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FOREWORD

I am pleased to put into the hands of readers Volume-7; Issue-3: May-June 2022 of **"International Journal of Environment, Agriculture and Biotechnology (IJEAB) (ISSN: 2456-1878)",** an international journal which publishes peer reviewed quality research papers on a wide variety of topics related to **Environment, Agriculture and Biotechnology**. Looking to the keen interest shown by the authors and readers, the editorial board has decided to release issue with DOI (Digital Object Identifier) from CrossRef also, now using DOI paper of the author is available to the many libraries. This will motivate authors for quick publication of their research papers. Even with these changes our objective remains the same, that is, to encourage young researchers and academicians to think innovatively and share their research findings with others for the betterment of mankind.

I thank all the authors of the research papers for contributing their scholarly articles. Despite many challenges, the entire editorial board has worked tirelessly and helped me to bring out this issue of the journal well in time. They all deserve my heartfelt thanks.

Finally, I hope the readers will make good use of this valuable research material and continue to contribute their research finding for publication in this journal. Constructive comments and suggestions from our readers are welcome for further improvement of the quality and usefulness of the journal.

With warm regards.

Editor-in-Chief
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Analysis of Household Food and Nutrition Security Status in Sudano Sahelian Region of Northern Nigeria

Aminu Abba[1, *], Muhammad Halliru[1], Sani Ubale[1], Amina Mustapha[2], Amina Mustapha Lawan[2], Nuhu Bello Rano[3], Amina Idris[1], Hauwa Ladi[4], Muhammad Musa Bello[5]

[1]Department of Agricultural Economics and Extension, Bayero University, Kano – Nigeria
[2]Centre for Dry Land Agriculture, Bayero University, Kano – Nigeria
[3]Department of Animal Science, Bayero University, Kano – Nigeria
[4]Department of Food Science and Technology, Bayero University, Kano – Nigeria
[5]Department of Community Medicine, Bayero University, Kano – Nigeria
* Email address of the Corresponding author: aabba.ext@buk.edu.ng

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Abstract— *Food and nutrition security information is a vital component and essential indicator for agriculture and livelihood development. Detailed information and stakeholders' participation in assessing food and nutrition security, especially community and household aspects, is inadequate in the Sudano-Sahelian region. This has necessitated the cross-sectional survey to assess the food and nutrition security status and factors influencing food security in the region. Cross-sectional data were collected from four (4) states (Kano, Jigawa, Bauchi and Gombe), covering 1,200 households. Primary data were collected using a structured questionnaire to elicit information on respondents' profiles, food security parameters and other household activities. Descriptive statistics, Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS), Household Hunger Scale (HHS) and Coping Strategy Index (CSI) and binary logistic regression were used for data analysis. Results show that household demographic characteristics, especially education, access to credit and the market, are essential components for strengthening household income-generating activities in Northern Nigeria. Food insecurity and nutrition deficiency exist among households with average food consumption scores, poor dietary diversity associated with increased hunger and averagely weak coping strategies. The significant factors influencing food security status positively include the volume of output produced, annual income, and access to credit. The output volume produced an annual income essential for strengthening household food and nutrition security in the Sudano-Sahelian Region. The study recommends the need for massive awareness of the importance of producing essential food crops. Their utilisation at the household level is essential to strengthening the food consumption score and dietary diversity by utilising various food groups. Stakeholders, particularly Government, NGOs, INGOs, and donors, should develop and implement measures to facilitate access to Food and basic social services, especially in vulnerable households. Lastly, income diversification and strengthening incentives for increased food production are essential for the households.*

Keywords— ***Food Security, Coping Strategy, Sudano-Sahelian.***

I. INTRODUCTION

Food security, as defined by the United Nations' Committee on World Food Security, is the condition in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Over the coming decades, a changing

climate, growing global population, rising food prices, and environmental stressors will have significant yet highly uncertain impacts on food security [1]. The concept was also defined from the perspective of community and households' food security: Community Food Security has been defined as "a situation when all citizens obtain a safe, personally acceptable, nutritious diet through a sustainable food system that maximises healthy choices, community self-reliance and equal access for everyone." On the other hand, Household Food Security: A household is Food secure when it has access to the Food needed for a healthy life for all its members (adequate in terms of quality, quantity, and safety and culturally acceptable) and when it is not at undue risk of losing such access. At the global or national level, Food

Security may not usually address the household level food security problem. The relationship between national food security and household food security is less prominent in developing countries than developed ones.

The report of the United Nations mentioned on food security and nutrition in 2018 indicated that the world hunger rate has begun to rise again, threatening 815 million people in 2017, that is 11% of the world's population, after a remarkable steady decline during the past decade. Meanwhile, multiple forms of malnutrition are threatening the health of millions worldwide. The report showed that the number of people affected by hunger compared to the previous year has increased by 38 million due to extreme vulnerability in productivity decline, conflicts, pests and diseases, and climate change (WHO, 2018). The trend was similar in Africa and Nigeria, particularly in rural areas where food availability, accessibility, and utilisation have been major livelihood constraints.

World Bank [2] estimates the population of Nigerians to be above 160 million people, the largest in Africa, almost accounting for 47% of West Africa's total population. As the population increases, the country's demand for food increases. In contrast, the ability to produce Food diminishes because pressures from the growing population in desertification, climate change, and erosion also impact the already diminishing resources and further threaten food production. Food security involves access and availability of foodstuff, stability of supplies, and diet quality [3]. According to FAO, Nigeria has an energy intake of 1730Kcal and an average protein supply of 64g per capita per day, far below the 2500 – 3400Kcal minimum recommended daily intake. This shows that Nigeria faces the challenge of an unbalanced diet leading to various deficiency symptoms [4]. Also, among the 109 countries assessed by the Global Food Security Index (GFSI) (2015), Nigeria is 91st with a 37.1 score based on affordability, availability, quality, and safety indices.

One of Nigeria's agricultural development policy goals is to ensure enough food reserve at the household, state and federal levels to forestall any threat to food security. Since domestic agricultural production has failed to meet the increasing demand for Food, the government had to spend on importation to feed her teeming population. For instance, food imports increased from 19.9% in 2000 to 30.6% and 22.7% in 2011 and 2012, while food exports were barely 5.3% of merchandise [5]. The second sustainable development goal of zero hunger incorporates the need to achieve food security and improved nutrition, promote sustainable agriculture, end rural hunger, empower small scale farmers, especially women, and ensure a healthy lifestyle by 2030. Food and nutrition security information is a vital component and essential indicator for agriculture and livelihood development policies. Detailed information and stakeholders' participation in assessing food and nutrition security, especially community and household aspects, is inadequate in the Sudano-Sahelian region. This has necessitated the cross-sectional survey to assess the food and nutrition security status and factors influencing food security in the region.

Conceptual Framework

According to World Food Summit, "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" [6]. This widely accepted definition points to the following dimensions of food security [7]: food availability, accessibility—utilisation and stability, respectively.

- ✓ ***Food availability***: the availability of appropriate Food in terms of quantity and quality, covered by either domestic production or imports (including food aid).
- ✓ ***Food access:*** the accessibility of people to appropriate food entitlements defined as commodities a person can command or manage given the legal, political, economic and social arrangements of the community in which they live (including traditional rights such as access to common resources).
- ✓ ***Utilisation****:* consuming Food via appropriate diet, clean water, sanitation and health care to reach a state of nutritional welfare where all physiological needs are satisfied.
- ✓ ***Stability:*** to be Food secure, a population, household, or individual must get adequate food. They should not lack Food due to sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). Therefore,

stability refers to food security's availability and access aspects.

Food security "hot spots" include the Vulnerable and war-affected, where logistics and distribution face difficulties even in normal conditions and circumstances; Countries affected by various crises resulting from extreme weather conditions and pests such as the current locust plague – the worst in decades— affecting food manufacture in 23 countries; The poor and vulnerable, including the more than 821 million people who already suffer from food insecurity before the Covid-19 crisis impacted movement and incomes and Countries with major currency depreciation, (driving up the cost of food imports) and countries seeing other commodity prices collapse (reducing their capacity to import Food).

Many Previous studies on households' food security status focused on using the food security index and Calorie intake approach. Such similar studies that used the food security index includes [8,910]. In recent times, modern approaches (FCS, HDDS, HHS, CSI, e.t.c) are gaining popularity, and it has been widely accepted among researchers, including Food and Agriculture Organization. The approaches include food consumption, livelihood evolution, nutritional perspectives and mortality indicators. The food consumption approach involved FCS, HDDs, HHS, and CSI. Daniel and Nicolas applied the food consumption score approach to determine food security status in rural Ethiopia [11]. There was little evidence for applying FCS and other indicators to estimate food security in Nigeria. This study, therefore, employed the use of the Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS), Household Hunger Scale (HHS) and Coping Strategy Index (CSI).

Ifeoma and Agwu conducted a study assessing the food security status among farming households in rural areas of Kano State, Nigeria. Data collected were analysed using percentages, mean score, logistic regression and food security index. Using the food security index approach, the study revealed that 74% of the respondents were Food secure while 26% were Food insecure. The results of the logistic regression revealed that educational level (p_0.05; z = 1.95), sex (p_0.05; z = 1.99), household size (p_0.05; -4.29) and access to credit (p_0.05; z = 2.4) were significant determinants of food security. Also, the major effect of food insecurity on households includes a reduction in household income/ savings due to increased expenditure on Food (M= 3.58). The perceived coping strategies in cushioning the effects of food insecurity include engaging in off-farm and non-farm jobs to increase household income (M= 2.77), among others [12].

Abu and Soom examined factors affecting household food security status among rural and urban farming households of Benue State, Nigeria. Data were collected through a structured questionnaire and analysed using descriptive statistics, Food Security Index, Surplus/Food Insecurity Gap, Factor analysis and Probit model. Using the calorie intake method, the result revealed that 53.3% and 62.2% of rural and urban households were Food secured. The rural and urban Food secure households exceeded the recommended calorie intake by 39% and 42%, respectively. In comparison, the rural and urban Food insecure households fell short of recommended calories by 24% and 26%, respectively. It was also found that the income of households head ($p<0.10$), rural households size ($p<0.01$), and farm size ($p<0.10$) had a positive impact on household food security. On the other hand, the age of the household head ($p<0.05$) and urban household size ($p<0.10$) had a negative relationship with household food security [9].

II. METHODOLOGY

Location, Sampling and Data Collection

The study was conducted in four (4) Sudano-Sahelian States, specifically Kano, Jigawa, Bauchi, and Gombe. The study area is a potential agricultural zone with diverse economic activities within rural communities and farming households. The four (4) states were purposefully selected for their importance in Agricultural activities and fewer security challenge than other states. Stratified sampling was used to classify each state into three (3) agro-ecological zones. Ten LGAs in each Zone were selected, thus giving 36 LGAs for the study. Simple random sampling techniques were used to select 10 respondents from each LGAs, implying 300 respondents per state and 1,200 sample sizes for the study. Primary data were collected using a structured questionnaire to elicit information on respondents' profiles, food security parameters and other household activities. The distribution of sample size is depicted in Table 1 below:

Table 1: Sampling Techniques

State	***Zone***	***No. of LGAs***	***No. of Respondents***	***Total***
Kano	Zone I	3	100	300
	Zone II	3	100	
	Zone III	3	100	
Jigawa	Zone I	3	100	300
	Zone	3	100	

	II			
	Zone III	3	100	
Bauchi	Zone I	3	100	300
	Zone II	3	100	
	Zone III	3	100	
Gombe	Zone I	3	100	300
	Zone II	3	100	
	Zone III	3	100	
Total		***36***	***1,200***	***1,200***

Analytical Approach

Descriptive Statistics

Descriptive statistics, Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS), Household Hunger Scale (HHS) and Coping Strategy Index (CSI) and binary logistic regression were used for data analysis.

