NP in the second cut. Shoot dry weight was at its highest value (144gm) with the NP treatment in the first cut whereas in the second season the combination NP+ AB produced the highest value (270gm) which might be attributed to the enhancement of nutrient availability induced by the microbial growth promoting effect.

TABLE 1
EFFECTS OF N, P AND BIOFETILIZER ON GROWTH PARAMETERS OF SUNFLOWER SEASON2014/15

Treatment	Plant height (cm)		No. Leaves/plant		Root dwt (g)		Soot dwt (g)	
	1st sample	2nd sample	1st sample	2nd sample	1st sample	2nd sample	1st sample	2nd sample
NP	139.3 a	140.0 a	38.7 a	42.0 a	12.8 a	23.2 b	144.0 a	249.8 a
AB	149.0 a	160.3 a	32.7 ab	40.7 a	11.2 a	65.7 a	83.7 a	203.8 a
NP + AB	129.0 a	144.3 a	31.3 b	37.3 a	9.5 a	61.1 a	125.0 a	270.4 a
control	137.0 a	148.7 a	37.0 ab	40.0 a	7.7 a	34.1 ab	91.7 a	189.2 a
$SE_{0.05}$	11.10	10.09	2.90	2.42	3.80	14.49	28.20	57.33

Means denoted by the same letters within the column are not significantly different at (p=0.05) according to Duncan's multiple range test.

In the second season as shown (table 2) the results of the effects of different treatments on plant height, number of leaves, root and shoot dry weights were fluctuating with AB biofertilizer mixture giving the highest number of leaves in both the first (35) and second (35.3) samples taken and the highest root dry weight in the second sample (69.5g). The combination treatment gave the highest values in both plant height (150.7cm) and shoot dry weight (173.1g) with the latter giving significant increase over NP treatment. This is in good agreement with the findings of Mostafa and Abo-Bakr (2010) who stated that using biofertilizers of nitrogen fixing and phosphate dissolving bacteria in Egypt, significantly increased plant growth parameters compared with untreated plants. The biofertilizer application had stimulated nutrient accumulation and plant growth compared to the non treated plants (Amir *et al*., 2003). Moreover, the growth parameters of 30-day-old sunflower plants significantly increased shoot lengths with a maximum effect by each of phosphorein and potash biofertilizers in sunflower (Hala *et al*., 2012).

TABLE 2
EFFECTS OF N, P AND BIOFETILIZER ON GROWTH PARAMETERS OF SUNFLOWER SEASON2015/16

Treatment	Plant height (cm)		NO. Leaves/plant		Root dwt (g)		Soot dwt (g)	
	1st sample	2nd sample	1st sample	2nd sample	1st sample	2nd sample	1st sample	2nd sample
NP	144.0 a	192.3 a	33.0 a	33.7 a	10.2 a	43.0 a	86.6 b	171.3 a
AB	137.3 a	181.3 a	35.0 a	35.3 a	13.7 a	69.5 a	145.7 ab	262.4 a
NP + AB	150.7 a	189.0 a	33.0 a	32.0 a	9.0 a	46.8 a	173.1 a	221.9 a
control	137.3 a	180.7 a	34.0 a	35.0 a	15.4 a	60.3 a	144.9 ab	303.1 a
$SE_{0.05}$	17.08	14.48	3.08	1.48	6.25	18.81	34.96	67.27

Means denoted by the same letters within the column are not significantly different at (p=0.05) according to Duncan's multiple range test.

Regarding yield attributes of head diameter and 1000 seed weight sample, synthetic NP fertilizer treatment induced the largest increase but not at a significant level this result is in line with the findings of Mekki and Ahmed (2005) who found that soybean plants treated with biofertilizer singly, showed the lowest values of 1000 seeds weight in comparison to the other synthetic fertilizer treatments. The largest head diameter values were 13 cm in the first sample and 16 cm in the second. The greatest 1000 seed weight value was 66.6 g with NP followed by 59.8 cm obtained with the biofertilizer mixture AB, while the combination treatment ranked third (table 3). This could be explained by the fact that the synthetic NP fertilizers

supplied the plant need while half their dose in combination with the microbial biofertilizer was not sufficient to support plant needs and at the same time suppressive to the microbes.