Food Consumption Score (FCS) Estimation

The Food Consumption Score (FCS) is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups. Household food consumption is households' consumption pattern (frequency * diversity) over the past seven days. The household food consumption score is calculated by multiplying each food group frequency by each food group weight and then summing these scores into one composite score. The household score can have a maximum value of 112, implying that each food group was consumed every day for the last seven days. The FCS is calculated based on the past 7-day food consumption recall for the household and classified into three categories: *poor consumption (FCS = 1.0 to 28); borderline (FCS = 28.1 to 42); and acceptable consumption (FCS = >42.0)*. The FCS is a weighted sum of food groups. The score for each food group is calculated by multiplying the number of days the commodity was consumed and its relative weight. The following equation indicates the mathematical representation of FCS

$$\text{Food Consumption Score (FCS)} = A_{cereal} X_{cereal} + a_{legumes} X_{legumes} + a_{leg} X_{leg} + a_{fruit} X_{fruit} + a_{animal} X_{animal} + a_{sugar} X_{sugar} + a_{Veg} X_{Veg} + a_{fruits} X_{fruits} \quad (1)$$

Where:

a_i = Weight attributed to the food group;

x_i = Number of days each food group is consumed (≤7days).

The different Food Groups and their Weighted Score considered for the study include Cereals *(bread, rice, maise, barley (2)*, Root and Tubers *(cassava, potatoes, etc.) (2)*, Pulses and nuts *(beans, lentils, peas etc.) (3)*, *Vegetables* (1), Fruits (1), Meat (4), egg (4), fish (4), Dairy products *(milk and milk products) (4)*, Sugar, honey (0.5), Oil, Fat, Butter (0.5) and condiments (0).

Household Dietary Diversity Score (HDDS) Estimation

HDDS-is meant to reflect the financial ability of a household to access a variety of foods. A frequently used method to indicate food consumption quality and quantity to a lesser degree. Regroup the 16 food groups used for FCS in the 7 food groups as per the Table by simply adding frequencies. Create a new binominal variable for each food group with two possible values: 1 – yes: the household/individual consumed that specific food group, and 0 – no: they did not consume that Food. Sum all the binominal variables to create a HDDS. The new variable will range from 0 through the maximum number of food groups collected (7). IFPRI proposes to use the following thresholds: 6+: high = good dietary diversity; 4.5 – 6: medium dietary diversity and <4.5: low dietary diversity.

Coping Strategy Index (rCSI) Estimation

Coping Strategy Index (CSI)- measures behaviour: what people do when they cannot access enough food. CSI is based on a list of behaviours (coping strategies). It combines the frequency of each strategy (how many times each strategy was adopted?); and their severity (how serious is each strategy?) for households reporting food consumption problems. Household CSI scores are then determined by multiplying the number of days in the past week each strategy was employed by its corresponding severity weight and then summing the totals. The total CSI score is the basis for determining and classifying the level of coping into three categories: No or low coping (CSI= 0-3), medium (CSI = 4-9) and high coping (CSI ≥10). Coping strategies, their weights and frequencies are depicted in the Table below:

Table 3: Coping Strategies and their Weights considered for the CSI estimation include Relying on less preferred and less expensive foods (1), Limiting portion size at mealtimes (1), Reducing the number of meals eaten in a day (1), Borrow Food or rely on help from relatives or friends (2) and Restricting consumption by adults for small children to eat (3)

Binary Logistic Regression Model

The binary logistic regression methodology has been employed in several agricultural, economic and extension

studies that call for the analysis and prediction of a dichotomous outcome such as fertiliser use or non-use, adoption and non-adoption, food security and food insecurity, poor and non-poor, and other general binary dependent variable. The logistic regression model has been popularly applied in analysing the factors influencing the food security status of rural farming households. Such similar studies that used a logistic or tobid model to determine factors influencing food security status include [8,9] to estimate the determinants of food security status. This section is based on Gujarati, Gujarati, and Porter [13.14]. Binary logistic regression requires the dependent variable to be converted into a dichotomous binary variable coded 0 and 1. For this study, the logistic model is developed as follows:

The logit equation based on Greene is written as

$$\Pr(Y=1) = \frac{e^{\beta' x}}{1+e^{\beta' x}} \quad (2)$$

With the cumulative distribution function given by

$$F(\beta' x) = \frac{1}{1+e^{\beta' x}} \quad (3)$$

The cumulative logistic distribution function (Eq 2) is expressed as (after Adunni and Doppler, 2007):

$$p = \frac{1}{1+e^{-z}} \quad (4)$$

If p_i is the probability of higher paddy yield, then the probability otherwise is 1-p_i, which in logistic function can be expressed as

$$1-p_i = 1-\frac{1}{1+e^{-z}} \quad (5)$$

$$= \frac{1}{1+e^{-z}} \quad (6)$$

The ratio of Eq 4 and 5 will give the odd ratio

$$\frac{p_i}{1-p_i} = \frac{1+e^{-z}}{1+e^{z}} \quad (7)$$

$$\frac{p_i}{1-p_i} = e^{z} \quad (8)$$

Equation 7 is the odds ratio in favour of Food secured. It is the ratio that a is Food secured to the probability of otherwise

Taking the natural log of both sides of Eq 7

$$L_i = ln\frac{p_i}{1-p_i} = z \quad (9)$$

L_i = the log odds ratio, which is also referred to as the logit

$$z = \beta_0 + \beta_1 x_1 - \beta_2 x_2 + \beta_3 x_3 + \dots\dots\dots\dots + \beta_k x_k + \mu \quad (10)$$

Where

x_i = the household-specific indicators hypothesized to food security

β_i = vector of parameters to be estimated using a maximum likelihood method

β_0= constant term

μ = error term which is normally distributed with zero mean and variance

$$\delta^2 = \frac{1}{N_i\, p_i\, (1-p_i)} \quad (11)$$

N_i = number of observations

Although z it is a linear combination of variables with both upper and lower bounds, no bounds can be assigned to the variable itself, as the values assumed will also depend on the unknown parameters s values. To obtain the values of z, the likelihood of observing the sample was formed by introducing a dichotomous variable Y_i such that $Y_i = 1$ and $Y_i = 0$ if otherwise. The specific application of the logistic model for this study is specified for food security analysis.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + U \quad (12)$$

Y = Food security status (Taking the value of 1 and 0 for the presence and absence of observed food security characteristics)

X_1 = Age of maize producers (years)

X_2 = Farming experience (years)

X_3 = Access to credit (1= access and 0= No access)

X_4 = Educational status (years)

X_5 = Farm size (ha)

X_6 = Access to market (Access 1, No access 0)

X_7 = Cooperative membership (Member 1, Non-member 0)

X_8 = Household size (Number)

X_9 = Volume of output (kg)

X_{10} = Extension contact (Contact 1, No contact 0)

X_{11} = Household annual income (₦)

β_0=Slope or intercept

β_1- β_{12} = Coefficient of regressors

U = error term

Results and Discussion

Demographic Profile of the Respondents

The result from figure 1 depicts that most of the respondents across the locations Kano (94.5%), Jigawa (96.4%), Bauchi (93.8%) and Gombe (89.4%) were male. This may be attributed to the culture, tradition and religion of the people living within these locations. It may also result from other social activities associated with household responsibilities that limit female engagement in other social activities outside the household. The result implies that male-dominated farming activities and other social activities within the locations deprive females of engagement in farming and social activities, which may contribute to food security and improve their livelihood. These findings are in line with Babatunde *et al.*, where most (90.4%) of the respondents considered in their study were male [15].

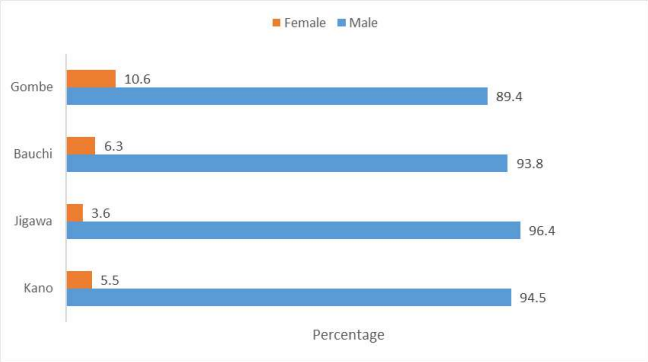

Fig.1: Gender Distribution of the Respondents

Looking at figure 2, the result shows that most of the respondents had formal education across the locations Kano (88.8%), Jigawa (84.8%), Bauchi (86.7%) and Gombe (82.3%), with respondents having one form of formal education or the other which shows that the respondents can be able to read, write and equality understand and analyse situations that came along their ways for improvement in their life. Having these forms of formal education implies that the respondents can use their knowledge to address an issue that has to do with food security by adopting different technologies that will help improve their food production to make their locations Food secure and the nation in general, which will equally improve their livelihood. These findings agreed with Babatunde et al., who found the majority (52.1%) of their respondents have one form of formal education.

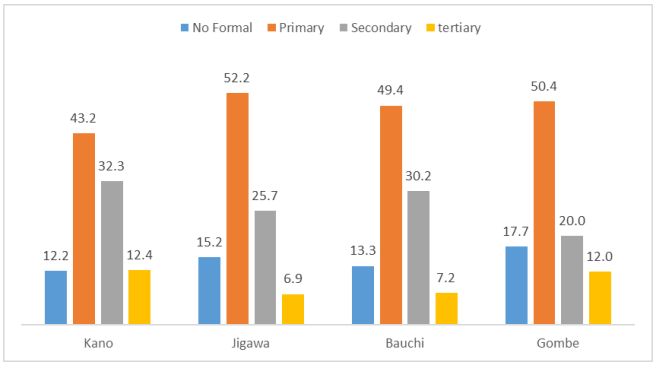

Fig.2: Distribution by Educational Status

The result in figure 3 showcases the accessibility of the market among the respondents, where most (of the respondents across the locations Kano (78.54%), Jigawa (79.45%), Bauchi (65.78%), and Gombe (69.05%) have market access. Availability of nearby marketplace plays a significant role among respondents in the study area. Having access to market among the respondents implies that they can market their produce for income or exchange; they can also engage in any marketing activities for income generation to be able to carter for the need of the household and at the same time access different kinds of Food at their disposal in ensuring food security within their household. These findings disagree with Kehinde and Kehinde, who reported that 80.67% of their respondents have access to credit [16].

The resulting form figure4 further revealed that most of the respondents across the locations Kano (78.45%), Jigawa (85.23%), Bauchi (87.25%) and Gombe (90.36%) have no access to credit. One of the constraints militating against food production, especially among small and medium-scale farmers, was inadequate capital. Accessibility to credit helps in acquiring the necessary capital for production. The respondents' poor access to credit may be associated with poor awareness of procedures to follow in accessing the credit, high-interest rates charged by commercial banks, provision of collateral, and conservativeness of farmers. Therefore, failure to access credit will significantly affect agricultural production considering the current inflation. By implication, food security will also be affected. Ogunniyi *et al.*, in their study, reported that 81% of the respondents have market access and also obtained market information. This is in line with the findings of this study [17].

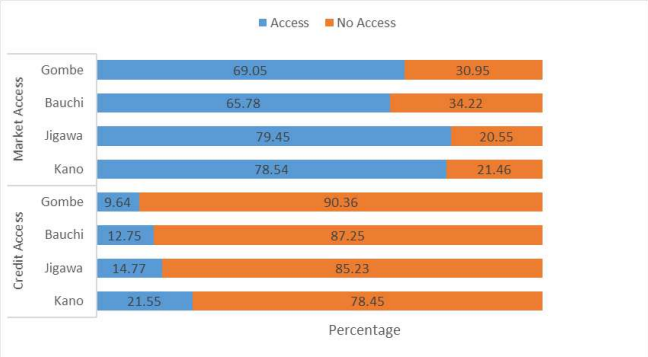

Fig.3: Access to Credit and Market

Application of Different Indicators for Food Security Status Estimation

Food Consumption Score (FCS)

Table 2 reveals the food consumption estimation as one indicator of food security status. The result revealed the findings based on categorising three zones across the locations and aggregating to the state level. Therefore based on the state level, it was found that 13.0% meet the acceptable consumption score of >42.0 in Kano, while only 41.7% meet the requirement in Jigawa. In Bauchi (59.0%) and Gombe (69.0%), the majority of respondents meet the acceptable food consumption score of >42.0, respectively. The results show that, based on the acceptable score of >42.0, most respondents in Kano and Jigawa were not Food secured, while in Bauchi and Gombe majority were Food secured. Going by the definition of food security by United Nations' Committee on World Food Security implies that the majority of respondents within Kano and Jigawa don't have at all times physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for active and healthy life despite commercial activities that are taking place in the state specifically Kano. This may be attributed to the fact that the two locations shared border and similarities in terms of social and economic activities, which led to the migration of people into the city of Kano and the concentration of developmental projects by previous and subsequent government administration and other development partners in the city neglecting the rural areas. These findings agreed with Nurudeen and Shaufique, where most (62.1%) of their respondents found food secure based on the food consumption score similar to an acceptable level considered in this study [18].

Table 2a: Food Consumption Score (FCS) Estimation

	Zone I			Zone II		
	Poor	Borderline	Acceptable	Poor	Borderline	Acceptable
Kano	45.0%	43.0%	12.0%	53.0%	38.0%	9.0%
Jigawa	32.0%	34.0%	34.0%	4.0%	30.0%	66.0%
Bauchi	3.0%	38.0%	59.0%	0.0%	25.0%	75.0%
Gombe	11.0%	26.0%	63.0%	8.0%	28.0%	64.0%

Table 2b: Food Consumption Score (FCS) Estimation

	Zone III			State (Level)		
	Poor	Borderline	Acceptable	Poor	Borderline	Acceptable
Kano	33.0%	49.0%	18.0%	43.7%	43.3%	13.0%
Jigawa	57.0%	28.0%	156.0%	28.7%	30.7%	41.7%
Bauchi	13.0%	44.0%	43.0%	15.5%	35.7%	59.0%
Gombe	0.0%	20.0%	80.0%	6.3%	24.7%	69.0%

Household Dietary Diversity Store (HDDS)

Table 3 above reveals the household dietary diversity estimated as another indicator of whether household/individual is Food secured. As revealed in the result, it shows that majority of the respondents in Kano (52.7%) and Jigawa (62.3%) location consumed more than five food groups out of the seven food groups, while in Gombe, most (80.3%) of the respondents consumed more than five food groups. The situation differs in Bauchi, where less than fifty per cent (38.0%) of the respondents consumed more than five food groups. This implies that the majority of the households in Kano, Jigawa and Gombe have the economic ability to access a variety of foods that are of good quality and at the required quantity for consumption which will strengthen their ability to think and act positively for development while in Bauchi majority of the household cannot be able to access more than five food group for consumption as their diet. This will affect their health status and economy since their capability to think and act positively for national development is affected. They cannot provide the workforce for economic development. Ajani reported that 83% (5-6) of the participants considered in their study had average/medium

dietary diversity scores, while this study reported a high dietary diversity score [19].

Table 3: Household Dietary Diversity Store (HDDS) Estimation

States	Zones	Minimal->= 5 food groups	Stress = 4 food groups	Crisis -3 food groups	Emergency =2 food groups	Famine-<= 1 food groups
Kano	Zone I	52.0%	9.0%	49.0%	0.0%	0.0%
	Zone II	43.0%	10.0%	47.0%	0.0%	0.0%
	Zone III	63.0%	23.0%	13.0%	0.0%	0.0%
	Pooled	52.7%	10.7%	33.3%	0.0%	0.0%
Jigawa	Zone I	82.0%	15.0%	3.0%	0.0%	0.0%
	Zone II	65.0%	20.0%	15.0%	0.0%	0.0%
	Zone III	40.0%	34.0%	26.0%	0.0%	0.0%
	Pooled	62.3%	23.0%	14.7%	0.0%	0.0%
Bauchi	Zone I	84.0%	16.0%	0.0%	0.0%	0.0%
	Zone II	94.0%	6.0%	0.0%	0.0%	0.0%
	Zone III	60.0%	27.0%	13.0%	0.0%	0.0%
	Pooled	38.0%	47.0%	15.0%	0.0%	0.0%
Gombe	Zone I	69.0%	17.0%	14.0%	0.0%	0.0%
	Zone II	90.0%	9.0%	1.0%	0.0%	0.0%
	Zone III	82.0%	17.0%	1.0%	0.0%	0.0%
	Pooled	80.3%	14.0%	5.7%	0.0%	0.0%

Household Hunger Scale (HHS)

Results from Table 4 above reveal the household hunger scale estimation across the locations where 47.7% of the households were not affected by hunger. In contrast, the majority (52.3%) of the household in the location experienced low to moderate hunger. This corresponds with the food consumption score of the households in the location where only 13% meet the acceptable food consumption score. In Jigawa, only 12% of the households experienced low to moderate hunger, with most (88.0%) of the households having no hunger. Similarly, in Bauchi, only 19% of the households experienced hunger.

In comparison, most (81%) of the households have zero hunger, while in Gombe is almost 50:50 between households with zero hunger and those with low to moderate hunger. The implication here is those in locations where the majority of the households experience hunger, their productivity in every aspect of human endeavour will be affected because hunger is a serious disease. In contrast, those with zero hunger are expected to be active, have good and sound decision-makers, and be productive. Alero, James and Victor's findings from their studies support the findings of this study, where 33.8% of the respondent have zero hunger while 41.5% have low to moderate hunger scores [20].

Table 4: Household Hunger Scale (HHS) Assessment

State	Zone	None 0	Low Score 1	Moderate Score 2-3	Severe Score 4	Very Severe Score 5-6
Kano	Zone I	54.0%	23.0%	23.0%	0.0%	0.0%
	Zone II	41.0%	28.0%	31.0%	0.0%	0.0%
	Zone III	48.0%	19.0%	33.0%	0.0%	0.0%
	Pooled	47.7%	23.3%	29.0%	0.0%	0.0%

Jigawa	Zone I	81.0%	16.0%	3.0%	0.0%	0.0%
	Zone II	87.0%	10.0%	3.0%	0.0%	0.0%
	Zone III	94.0%	1.0%	5.0%	0.0%	0.0%
	Pooled	88.0%	9.0%	3.7%	0.0%	0.0%
Bauchi	Zone I	66.0%	10.0%	24.0%	0.0%	0.0%
	Zone II	96.0%	3.0%	1.0%	0.0%	0.0%
	Zone III	81.0%	11.0%	8.0%	0.0%	0.0%
	Pooled	81.0%	8.0%	11.0%	0.0%	0.0%
Gombe	Zone I	33.0%	16.0%	51.0%	0.0%	0.0%
	Zone II	65.0%	17.0%	18.0%	0.0%	0.0%
	Zone III	50.0%	19.0%	31.0%	0.0%	0.0%
	Pooled	50.3%	12.0%	37.7%	0.0%	0.0%

Coping Strategy Index (CSI) Assessment

The result from Table 5 reveals the coping strategy adopted by affected households in trying to cope with the issue of food insecurity. It was found from the results that the entire locations Kano (75.7%), Jigawa (97.7%), Bauchi (91.0%) and Gombe (97.7%) were found to have adopted low coping strategies concerning food security. This may be associated with the fact that except for kano, the entire locations have no cases of food insecurity, meaning that the location was food secure base on the upper mentioned food security indicators. Adegoroye, Adewale and Aturamu, in their study, reported that withdrawal from personal savings relied on less preferred Food and cutting down expenditure on non-food items were the major coping strategies adopted by the respondents [21].

Table 5a: Coping Strategy Index (CSI) Assessment

States	Zone I			Zone II		
	rCSI 0-3	rCSI 4-18	rCSI >=19	rCSI 0-3	rCSI 4-18	rCSI >=19
Kano	66.0%	34.0%	0.0%	73.0%	27.0%	0.0%
Jigawa	100.0%	0.0%	0.0%	93.0%	7.0%	0.0%
Bauchi	88.0%	12.0%	0.0%	96.0%	4.0%	0.0%
Gombe	99.0%	1.0%	0.0%	94.0%	6.0%	0.0%

Table 5b: Coping Strategy Index (CSI) Assessment

States	Zone III			State(Level)		
	rCSI 0-3	rCSI 4-18	rCSI >=19	rCSI 0-3	rCSI 4-18	rCSI >=19
Kano	84.0%	16.0%	0.0%	75.7%	25.7%	0.0%
Jigawa	100.0%	0.0%	0.0%	97.7%	2.4%	0.0%
Bauchi	81.0%	11.0%	0.0%	91.0%	9.0%	0.0%
Gombe	100.0%	0.0%	0.0%	97.7%	2.3%	0.0%

Factors Influencing Food Security Status in Sudano-Sahelian Region

As shown in Table 6, the estimated logistic regression model indicated that the statistical parameters that express the "goodness of fit" of the model specified for this study are highly significant at a 5% probability level. The chi-square (x^2) of 93.916 with its degree of freedom (df) respectively indicates support for the model and implies that the model containing the intercept and the independent variables are accepted. The Cox and Neglekerke estimates of 0.261 and 0.375 suggested that between 26.1% and 37.5% of the variance observed in the model is attributed to the regressors' contribution to the analysis. The log-likelihood of 317.305 further confirmed the validity and reliability of the estimated model in explaining the statistical influence of the selected variables.

The significant variables positively related to household food security status include access to credit, contact with extension agents and animal income. On the other hand, age and experience significantly influence food security status. The coefficient of access to credit was positive and significant at a 5% probability level with an exponentiated coefficient of 1.052. This implies that increased access to

credit can increase the food security status of farming households. This might be possible considering that credit availability will help households timely acquire appropriate and adequate production inputs, resulting in increased household productivity. The coefficient of farmers' contact with extension agents (0.674) was positive and significant at a 1% probability level. This implies that farmers with more contact with extension agents are more likely to apply good production practices leading to increased output to improve food security. Farmers with more contact with extension agents become more aware of modern agricultural innovations and put them into practice for productivity improvement, which might positively impact household food security.

The estimated coefficient of annual household income (1.312) was positive and statistically significant at a 1% probability level. These findings cannot be disputed, considering that increased annual income of households might help in food provision either directly through purchase or indirectly through financing production and diversification of income sources. The major determinants that positively influence food security are household income, education, assets, cooperative membership, and dietary diversity. The study further revealed the farmer's age as a significant variable that negatively influences food security. With more increase in age, farmers are more likely to become older and less energetic, hence could not efficiently be active for increased productivity. Ahmed, Eugene, and Abah reported contrary findings regarding positively related age to food security [8].

Table 6: Factors Influencing Food Security Status in Sudano-Sahelian Region

Variables	**B**	**S.E**	**Wald**	**Sign.**	**Exp (β)**
Age of the farmer	-0.048	0.009	3.036	0.018**	0.876
Farming experience	0.008	0.119	0.514	0.014**	1.008
Access to credit	0.632	0.642	2.911	0.015**	1.052
Educational status	0.049	0.219	0.302	0.509	2.082
Household farm size	-0.065	0.168	2.211	0.764	0.703
Access to market	0.465	0.438	3.091	0.432	2.934
Cooperative Mship	-0.721	0.163	1.006	0.203	0.871
Household size	0.0326	0.024	1.156	0.395	2.036
Volume of output	0.136	0.041	5.771	0.019**	2.006
Extension contact	0.674	0.431	3.445	0.005***	2194
Annual income	1.312	0.431	10.039	0.002***	8.066
Constant	-11.238	2,987	11.318	0.003***	0.649
Model Statistics					
-2loglikelihood	317.305				
Cox & snell estimate	0.261`				
Neglekerke estimate	0.375				
Model chi-square	793.916***				

Major Shocks Associated with Food and Nutrition Security in the Region

The major shocks concerning food and nutrition security observed by respective households from different locations, as revealed by the result in table 7, were high price of food items as reported by 40.2% of households from Kano, 35.0% from Jigawa, 40.2% from Bauchi and 38.6% from Gombe. The second shock observed is the covid-19 pandemic, which was reported by 36.8% from Kano, 26.9% from Jigawa, 36.6% from Bauchi, and 39.1% from Gombe. These were the major shock observed as reported by households across locations. These are attributed to inflation realised in the country and the globe, especially in line with the covid-19 pandemic, which crippled many economic activities, significantly affecting food and

nutrition security, especially among small-income households.