These results showed that the differences between the treatments were not reaching the significant level. On the other hand, the treatment containing the sole mineral nitrogen was the superior one in the first season (table 3).

TABLE 3
EFFECTS OF N, P AND BIOFETILIZER ON HEAD DIAMETER AND 1000 SEED WEIGHT OF SUNFLOWER SEASON 2014/15

Treatment	Head diameter (cm)		1000 seed wt (g)
	1st sample	2nd sample	
NP	13.3 a	18.7 a	66.6 a
AB	10.7 a	14.7 a	59.8 a
NP + AB	12.0 a	16.0a	56.9 a
control	10.0 a	15.3 a	45.2 a
$SE_{0.05}$	1.70	2.50	11.02

Means denoted by the same letters within the column are not significantly different at (p=0.05) according to Duncan's multiple range test.

In the second season there were no heads and in the first sample and in the second all values were lower than the control. The same way, Keshta *et al*. (2008) reported that biofertilizer alone gave the lowest values of yield traits. However, the application of cerealine biofertilizer significantly increased head diameter of sunflower. Whereas, N at 45 kg /feddan was superior to bioertilizer in head diameter trait except for the 100 seed weight of sunflower (Keshta *et al*., 2008). According to our results the largest thousand seed weight was 83.4 g obtained by the NP treatment followed by 80.8 g at the AB microbial biofertilizer treatment (table 4).That could be due to that the release of N by the biofertilzer was not enough to compensate for then need by. These results are in agreement with those obtained by Abou-Khadrah et al. (2002).

TABLE 4
EFFECTS OF N, P AND BIOFETILIZER ON HEAD DIAMETER AND 1000 SEED WEIGHT OF SUNFLOWER SEASON 2015/16

Treatment	Head diameter (cm)		1000 seed wt (g)
	1st sample	2nd sample	
NP	-	18.3 a	83.4 a
AB	-	23.7 a	80.8 a
NP + AB	-	20.3 a	71.8 a
control	-	24.3 a	81.7 a
SE0.05	-	2.62	12.71

Means denoted by the same letters within the column are not significantly different at (p=0.05) according to Duncan's multiple range test.

IV. CONCLUSION

In this experiment where sunflower plants were treated with synthetic NP fertilizers and/ or NP biofertilizers, the growth parameters at the first season were enhanced by the synthetic NP fertilizers followed by the biofertilizers. In the second season biofertilizers caused the largest increase followed by the combination NP+AB. The head diameter and 1000 seed weight yield attributes were fairly increased by the synthetic fertilizers NP. Very few significant effects were recorded specially in yield attributes. We could conclude that biofertilizers could have a better impact on measured parameters and much work has to be carried out concerning dose adjustment of synthetic biofertilizers in particular when employing combination treatments.

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Influence of Project Management Practices on Construction Projects in Rwanda

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Abstract*—The construction industry is among the leading sectors in economic growth of Rwanda. Most of construction projects failed to maintain their schedules, and remain within budgetary costs; this despite there being knowledge of project management practices introduced in construction project. Generally this study aimed to investigate influence of project management practices on construction project in Rwanda. 99 survey questionnaires were administered to 99 active contractors and consultants registered in RPPA. It was found that 91.9 % of respondents confirmed that they applied project management practices in their daily assignments however 74.7 % got skills from experience, therefore majority in industry are not professional managers. Construction planning like risk plan, communication plan are not done satisfactory, 77.7% confirmed that risk plan analysis is less applied; few analysis done the top management involvement is not satisfactory, uncertainties contribute a lot in time and cost overruns. Other researches revealed that the best organization structure is project-based and matrix while it was found that in Rwanda 85.8 % confirmed the functional structure, the later was proved not suitable in multidisplinary projects. The study concluded that industry has not professionals in management therefore less application of management practices. The contractors and consultants are recommended to encourage their engineers to go ahead management classes or profession trainings (PMI, PRINCE 2, AGILE….) to save the construction industry.*

***Keywords*—Construction projects, organization structure, effective project manager and risk analysis.**

I. INTRODUCTION

The construction industry is one of the major industries contributing significantly to the socio-economic development growth (Choge&Muturi, 2014). Project management emerged because of the growing demand for complex, sophisticated, customized goods and services and the exponential expansion of human knowledge (Bakouros&Kelessidis, 2000).