Table 7: Major Shocks Associated with Food and Nutrition Security

	States				
	Kano	Jigawa	Bauchi	Gombe	Pooled
Loss of employment and reduced income	2.2%	2.5%	3.4%	3.3%	2.9%
Sickness of HH member	3.2%	1.9%	2.4%	2.1%	2.4%
Insecurity and conflict	2.8%	1.9%	2.1%	2.0%	2.2%
High food prices	40.2%	35.0%	40.2%	38.6%	38.5%
Heavy rains/floods	1.0%	11.6%	1.9%	1.8%	4.1%
Crop failure	11.6%	19.0%	11.2%	10.7%	13.1%
Restricted access to markets	2.2%	1.2%	2.2%	2.4%	2.0%
COVID-19 Pandemic	36.8%	26.9%	36.6%	39.1%	34.9%

III. CONCLUSION AND RECOMMENDATIONS

The study concluded that household demographic characteristics, especially education, access to credit and the market, are essential components for strengthening household income-generating activities in Northern Nigeria. Food insecurity and nutrition deficiency exist among households with average food consumption scores, poor dietary diversity associated with increased hunger and averagely weak coping strategies. The output volume produced an annual income essential for strengthening household food and nutrition security in the Sudano-Sahelian Region. The study based on the findings, therefore, recommends the following:

1. The need for massive awareness of the importance of producing essential food security crops and their utilisation at the household level is essential. This will strengthen the food consumption score and dietary diversity by utilising various food groups.
2. Stakeholders, particularly the Government, NGOs, INGOs and donors, should develop and implement measures to facilitate access to Food and basic social services, especially in vulnerable households.
3. Promoting income diversification and strengthening incentives for increased food production is essential. This will facilitate income dependency and additional food provision for the households.

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Indonesian Permanent Single GPS Station Potential for Precipitable Water Vapor (PWV) Calculation

Syachrul Arief

Geospatial Information Agency Indonesia – Jl. Raya Bogor KM. 46 Cibinong 16911
Email: syachrul.arief@big.go.id

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Abstract— *The establishment of a GPS Permanent Station network in Indonesia began in 1996, and is now known as Indonesia continuously operating reference station (INA-CORS), its management authority under the Geospatial Information Agency (BIG). Based on information from BIG, data of 2016, the distribution of CORS in Indonesia has as many as 135 stations. INA-CORS is built, has the main objective is to maintain national geodetic reference frames in active seismic zones for survey and mapping purposes, as well as basic tasks and BIG functions. In its development, based on (BEVIS 1992) RINEX data is not only to determine the position as a reference geodesy for survey and mapping, but also to determine the water vapor for meteorological purposes. The observational accuracy is similar to the results obtained from other methods. Water vapor plays an important role in the atmospheric system because it affects the balance of elements and energy in space, so it is worth developing.*

Keywords— ***INA-CORS, troposphere, radiosonde.***

I. INTRODUCTION

Global Positioning System (GPS) technology has been known only for the purposes of positioning, and navigation in general. In addition to mapping and navigation purposes, this technology also has the competence for various studies of the earth (earth sciences). One of the most reviewed is the GPS application to get the volcano. In addition to the field of volcanology, there is still much that can be expressed through this GPS technology, such as the content of air vapor (moisture content) in the atmosphere (Bevis et al., 1992; Duan, et.al., 1996; Tregoning, et al ., 1998; Ware, et.al., 2000 and Liou, et.al., 2001) known as the Meteorological GPS Project.

As has often been the case in various literature, the working principle of this GPS technology is GPS satellite signals located at an altitude of approximately 20,000 km in space. By having a receiver, information about the position (horizontal and vertical) in various coordinate systems will be known. This is a basic function of GPS technology and can be applied for positioning, construction activities, and mapping surveys.

From this basic function then raised various other functions of the direction, estimating the distance and time (for the purposes of navigation), speed and acceleration and so forth (Abidin, 1995). Its applications include land, sea and air navigation, research on earth plate movements (geodynamic studies), volcano observations (volcanology studies).

An important aspect of this GPS technology is accuracy (accuracy), as it relates to the "truth level" of the GPS observation information. Various ways are developed to improve the accuracy of information from the view with GPS technology, among others: improve the ability of the recipient, develop GPS methods, more sophisticated and so forth.

With the above advances and combinations, the accuracy of the GPS observations can be improved. This needs to be done that has been done by GPS satellites up to the receiver (recipient) so that various studies are done to

eliminate these errors. The various errors that arise and their effects have been discussed by Abidin (1995). One method that has been successfully developed is the Differential GPS method that is the method of determining the operating point dot that serves to estimate the magnitude of GPS signal errors at a certain time.

With this method reversed, that is by comparing the observation results with the control point coordinates, then the component of the error signal can be estimated. With what can be tried price data such as temperature, air pressure, then the air-vapor content can be determined. This paper attempts the method of water vapor modeling that has been implemented in various places and the possibility of its application in Indonesia.

Components of Troposphere and Water Vapor

The troposphere layer is the layer closest to the surface of the earth. This layer has a thickness of approximately 8 - 10 km above the surface of the earth with the main components of gas Nitrogen (78%) and Oxygen (21%) (Miller, et.al., 1983). The water vapor contained in this layer is quite small in quantity (less than 4%) but plays an important role in the process of decelerating the propagation of electromagnetic waves known as a tropospheric delay.

In addition water vapor also plays an important role in the process of determining the weather, is a radiation absorber that affects the energy balance in the atmosphere, and plays a role in the release of latent heat from the condensation process so as to maintain processes that occur in the atmosphere (Miller, et.al., 1983). To that end, various methods were developed to estimate the amount of water vapor in the atmosphere.

Currently, there are several methods used in the determination of water vapor content in the atmosphere, namely: radiosondes, water vapor radiometer, special sensor microwave imager, TIROS operational vertical sounder, SAGE II and so forth. Popularly used are radiosondes and VWP. But these two methods have the disadvantages of high cost, lack of spatial and temporal resolution, and less good for areas with high rainfall (Liou, et.al., 2001). For that developed a method by using GPS.

II. DATA DAN METHOD

The slowing of the GPS signal, which is one type of electromagnetic wave, due to through the troposphere layer can be estimated in processing GPS observation data. The tropospheric delay consists of two components: the dry (hydrostatic) component, which accounts for about 90% of the total throttling, and the moist components that depend on the air humidity. The wet component provides a much larger component of the error than the dry component since it is more variable spatially and temporally.

In order to determine the magnitude of tropospheric correction in GPS data processing, usually used existing troposphere models such as Hopfield, Saastamoinen, and Black. In the case of determination of moisture content, the model is used by reversing known parameters and variables and estimating the total value of zenith delay (ZTD) ie the magnitude of the delay from the vertical direction of the signal to the receiver. This value is a composite of the wet component and dry component values. In practice, the wet component is harder to determine, so the most common is to estimate the value of a dry component known as zenith hydrostatic delay (ZHD). So the equation is obtained:

$$ZWD = ZTD - ZHD \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The value of ZHD itself is estimated by formula (Elgered, et.al., 1991) :

$$ZHD = \frac{(2.779+0.0024)*Ps}{F(\omega,H)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

- Ps is the total air pressure on the earth's surface,
- F is the variation of the Earth's gravitational acceleration at the point with the latitude (ω) and height (H) of the earth ellipsoid model.

Next, is calculate the value of integration of water vapor (Integrated Water Vapor = IWV) that is the amount of water vapor calculated from GPS signal in one air column. To calculate the moisture content (Precipitable Water Vapor = PWV) is to divide the IWV value by the density of water.

$$PWV = \frac{10^6}{(\rho w Rv \left[\frac{k3}{Tm+k'2}\right])} * ZWD \ldots\ldots\ldots\ldots (3)$$

Where:

ρw = water density,

Rv = constant for gas

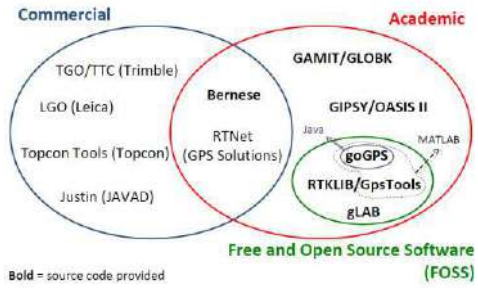
k'2 = 22.1 K / hpa

k3 = 3.739 * 105 K2 / hPa

Tm = 70.2 + 0.72 * Ts

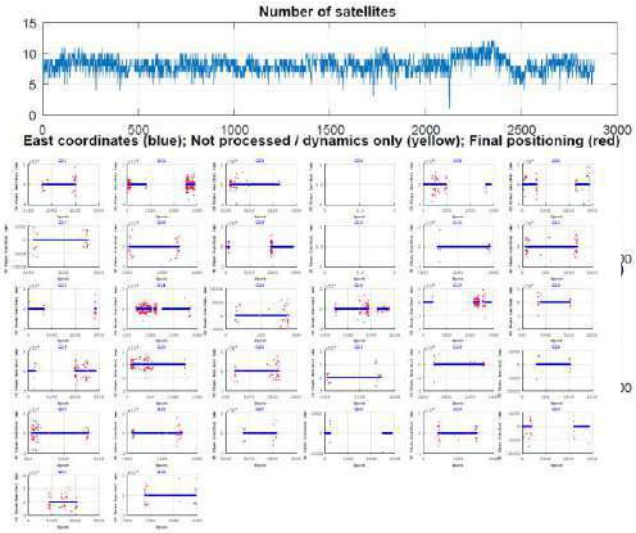
with Ts is the temperature at the surface (Bevis, et.al., 1992).

Actually, a lot of software for data processing Rinex format to determine the positioning and navigation, ranging from commercial to open source. Among others, RTNet, Trimble, Bernese are commercial categories and GAMIT, GIPSY-OASIS II and opensource categories are RTKLIB, GPSTk, GoGPS. For the purposes of this research, the software used is goGPS version 0.5.1 Beta 3 with PPP strategy, combined with Matlab R2016b version development of goGPS started in 2007 at Politecnico di Milano, Como campus (Italy).



The The first version of goGPS MATLAB was published as free and open-source software in 2009, under a GPLv3 license; the software has evolved steadily through the years, improving stability and performance. The development of an alternative version of goGPS, written in Java and published under a LGPLv3 license, was started in 2010 with the aim of providing a positioning library in a coding language more suitable for the implementation of positioning Web services (Realini et al. 2012). It is important to note goGPS does not require MATLAB special supporting toolboxes. The user only requires the Instrumental Control Supporting Toolbox when the connection of a GPS device to a COM port is desired. In this paper, we focus on the MATLAB version, from here on simply referred to as "goGPS".

goGPS processes single-frequency (L1) code and carrier phase observations either by epoch-by-epoch least squares adjustment (LSA) or by an extended Kalman filter (EKF), applied to either undifferenced or double-differenced observations, to produce solutions based on multiple epochs. goGPS can apply different observation-weighting strategies: based on satellite elevation or on tailored weight functions that exploit the known signal-to-noise ratio characteristics of low-cost receivers. The modular design of the goGPS EKF allows for the seamless addition of optional external data sources, e.g., pseudo-observations interpolated from digital terrain models (Realini and Reguzzoni 2013).