Standish (2013), according to a recent Standish Group survey report, 61% of the projects either failed or was challenged to meet success criteria; and 74% faced schedule overruns.

Numerous researches have outlined the issue of poor time and cost performance of construction projects worldwide. In a study of 8,000 projects, found that only 16% of the projects could satisfy the three famous performance criteria: completing projects on time, within budgeted cost and quality standard, while in a global study on cost overrun issues in transport infrastructure projects covering 258 projects in 20 nations concluded that 9 out 10 projects face cost overrun. Time and cost overrun has been reported as major problems globally (Aftab, Ismail, & Ade, 2012).

Rwanda has seen a significant rise in infrastructure developments in the recent past, especially in the fields of real estate development. However, many house construction projects have failed to achieve project success due to increase risk and uncertainty (Njagi, Mbabazi, & Kibachia, 2016). There are also various failed or abandoned projects which have denied beneficiaries envisaged facilities and services. Contracts for 78 projects worth Frw 126,052,898,036 delayed and were not completed within contract period. Out of these, 14 projects worth Frw 3,368,946,434 failed to proceed or contracts were abandoned after paying Frw 1,898,334,461 to the contractors (OAG, 2014). In addition, report on 8th July, 2016 by KT Press Team an editor in Kigali Today newspaper stated that Regional Convention Centre get opened after failing 3 times, Kigali convention centre is worth$300 Million, commenced in 2009, was initially supposed to be completed and opened in 2011 but had to be postponed several times till 2016.

1.1 Statement Of The Problem

Most of construction projects failed to maintain their schedules, and remain within budgetary costs; this despite there being knowledge of project management practices introduced in construction project. According to Munns& Bjeirmi, (1996), the definition of project management suggests a shorter term and more specific context for success. The outcomes of project management success are many. They would include the obvious indicators of completion to budget, satisfying the project

schedule, adequate quality standards, and meeting the project goal. Construction managers plan, coordinate, budget, and supervise construction projects from development to completion. In spite of so many efforts, man hours and resources, we still find it very difficult to finish construction projects on time within budget and available resources (Pranam, Madhusudan, & Sudharshan, 2013). This brings to focus the effectiveness of the said project management practices introduced in construction sector.

1.2 Aim And Objectives

The aim of this study is to investigate the influence of Project management practices on construction project in Rwanda. The specific objectives are:

1. To describe the context of project management practices that are applied in Rwanda,
2. To identify the most required practices and characteristics of an effective project manager,
3. To develop a project management framework that will be used in construction project in Rwanda.

II. LITERATURE REVIEW

The project management process is complex, usually required extensive and collective attention to a broad aspect of human, budgetary and technical variables (Salma, Abdul, Abdelnaser, & Mahyuddin, 2009). According to Drob, (2009), the appearance and development of the project management has occurred as a consequence of the need to adapt the theory and practice of management to the projects specific. In practice, the application of the tools and techniques of project management is facilitated by the use of specialized software for project management.

Uneb&Raza(2018) conducted a study dedicated towards finding out the perceptions regarding factors related to project failures in the construction industry of Pakistan. It was observed that organizational structure plays a lot. Sarfo (2007) in his study reported that the organizational structure adopted for management of building projects is an important area to consider for the success of projects. Hyvari (2006), results of his study indicated that organizational design is associated with project management effectiveness. For example, they indicate that project matrix and project team-based organizations are the most effective.

Ahmed et Al. (2013), stated that the essential leadership and managerial knowledge, skills, competencies and characteristics ensure successful completion of projects through right decisions at right time and by employing right people at right places. Nguyen, Ogunlana, & Lan, (2004), carried a research to assess factors affecting project success in Vietnam. They acknowledged the complex nature of construction projects. They divided the success factors into 4 major categories; comfort, competence, commitment and communication. They concluded that the factors which were ranked higher by the professionals were all human related. They also claimed that the results of their study can be applied construction sectors of other Asian countries.

Hwang et l. (2013) carried out a research and results show that scheduling and planning management is the most significant knowledge for the construction project while cost, quality, human resource and communication management are the second most competencies in the construction project. Patanakul et al. (2010) concluded that by using appropriate tools and techniques in the right way will have direct impact on the delivery of a successful project. Hwang et. Al. (2013), in their study in Singapore, they determined the allocation of project risk factors for infrastructure projects involving public – private partnerships. Their study area was Singapore in which this project delivery method has been commonly used for infrastructure projects. The important success contributing factors were found to be “well-organized public agency”, “appropriate risk allocation and sharing” and “strong private consortium”.

III. RESEARCH METHODOLOGY

This study aims to investigate the influence of Project management practices on construction project success in Rwanda. Therefore the research is designed to investigate the information from documentations, consultants and contractors. The study adopts both quantitative design (exploratory and descriptive); and qualitative design (explanatory). Explanatory design is used during a collection of insights and ideas about research problem and variables through literature and pilot interview while descriptive design helps in a collection of data describing the situation, set of events or the characteristics of a particular individual, or of a group through questionnaires. This entailed collection of data on more than one respondent at any one selected case so as to collect a body of data related with more than one variable. In fact this study applies triangulation to increase the reliability and validity of the study or to increase the comprehensiveness of the study. According

to Munhall (2001), research triangulation is a term that refers broadly to the research practice of combining methods within a single tradition (quantitative or qualitative) or across those traditions.

The target population for the research is contractors and consultants who are registered by RPPA. In the period of 2018, RPPA published the categorization lists 2018-2019. Both contractors and consultants are categorized basing on construction types and the value of bid to tender (Project cost).

A total of 99 questionnaires will be distributed to sampled contractors and consultants. According to Zikmund (1994), the choice of the method for statistical analysis depends on the type of questions to be answered, the number of variables and the scale of measurement. In this research, all data will be coded and analyzed using frequency and regression tool in the statistical software, namely, Statistical Package of Social Science (SPSS) 22.0.

IV. RESEARCH RESULTS AND FINDINGS

4.1 Reality insurance of results

Most of failed projects are governmental funded projects, having 75.8 % of respondents participated in public constructions ensures the reality of information, the gotten information were grounded as only 5.1% of respondents had less than 5 years of experience, while others had more than 5 years, having information from experienced people provide insurance of ground reality.

4.2 Application of management practices

The aim of this study was to assess the influence of project management practices on Rwanda project, in this research it was much needed to know if the personnel of construction industry applied management practices, 91.9 % of respondents confirmed that they apply project management practices in their daily assignments. There are numerous researches confirmed that application of management practices imply successful completion of project (Lock (2004), Bayani et Al. (2015) .etc.), applying those practices in Rwanda on rate of 91.9% can guarantee only success whilst cost and time overruns are experienced in several projects. This result confirmed application of management practices brought an attention of how they apply them and assessing if the main practices are applied, at which rate?

Majority of respondents 74.7 % applying management practices in their daily works did not acquire management skills from schools (education) or professional training, their management skills increase with experience. Due to complexities of construction projects there are much managerial skills to be acquired from school and professional training that you cannot have by experience. In conclusion majority of managers in Rwanda construction industry are not professional managers but the experienced engineers become managers.

4.3 Project planning and scheduling & Management tools and technique

It was found that detailed planning is not fully covered in Rwandan constructions, only project planning (outlining the activities, tasks, dependencies and timeframes), resource plan (listing the labour, equipment and material required), financial plan (listing the labour, equipment and material costs) are applied in Rwanda on average majority, 68.7%, 63.7%, 52.6% respectively. Other construction planning like risk plan, communication plan are not done satisfactory, while quality plan, acceptance plan are also considered on average majority of 63.6% and 68.6% respectively. The use of planning and scheduling tools in Rwandan constructions is not satisfactory; the only tool applied on average majority is Gnatts charts (bar charts), either critical path diagrams, primavera, PERT are applied on unsatisfactory rate in Rwanda. Reference is made to literature review, the project managers who don't apply at maximum the management tools and techniques cannot deliver a complex project successful. Earned value management is less considered where 76.6% of respondents disapprove its application in Rwandan construction; EVM is applied to predict the future of project.