III. RESULT AND DISCUSSION

By using goGPS software and PPP strategy, to obtain ZTD value, the results obtained related to satellite measurement and constellation are presented in the following figure: :

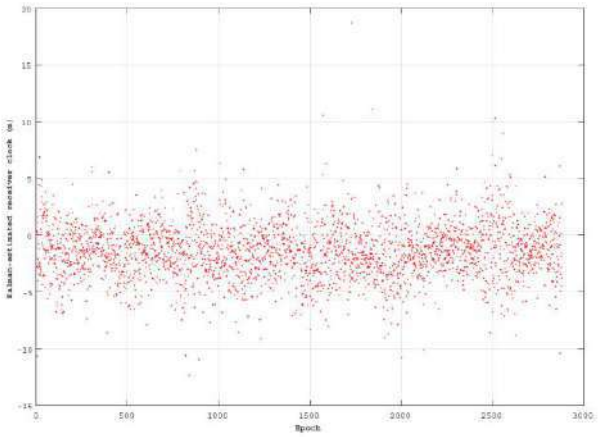
The figure shows the results of the CMAK station positioning measurement process in a day, on December 19, 2015, with a duration of 30 seconds. So in a day, very dynamic one position moves in different directions.

A GPS receiver determines the travel time of a signal from a satellite by comparing the "pseudo random code" it's generating, with an identical code in the signal from the satellite. The receiver "slides" its code later and later in time until it syncs up with the satellite's code. The picture above is a residual GPS code view with outlier, from each satellite GPS of 32 satellite. This information to explain for the change in position satellite within the orbit.

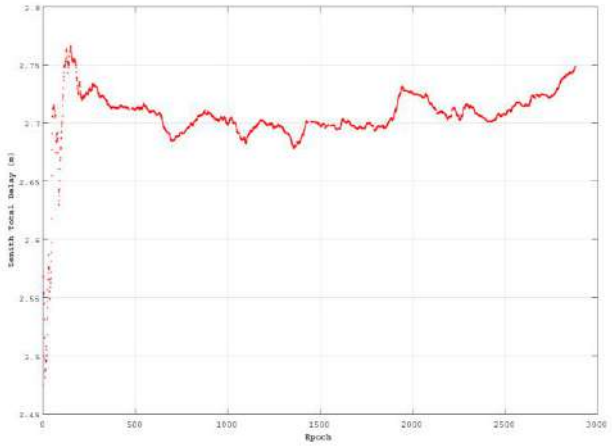
The carrier phase measurement is a measure of the range between a satellite and receiver expressed in units of cycles of the carrier frequency. This measurement can be made with very high precision. The picture above is a residual GPS carrier phase view with outlier, from each satellite GPS of 32 satellite.

And this below, a picture show Kalman estimated receiver oclock for the processing Rinex data, plotting with epoch as time for constellation satellite.

For positioning and direction are controlled by as many as

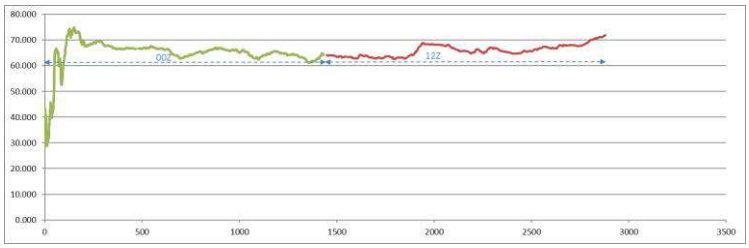


32 satellite GPS circulating in orbit.In the process of measuring the position, the correction process is done to eliminate noise and noise it is Zenit Total Delay (ZTD).



GPS delays are related to water vapor. Using meteorological observation data on the surface or modelling, ZTD GPS is converted to Precipitation Water Vapor (PWV). Water vapor is a very important element of the atmosphere. One of its roles is Water vapor is crucial in forecasting precipitation and important to atmospheric dynamics. Then the other water vapor size is very rough in space and time, for example, the measurement of water vapor uses Radio Sonde, which in a day only get data twice.

The figure shows the result of GPS PWV from CMAK station in one day, every 30 seconds ie on December 19, 2015. The green color is the period from 00:00 AM to



11:59:30 AM we call 00Z - UTC and the red color is from 12.00.00 PM to 23.59.30 PM, called 12Z - UTC

At 00Z, Max value: 74.942 mm at 1:15:30 AM and min value: 27.964 mm at 12:00:00 AM, and average PWV value of 64.8948 mm. While at 12Z Max value: 71.962 mm at 11:59:00 PM and min value: 62,601 mm at 2:58:30 PM, average 65.999 mm.

At 00Z shows an interesting pattern, and this is known at a distance of 40-80 minutes the value of PWV decreases and increases. And at 00Z trend the PWV value tends to

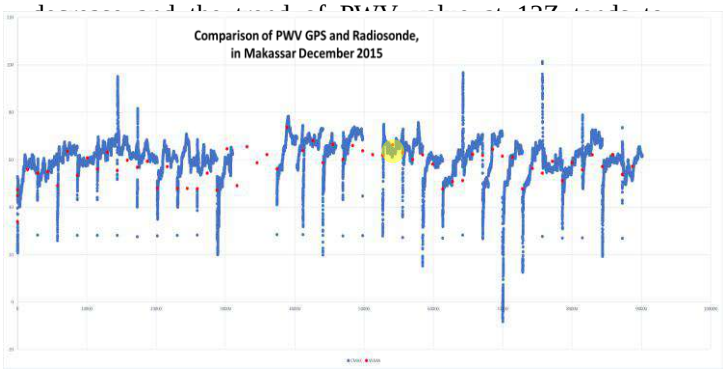


Figure above shows, is a comparison between Precipitation water vapor (PWV) data, from radiosonde measurements at station WAAA , and GPS observations from CORS at station CMAK, both stations are located in Makasar City for December 2015. Radiosonde data is obtained from HTTP: // weather.uwyo.edu and CORS data obtained from BIG.

PWV determined by GPS and radiosonde for one month provide a good pattern and tend to be the same..

IV. CONCLUSION

At 00Z, Max value: 74.942 mm at 1:15:30 AM and min value: 27.964 mm at 12:00:00 AM, and average PWV value of 64.8948 mm. While at 12Z Max value: 71.962 mm at 11:59:00 PM and min value: 62,601 mm at 2:58:30 PM, average 65.999 mm. INA-CORS data processing to get ZTD in a day indicating the value of PWV at the lowest point and at night the value of PWV at the highest point.

PWV determined by GPS and radiosonde for one month provide a good relationship, and data processing from INA-CORS has the potential to obtain information to study climate and environmental science.

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The Application of Slow Release NPK Fertilizer on Inceptisols to Changes of Soil Chemical Properties and Growth of Sweet Corn (*Zea mays* L. *saccharata*).

Fardian Khairul Hakim[1,*], Emma Trinurani Sofyan[2], Rija Sudirja[2], Benny Joy, Anni Yuniarti[2], Diyan Herdiyantoro[2]

[1]Department of Soil Science and Land Resouces Management, Agriculture Faculty, Universitas Padjadjaran –
[2]Magister of Soil Science, Agriculture Faculty, Universitas Padjadjaran
*Email : fkhakim96@gmail.com

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Abstract— *Effort to increase the efficiency of fertilizer use, reduce loss of nutrients in the soil due to leaching, evaporation and reduce residues which can be one of the causes of soil damage, slow release fertilizer is needed. This slow-release fertilizer can optimize plant growth and production as well as nutrient absorption by plants because the release of nutrients is according to the time and amount needed by the plant, while fertilization costs can be reduced because this type of fertilizer is only applied once in a growing season. The experiment was carried out to determine the effectiveness of inorganic fertilizers (NPK) which are slow release with various types of coating percentages to help provide nutrients slowly for sweet corn to grow and produce optimally and reduce environmental pollution due to excessive fertilizer application on the soil. The pot experiment was carried out using a Randomized Block Design (RBD) which consisted of four treatments with the percentage of slow release fertilizer (SRF) i.e. 0%, 3-4%, 5-6% and 7-8%. Each treatment was repeated six times. The results showed that in 60 days after application of slow release NPK fertilizer gave the best effect for improving the chemical properties of Inceptisol (N-total, P-potential, and K-potential), by releasing the entire content of 75.03%. Slow Release NPK fertilizer with 0% coating percentage gave the best effect on the chemical properties of Inceptisol and increased growth (plant height and stem diameter) of sweet corn (Zea mays L. saccharata).*

Keywords— ***coated, NPK, N total, P potential, slow release, Anorganic.***

I. INTRODUCTION

The availability of nutrients in the soil is the main factor that determines the success of cultivating a plant, but the nutrients in the soil have a high mobilization which causes the unavailability of nutrients in the soil due to leaching or loss in other forms. One of the soil orders that have problems with low nutrient content is Inceptisols. The low content of macronutrients (N, P and K), a slightly acidic pH value (5.6), is an obstacle to the utilization of Inceptisols [1].

Efforts can be made to improve Inceptisol soil conditions by applying inorganic fertilizers containing nitrogen, phosphorus and potassium. However, excessive application of inorganic fertilizers to the soil can affect the environment, reactions in the soil such as P fixation, NO_3 and N_2O volatilization. Ahmed et al. [2] stated that to minimize environmental pollution due to the use of inorganic fertilizers with excessive doses, the use of Slow Release Fertilizer (SRF) in agricultural practice is an important and effective method.

According to Himmah et al. [3] Slow Release Fertilizer (SRF) is made to release nutrients slowly and

according to plant nutrient needs. The use of this type of fertilizer can minimize soil and water pollution caused by the application of excessive fertilizer doses and fertilizer leaching. The results of Trenkel's research [4] show that the application of slow release fertilizer has the potential to reduce the use of fertilizer doses by 20-30% recommended from conventional fertilizers while getting the same results. The advantage of using slow-release fertilizers is to maintain the concentration of available nutrients in the soil, reduce runoff and loss of nutrients in the soil due to leaching due to the slow rate of nutrient release [5].

Slow release fertilizer is expected to support plant nutrient needs in accordance with the required dose based on the age of the plant. Fertilizers with these characteristics generally use materials that are able to retain the nutrients contained in the fertilizer so that it does not release quickly [6]. The application of Slow Release Fertilizer (SRF) in the rate of release of nutrients contained in the fertilizer will be controlled by the coating material that coats the fertilizer. Ahmad et al. [7] stated that polymer coated fertilizers are the most popular type of this SRF technology. One of the synthetic polymers used as coatings for inorganic fertilizers is polyurethane. Slow release fertilizers coated with polyurethane are made from the direct reaction between polyol reactants and isocyanates on the surface of fertilizer particles [8]. Therefore, it is necessary to experiment to determine the effectiveness of inorganic fertilizers that are slow release with various types of coating percentages to help provide nutrients slowly for plants, especially growth of sweet corn optimally and reduce environmental pollution.

II. MATERIALS AND METHODS

Inceptisol from Jatinangor was used which belongs to the Fluventic Eutrudepts sub group which has a pH of 6.25, soil N of 0.23%, total P 24.93 $mg100g^{-1}$ and K 23.88 $mg100g^{-1}$ with a dusty clay texture. NPK coated with polyurethane is a compound NPK fertilizer that is slow release. Talented variety sweet corn was used as an indicator plant.

The experimental design used a Randomized Block Design which consisted of four treatments with the percentage of slow release fertilizer (SRF) i.e. 0%, 3-4%, 5-6% and 7-8%. Each treatment was repeated six times. 10 kg of soil in polybags by 30x40 cm. The dose of NPK applied was 0.17 g per kg of soil.

The observed soil parameters were total N, potential P, potential K and soil pH at 15, 30, 45 and 60 days after fertilizer application. Growth parameters observed were plant height and stem diameter periodically every week (14-56 days after planting).The data obtained were tested statistically using Fisher's exact test at a significance level of 5%, if the effect was very real or significant, then to find out the difference between the mean treatment values, the Duncan's Multiple Range Test (DMRT) test was carried out at a significant level of 5%.

III. RESULTS AND DISCUSSION

Soil Nitrogen

The results showed that the application of slow-release NPK inorganic fertilizer had a statistically significant effect on the total N content of Inceptisol soil. The results of statistical analysis can be seen in Table 1.