4.4 Organizational Structure & Leadership style

The dominated organization structure is functional, 85.8 % of the respondents confirmed this type of organization structure in their companies. This is contrary to literatures where, they indicate that project matrix and project team-based organizations are the most effective. Sarfo (2007) in his study reported that the organizational structure adopted for management of building projects is an important area to consider for the success of projects. No leadership styles is a dominant in Rwanda, the average majority of respondents 50.5% agreed the existence of situational leadership style where no single style can be applied on all projects.

4.5 Risk analysis

It was found that risk plan does not done in Rwandan construction with average percentage of 77.7%. Where 15.2 % of respondents agreed the application of risk planning, 7.1% had no idea about risk planning referred as highlighting potential risks and actions taken to mitigate them. Lack of risk plan confirmed the lower risk analysis, 66.7% disagreed the existence of room for risk management, 13.1 % were neutral, while 20.2% agreed, there for risk management is less assessed and handled suitably, the few risk done, top management involvement is low. Uncertainties contribute significantly in construction project failures.

4.6 Appreciated qualities of an effective project manager

The qualities of an effective project manager appreciated by respondents were dominated by motivation, decision making and flexibility where majority of the respondents agreed them on rates of 81.2%, 70.6% & 74.8% respectively.

V. CONCLUSION AND RECOMMENDATIONS

This study used literature review and questionnaire survey methods, to achieve its aim of investigating the influence of Project management practices on construction project in Rwanda. The study concludes that there is a lot that the construction industry itself can do to improve the performance in construction project management. The weakness of construction project management is a key cause of most of project failures like lack of professional managers. The generalization of this study can be applied on entire population as the sample data used was efficient. The results of this study are the paramount academic reference and mainstay resource for construction management practitioners.

The project management participants are not academically qualified in management; there is also much weakness in organization structures in companies. Here below are list of recommendations and proposed construction project management framework:

- The contractors and consultants are recommended to encourage their engineers to go ahead management classes or profession trainings like PMI, PRINCE 2, AGILE, etc. to have all required skills of an effective project manager.
- The contractors are recommended to introduce project based management or matrix from functional structure that seems outdated.
- It is recommended to work out risks plan, and involvement of top management is merely mandatory.

It is recommended to follow the following proposed project management framework, where project management should work on two areas organization and project, the project should be managed as parallel organization with its budget, all management planning must be fully covered such as work break down structure, organization breakdown structure, resources, financial, risk analysis, quality standards, acceptance standards, and communication planning. Risk management is mandatory for project performance.

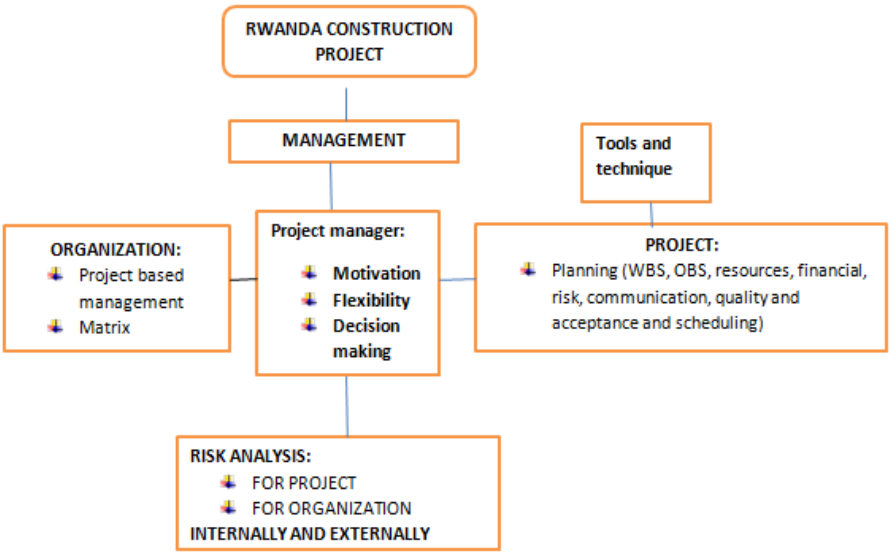

FIGURE 1: Proposed construction project management framework
Source: Researcher 2020

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