Each treatment released a different total nitrogen. The difference in nitrogen release in each treatment could be due to differences in the percentage of coating on the outer layer of fertilizer. Treatment D (SRF 7-8%) had a very slow release pattern when compared to treatment C (SRF 5-6%), treatment B (SRF 3-4%) or with treatment A (SRF 0%). due to the influence of the percentage of the coating applied to the fertilizer which inhibits the release of nutrients in the fertilizer.

Table 1. Effect of Slow Release NPK Fertilizer on Total Soil N

Treatments		Soil N-total (%)			
		15 d	30 d	45 d	60 d
A	NPK SRF 0%	0,21 d	0,23 c	0,25 c	0,28 d
B	NPK SRF 3-4%	0,19 c	0,20 b	0,21 b	0,24 c
C	NPK SRF 5-6%	0,18 b	0,18 a	0,20 b	0,22 b
D	NPK SRF 7-8%	0,17 a	0,17 a	0,18 a	0,20 a

Note: The numbers followed by the same letter are not significantly different according to the DMRT test at the 5% level.

The coating method is a coating that is applied to the surface of the fertilizer which functions to bind NPK fertilizer so that it does not evaporate easily when exposed to sunlight and also the fertilizer lasts longer so that it is not

carried away by water [9]. The results of statistical tests on the release of N-Total for each treatment showed a significant difference in all fertilizer treatments tested.

The average soil N-total content at 15-30 days after application (DAA) in each treatment decreased when compared to the initial soil N-total content of 0.23 (medium category). This is because the slow release NPK fertilizer has not released the nutrient content in the fertilizer optimally, while the roots of corn plants at the age of 14-28 days after planting (DAP) have begun to develop and absorb nutrients in the soil in the early vegetative phase [10]. Other factors that can reduce N in the soil are denitrification, volatilization, leaching, and soil surface erosion [11].

The total N-content of soil occurring at 45-60 DAA in treatment A (0% SRF) experienced a significant increase when compared to other SRF treatments. Inceptisol soil N-total treatment A (0% SRF) at 45 DAA increased by 8% and at 60 DAA increased 17.85 % when compared to the initial N-total, but treatment B (SRF 3-4%) could increase N-total soil by 4.16% at 60 DSA. This is because in treatment A (0% SRF) the nutrient content in the fertilizer can be quickly available in the soil, in contrast to NPK fertilizer which is coated with polyurethane in various percentages.

Soil P_2O_5

During the incubation period, the release of phosphorus (P) in each treatment gave significantly different results (Table 2). The P data presented represents the change in P-potential content in Inceptisol soil from the release of P which was given SRF fertilizer with various types of coating percentages.

Table 2. Effect of Slow Release NPK Fertilizer on Soil P_2O_5

Treatments		Soil P_2O_5 (mg/100g)			
		15 d	30 d	45 d	60 d
A	NPK SRF 0%	25,10 d	25,18 d	25,23 c	25,25 d
B	NPK SRF 3-4%	25,00 c	25,04 c	25,11 b	25,14 c
C	NPK SRF 5-6%	24,91 b	24,95 b	24,98 a	25,04 b
D	NPK SRF 7-8%	24,88 a	24,92 a	24,97 a	25,01 a

Note: The numbers followed by the same letter are not significantly different according to the DMRT test at the 5% level.

The release of P in slow-release fertilizers occurred gradually, nutrients released from SRF did not dissolve immediately after application and increased during 60 days of incubation. The greatest release of P element since the beginning of sampling (15-60 DAA) was obtained from treatment A (0% SRF) with a total percentage of release of 76.78%. The advantage of fertilizer in the form of granules is that it has a larger surface area so that the greater the reaction surface area, the solubility of fertilizer will be faster and nutrients will be available more quickly [12].

The release of P elements from SRF with a coating percentage of 3-4% was able to release the total P contained in the fertilizer by 41.61%. The release of P in treatment C (SRF 5-6%) was able to release a total of 11.18% P, while treatment D (SRF 7-8%) was only able to release a total P of 4.72%. The type of fertilizer in treatment B (SRF 3-4%) has a coating that will affect the pattern of phosphorus nutrient release. When fertilizer is applied, the coating will slowly dissolve first until it decays completely before finally the nutrients contained in the fertilizer will be dissolved [13].

According to Trenkel's research [4] fertilizers can be categorized as SRF must meet the following three criteria: a) within 24 hours SRF must release less than 15% of nutrients, b) within 28 days of nutrients that must be released less than 75%, c) at least 75% of nutrients should be released within 40-60 days after application of fertilizer. Based on this statement, treatment B (SRF 3-4%), treatment C (5-6%), and treatment D (7-8%) could not be said to be a slow-release fertilizer.

Soil K_2O

The application of slow release NPK inorganic fertilizer had a statistically significant effect on the potential K content of Inceptisol soil (Table 3).

Table 3. Effect of Slow Release NPK Fertilizer on Soil K2O

Treatments	Soil K_2O (mg/100g)

		15 d	30 d	45 d	60 d
A	NPK SRF 0%	23,99 d	24,10 d	24,19 d	24,24 d
B	NPK SRF 3-4%	23,93 c	23,98 c	24,05 c	24,12 c
C	NPK SRF 5-6%	23,87 b	23,91 b	23,96 b	23,99 b
D	NPK SRF 7-8%	23,84 a	23,87 a	23,91 a	23,95 a

Note: The numbers followed by the same letter are not significantly different according to the DMRT test at the 5% level.

Treatment A (SRF 0%) showed the highest solubility of K nutrients compared to other treatments at 7.78% or an increase of 0.45% from the initial K-potential value of 23.88 mg/100g. The total solubility of the highest to lowest K elements released by SRF for 60 days after application was obtained from treatment A (0% SRF) of 73.28% and followed by treatment B (SRF 3-4%) 40.09%, treatment C (SRF 5-6%) 16.10% and the lowest was obtained from treatment D (SRF 7-8%) of 2.82%.

Coating on slow-release fertilizer will affect the solubility of potassium. Based on research by Saleem et al. [14] that slow-release fertilizer with coating is able to release nutrients gradually and is 14% better than fertilizer without coating. Polyurethane coating material is an oil-based hydrophobic polymer system that functions as a diffusion barrier for excessive release of potassium nutrients [8]. The coating material changes its structure during release due to interaction with water that enters through the surface pores and will be slowly degraded over time and will end in the release of potassium nutrients contained in fertilizers.

Nutrient K is a macro nutrient for plants that is needed in large quantities after N and P. Potassium has a role in plant metabolic processes. The transfer or movement of K mainly through the process of diffusion and soil K nutrient levels need to be known to determine the amount of fertilizer applied for efficient fertilization. Potassium is often lost due to leaching and is in an unavailable form because it is bound by clay minerals. According to Lasindrang [15] that slow-release fertilizers can increase the efficiency of nutrient uptake and reduce the loss of K nutrients due to leaching. This is because the slow-release fertilizer has low solubility in water and releases nutrients gradually over a long period of time for plants, therefore the availability of K nutrients is expected to always be available in the soil so that later it will be absorbed by plants in the form of K+ ions.

Soil Acidity (pH)

The soil acidity decreased with incubation time. The pH value in the initial soil media analysis was obtained at 6.25. At 15 days after application, it is shown in Table 5. that treatment A (SRF 0%) experienced a significant decrease in pH value compared to treatment B (SRF 3-4%), C (SRF 5-6%) and D (SRF 7-8). %) with a decrease in pH to 6.14. Treatment C (SRF 5-6%) and D (SRF 7-8%) at 15 days after did not give significant results. At 30 days after application of treatment A (0% SRF) the pH value of the soil was reduced to 5.98 from 6.25 or 4.5% (Table 4).

Table 4. Changes in the Value of Soil Acidity (pH)

Treatments		Soil pH			
		15 d	30 d	45 d	60 d
A	NPK SRF 0%	6,14	5,98	5,80	5,50
B	NPK SRF 3-4%	6,24	6,14	6,03	5,83
C	NPK SRF 5-6%	6,25	6,18	6,09	6,01
D	NPK SRF 7-8%	6,26	6,21	6,17	6,06

A significant decrease was experienced by each treatment at 60 days after application, treatment A (SRF 0%) could reduce the pH value of the soil to 5.50, treatment B (SRF 3-4%) could reduce the pH value of the soil to 5.83, treatment B (SRF 3-4%) decreased the pH value to 5.83, and treatment C (SRF5-6%) can reduce the pH value of the soil to 6.01 and treatment D (SRF 7-8%) can reduce the pH value of the soil to 6.06 from the initial soil pH value of 6.25. The pH value of a solution is usually affected by the hydrolysis of the salt [16].

Plant Height

Observation of plant height during the study showed that there was a significant difference between the

treatments of slow release NPK fertilizer starting from 14 days after planting (DAP) to 56 DAP The results showed that the application of slow release NPK fertilizer coated with polyurethane polymer did not give the best results on the growth of sweet corn plant height. The highest results in plant height observations were achieved by treatment A (0% SRF) which was 30.03 cm (14 DAP), 42.50 cm (28 DAP), 58.49 cm (42 DAP) and 74.48 cm (56 DAP).). The height of the garden can be said to increase gradually according to the age of the plant along with optimal fertilizer application [17]. Plants will not give maximum results if the necessary nutrients are not available. This is in line with the results of research by Marlina et al. [18] that the application of complete fertilizer N, P, K at the right time and in the right dose can increase the growth and yield of sweet corn.

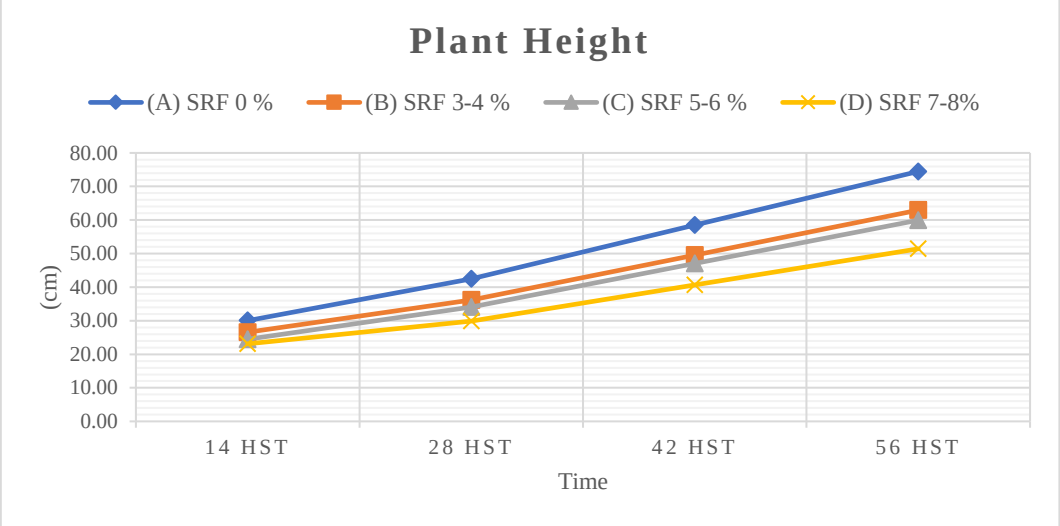

Fig.1. Plant Height of Sweet Corn

Figure 1 shown that the plant height at 14 DAP was uniform. The application of slow release NPK fertilizer had an effect on plant height after sweet corn passed 14 DAP. Mahdianoor et al. [10] stated that plants at the age of 14 DAP entered the stage of becoming new plants or were in a slow growth phase, so that at that phase the plant roots had not developed and had not optimally absorbed nutrients in the soil but already needed nutrients to grow optimally.

The increase in plant height was thought to be due to nitrogen, phosphorus and potassium nutrients in the soil at the beginning of the plant before application was in the medium category and the addition of nitrogen, phosphorus and potassium nutrients released by slow release NPK fertilizers. According to Advinda [19] the element nitrogen is very important for plants because it is a component of cells, amino acids, nucleic acids, chlorophyll, and hormones.

Stem Diameter

The experimental results showed that the addition of slow release NPK fertilizer with 0% coating gave significantly different results between treatments at the age of 14 DAP, but the other treatments were not significantly different from each other. This is because the difference in the percentage of coating applied to each NPK fertilizer, treatment B (SRF 3-4%), treatment C (SRF 5-6%) and treatment D (SRF 7-8%) showed a relatively growth in stem diameter. slower with values of 4.37 mm, 4.19 mm and 4.28 mm, and not significantly different from each other, when compared to treatment A (SRF 0%) with a value of 4.89 mm. According to Mahdianoor et al. [10] at the age of 28 DAP plant roots have started to grow and are actively moving to obtain water and nutrients to support growth and development.

Corn plants at 56 DAP showed a significant difference between treatment A (SRF 0%) and treatment B (SRF 3-4%), treatment C (SRF 5-6%) and treatment D (SRF 7-8%). This happened because the plants that were given SRF 0% had absorbed the nutrients available in the soil well, but the final result of the growth of the stem diameter of the sweet corn plant did not match the description of the Talent Varieties, this variety was able to produce a stem diameter of 29.0 – 32.0 mm [20], while the highest stem diameter value was achieved by treatment A (SRF 0%) of 14.5 mm and the lowest stem diameter value was found in treatment D (SRF 7-8%) of 10, 67mm.

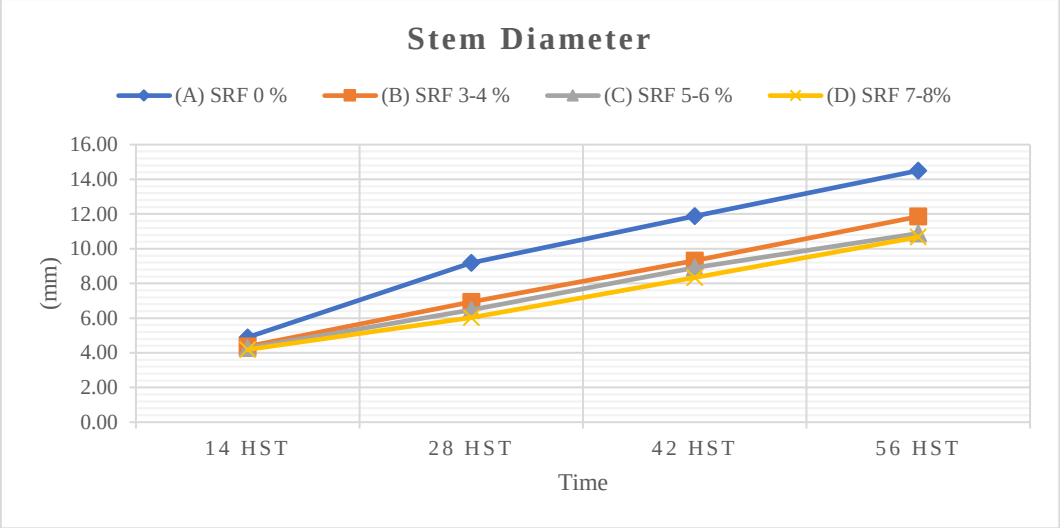

Fig.2. Stem Diameter of plant

Figure 2 shown that the diameter growth of sweet corn in treatment B (SRF 3-4%), treatment C (SRF 5-6%) and treatment D (SRF 7-8%) was inhibited due to the slow release of nutrients in slow-release NPK fertilizers. not in line with expectations because there is no hydrolysis process in the soil between the coating surface and water properly which has an impact on the unavailability of nitrogen, phosphorus and potassium nutrients that are in accordance with the needs of sweet corn plants in order to grow optimally. In contrast to treatment A which was given SRF 0%, this kind of fertilizer will provide the nutrients nitrogen, phosphorus and potassium in fertilizers that are needed by plants to be optimal and grow faster. Research by Irfan et al. [21] showed that the coating on the slow-release fertilizer functions to control the pattern of nutrient release through the diffusion process, then the nutrient dissolution process occurs in the fertilizer and ends in the release of nutrients.

IV. CONCLUSION

Based on the experimental results, it can be concluded that within 60 days the treatment of NPK inorganic fertilizer which is Slow Release gives the best results for improving the chemical properties of Inceptisol soils (N-total, P-potential, and K-potential), by releasing the entire content of 75, 03%. Slow Release NPK fertilizer with 0% coating percentage gave the best results on the chemical properties of Inceptisol soil (N-total, P-potential and K-potential) and increased growth (plant height and stem diameter) of sweet corn (*Zea). mays* L. saccharata) Variety of Talents.

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Impact of Seawater Intrusion on Freshwater Quality in Coastal Area of South Kalimantan

Sri C. Wahyono*[1], Simon S. Siregar[1], Ori Minarto[2], Totok Wianto[1] and Nurma Sari[1]

[1]Physics Study Program, University of Lambung Mangkurat, Banjarbaru 70714, Indonesia
[2]Basic Science Laboratory, University of Lambung Mangkurat, Banjarbaru 70714, Indonesia
*Email: scwahyono@ulm.ac.id

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Abstract*—Climate change and sea level rise as both have the potential to affect saltwater intrusion into the coastal area. The aim of this study is finding seawater influence on coastal area freshwater. To this purpose, it is conducted study of groundwater aquifer as freshwater and its electrical characteristics by electrical resistivity survey in the coastal area of Muara Asam-Asam Village, South Kalimantan. It channeled from three different positions to find its impacts on the well water quality. The data interpreted and analyzed based on the two-dimensional mapping of the distribution of subsurface resistivity values. At a distance of 100 m from the shoreline, it experienced intrusion at a depth of 1.24 – 9.68 m with a thickness of 8.44 meters with resistivity values 1.17 – 4.20 Ωm. Furthermore, at a distance of 200 m from the shoreline, it experienced intrusion at a depth of 0.80-5.14 m with a thickness of 4.34 meters with a resistivity value of 0.26-4.70 Ωm. Finally, at a distance of 300 m from the shoreline is free of seawater intrusion. Meanwhile, the physical parameter of well water as freshwater and water consumption conducted to monitor water quality for the settlement around the area. Mean value of physical parameter of well water for TDS, level of turbidity and pH are 124.03 mg/L, 5.80 NTU and 6.80 respectively. Both TDS and pH are meet health requirements, but it is not for turbidity level value.*

Keywords*— *Seawater intrusion, coastal area, freshwater, electrical resistivity, physical parameter, water quality.

I. INTRODUCTION

Global warming impacts in Indonesia with surface temperatures increasing from 0.2 to 0.3 ºC/decade (Case et al., 2007) (Prinz, 2009) and its rise estimated at 0.9 to 2.2°C by the 2060s and 1.1 to 3.2 °C by 2100 (Ministry of Foreign Affairs of the Netherlands, 2018). Groundwater withdrawals from coastal aquifers are vulnerable to climate change and sea level rise as both have the potential to affect saltwater intrusion and hence groundwater quality depend on hydrogeological settings.(Rasmussen et al., 2013). Seawater intrusion (SWI) as a global issue, exacerbated by rising demands on freshwater in coastal areas and predisposed influencing the rising of sea levels and the climate change (Werner et al., 2013) (Paul & Rashid, 2017b). SWI degrades groundwater quality through enormous pumping activities or natural phenomena such as tidal waves (Sahana & Waspodo, 2020). The climate change influences seawater intrusion by seeing both Sea Level Rises and freshwater recharge rates (Chun et al., 2018) (Paul & Rashid, 2017a).

The study of groundwater aquifer and its electrical characteristics had been carried out by electrical resistivity survey with the pole–pole configuration (Wahab et al., 2021). The gap of electrical resistivity using geophysical techniques between seawater (0.2Ωm) and freshwater (> 5Ωm) is able to map the subsurface groundwater salinity distribution (Werner et al., 2013). The research by (Chen et al., 2018) showed that Electric Resistivity Tomography could detect the front edge of the seawater intrusion and

means of time-lapse observed a delay effect existing between seawater intrusion and tidal action.

Water quality criteria are used to assess risk and establish or revise water quality standards (Zhao et al., 2018). Each country develops their water quality criteria to reflect country-specific human exposure patterns and ambient water environmental conditions before incorporating water quality criteria into water quality standards such as USA (USEPA, 2022), Singapore (PUB Singapore's National Water Agency, 2019), Indonesia (Permenkes RI, 2010), Malaysia (Ministry of Health Malaysia, 2000) and Japan (Wakayama, 2004). Road salt (mainly NaCl) is commonly used during the winter to ensure road and pavement safety; however, the long-term application of NaCl has negative consequences on soil and the water environment (Szklarek et al., 2022).

Saline water play an important factor for hypertension or high blood pressure in the coastal areas (Shammi et al., 2019). Red Sea coast in Saudi Arabia. the influence of seawater intrusion and heavy metals are contaminating groundwater quality (Alshehri et al., 2021). In particular country such as Bangladesh, groundwater quality is a serious environmental concern for sustainable development specially in the southeast coastal region to guarantee drinking water safety (Islam et al., 2021).

The objective of this study is finding seawater influence on coastal area freshwater. To this purpose, it is conducted study of groundwater aquifer as freshwater and its electrical characteristics by electrical resistivity survey in the coastal area of Muara Asam-Asam Village, South Kalimantan from three different positions. The outcome of this study is providing the baseline data of the seawater impact for sustainable groundwater management and human health protection in the coastal region of Muara Asam-Asam Village, Tanah Laut Regency, South Kalimantan. Specifically, it provides:

- Seawater intrusion into the coastal area up to 200 m from the shoreline at a depth of 0.80-5.14 m with a thickness of 4.34 meters with a resistivity value of 0.26-4.70 m.
- Measurement at 300 m from the shoreline is free of seawater intrusion.
- For the settlement around the area, average value of physical parameter of well water for TDS, level of turbidity and pH are 124.03 mg/L, 5.80 NTU and 6.80 respectively. Both TDS and pH are meet health requirements, but it is not for turbidity level value.

II. MATERIAL AND METHODS

The research was conducted on the part of coastal region of Muara Asam-Asam Village, Tanah Laut Regency, South Kalimantan (as seen in Fig. 1). The data collection process consists of two parts that are resistivity data collection and well water sampling. The well water are representing ground water of the certain area.

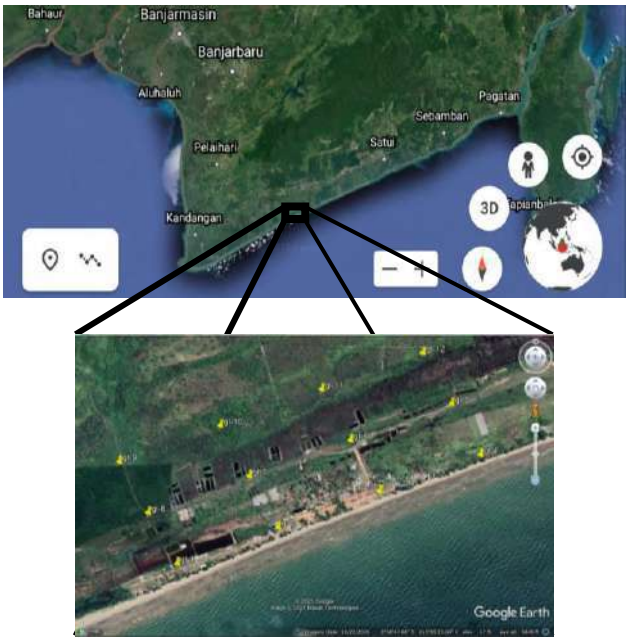


Fig.1: Map of measurement locations on the coast of South Kalimantan (above) and the research location of coastal area (below)

Resistivity data retrieval was carried out on 12 tracks with a length of 200 m each. The shortest electrode spacing as (a) is 5 m. Data collection in the field is carried out with the following steps:

• Spread the meter along the 200 m on a track that has been determined starting, middle and end points.

• Arrange a series of resistivitymeter and install electrodes according to Wenner's configuration, namely C_1-P_1-P_2-C_2. For the first layer (n_1=1), the space is na=a.

• Clamp the electrode so that it is connected to the resistivitymeter wire.

• Turn on the resistivitymeter with the battery and record the measured resistance value, potential difference and current.

• Move the electrode a with distance a, then re-measure the value of the resistance potential difference and current.

After obtaining field data in the form of measured resistivity data from each datum point in the measurement path, the data multiplied by the geometric factor to obtain the apparent resistivity value. The data processed using

Software Progress to obtain a subsurface vertical layer. The results obtained from data processing are interpreted and analyzed. Data interpretation and analysis was carried out based on the interpretation of the two-dimensional mapping of the distribution of subsurface resistivity values. Furthermore, it can be seen the layer of soil / rock on each measurement path.

Sampling of well water was carried out to analyze physical parameters including odor, color, TDS, turbidity, taste and temperature as well as the content of Sodium (Na) and Chloride (Cl). Sampling was carried out as many as five 1.5 liters glass bottles.

Odor parameters were measured directly with organoleptic assistance, which was carried out by two respondents to smell the water sample, then gave smell's opinion. The color parameter is measured directly with the help of the sense of sight, which is done by two respondents to see the color in the water sample, then give an opinion about the color or not (Sari & Huljana, 2019), (Hapsari, 2015). The pH value was measured using a universal indicator, namely inserting the universal pH meter into a beaker containing a sample of dug well water and inserting it for 2 seconds (Sari & Huljana, 2019); (Hasrianti & Nurasia, 2016).

The basic principle of TDS is evaporation. Well water that has been filtered with 2 µm porous filter paper and then dried to dry. Then weighed until the weight remains (Hapsari, 2015). Testing for water turbidity uses a tubidimeter and materials that include distilled water, well water samples, 200 ml sterile plastic bottles (Parera et al., 2013). The taste parameter is measured directly with the help of the sense of taste. Two respondents feel the water sample, and then give an opinion related to the water tastes. Good water has a normal temperature, approximately ±3º from room temperature (27 ºC). Water temperatures that exceed normal limits indicate that there are dissolved chemicals in large enough quantities or that the process of decomposition of organic matter by microorganisms is taking place. The standard regarding drinking water quality requirements as follows: TDS is 500 mg/L, the maximum turbidity level is 5 NTU, the pH level is ranging from 6.5 – 8.5, the temperature has a value of ± 3º from the air temperature, the taste is tasteless, water color is colorless and the smell is odorless (Permenkes RI, 2010).

Elemental sodium (Na) using atomic absorption spectrophotometry (ASS), in addition to testing the element sodium can also use the flame photometric method and analyze sodium using flame emission spectroscopy testing in isotonic drinks. Testing the content of chloride (Cl) in water samples in the research area using the national standard Argentometry method (SNI 6989.19, 2009). In the Regulation of the Minister of Health of the Republic of Indonesia concerning the sodium content is a maximum of 200 mg/L and Drinking Water Quality Requirements, the maximum level of chloride in drinking water is 250 mg/L (Permenkes RI, 2010).

III. RESULTS

Resistivity data collection

Field data acquisition was carried out on 06 – 08 April 2021 with measurements of 12 points. The coordinates of the geoelectrical measurement point are as shown in Table 1.

Table 1. Geoelectric measurement point

No.	Code	Coordinates	
		South Latitude	East Longitude
1	GL-1	3º 59′ 00″	115º 04′ 26″
2	GL-2	3º 58′ 55″	115º 04′ 40″
3	GL-3	3º 58′ 50″	115º 04′ 54″
4	GL-4	3º 58′ 45″	115º 05′ 08″
5	GL-5	3º 58′ 38″	115º 05′ 04″
6	GL-6	3º 58′ 43″	115º 04′ 50″
7	GL-7	3º 58′ 48″	115º 04′ 36″
8	GL-8	3º 58′ 53″	115º 04′ 22″
9	GL-9	3º 58′ 46″	115º 04′ 18″
10	GL-10	3º 58′ 41″	115º 04′ 32″
11	GL-11	3º 58′ 36″	115º 04′ 46″
12	GL-12	3º 58′ 31″	115º 05′ 00″

In the GL-1 point area, the types of lithologies that make up are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has a resistivity value of 1.82 Ωm which is at a depth of 4.48 – 9.68 m and with a layer thickness of 5.20 m. In the GL-2 point area, the types of lithological constituents are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has a specific resistance value of 4.20 Ωm which is at a depth of 7.87 – 17.01 m and with a layer thickness of 9.14 m.

In the GL-3 point area, the lithological types of the constituents are sand and clay. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has a resistivity value of 1.17 and 2.02 Ωm which is at a depth of 3.01 – 6.77 and 17.80

– ∞ m, with a layer thickness of 3.76 and ∞ m. In the GL-4 point area, the lithological types of the constituents are sand and clay. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has a resistivity value of 5.96 and 3.24 Ωm which is at a depth of 1.24 – 2.32 and 9.25 – 14.90 m, with a layer thickness of 1.08 and 5.65 m.

In the GL-5 point area, the types of lithological constituents are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has resistivity values of 4.01 and 1.95 Ωm at a depth of 0.80 – 1.43 and 4.09 – 6.25 m, with a layer thickness of 0.63 and 2.16 m. In the GL-6 point area, the types of lithological constituents are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has a specific resistance value of 0.26 Ωm which is at a depth of 11.56 –∞ m and with a layer thickness of ∞ m.

In the GL-7 point area, the types of lithological constituents are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has a resistivity value of 4.70 Ωm which is at a depth of 4.16 – 7.37 m and with a layer thickness of 4.68 m. In the GL-8 point area, the types of lithologies that make up are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has a resistivity value of 3.38 Ωm which is at a depth of 4.47 – 6.47 m and with a layer thickness of 2.00 m.

In the GL-9 point area, the types of lithological constituents are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). The intrusion layer has a resistivity value of 3.80 Ωm which is at a depth of 3.17 – 5.14 m and with a layer thickness of 1.97 m. In the GL-10 point area, the types of lithological constituents are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). At this point there is no seawater intrusion. In the GL-11 point area, the types of lithologies that make up are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). At this point there is no seawater intrusion. In the GL-12 point area, the types of lithological constituents are sand, clay and sandy loam. Seawater intrusion is thought to have a value of 0.2 – 6 Ωm (Astutik et al., 2016). At this point there is no seawater intrusion.

Well water data collections

The distribution of the value of the amount of dissolved solids (TDS) in the study area is 74.9 – 230.9 mg/L as shown in Figure 2a. The amount of dissolved solids (TDS) in the water samples in the study area on average is 124.03 mg/L. The test results from water samples can be concluded that the amount of dissolved solids (TDS) in the study area still meets health requirements. The distribution of the turbidity level in the study area is 0.47 – 13.68 NTU as shown in Figure 2b. The average turbidity level in water samples in the study area is 5.80 NTU. The test results from water samples can be concluded that the level of turbidity in the study area does not meet health requirements.

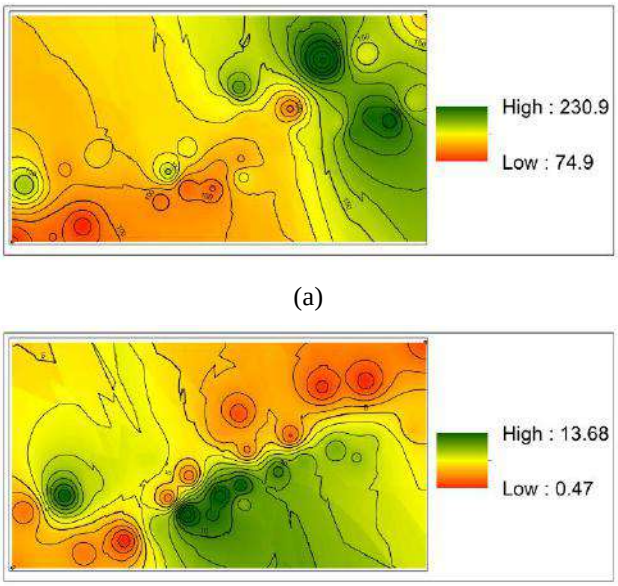
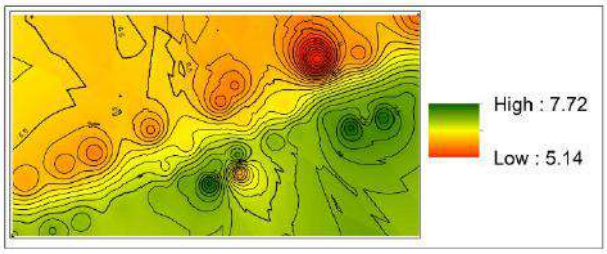


Fig.2: Contour of (a) TDS level and (b) turbidity level on this research

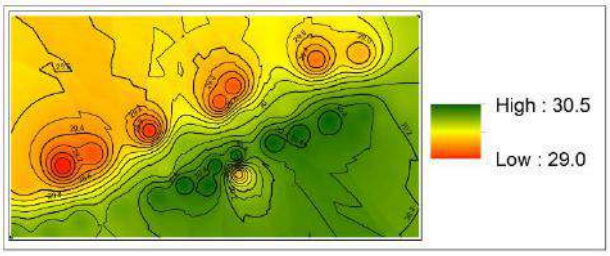
The distribution of pH values in the study area is 5.14 – 7.75 as shown in Figure 3a. The average pH level in water samples in the study area is 6.80. The test results from water samples can be concluded that the level of turbidity in the study area still meets health requirements. The distribution of temperature values in the study area is 29.0 – 30.5 as shown in Figure 3b. The average temperature value of water samples in the study area is 29.98 ± 2.5. The test results from water samples can be concluded that the temperature in the study area still meets the health requirements.

The taste assessment of water samples in the study area was 30% of the water samples still tasted salty. The test results from water samples show that the odor in the research area still meets health requirements. The color assessment of the water samples in the research area is 6.67% of the water samples still look colored. The test results from water samples indicate that the color in the research area still meets health requirements. The odor assessment of the water samples in the study area was that

30% of the water samples still smelled. The test results from water samples are still meets health requirements.

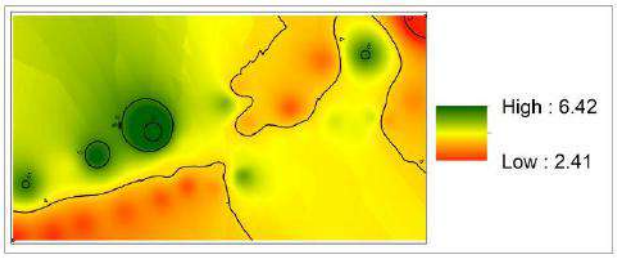


(a)

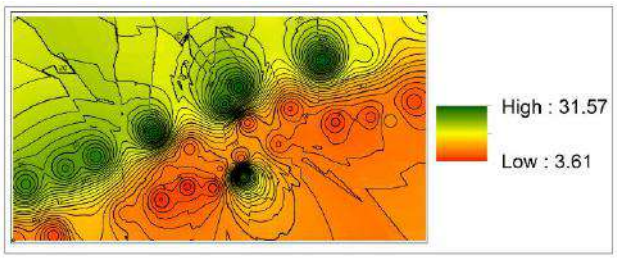


(b)

Fig.3: Contour of (a) pH level and (b) temperature level on this research



(a)



(b)

Fig.4: Contour of (a) sodium content and (b) chloride content on this research

IV. CONCLUSION

In conclusion, this research shows that seawater intrusion in the coastal area of Muara Asam-Asam Village, Tanah Laut Regency, South Kalimantan from three different positions has several impacts on the well water quality. At a distance of 100 m from the shoreline, it experienced intrusion at a depth of 1.24 – 9.68 m with a thickness of 8.44 meters with resistivity values 1.17 – 4.20 Ωm. Furthermore, at a distance of 200 m from the shoreline, it experienced intrusion at a depth of 0.80-5.14 m with a thickness of 4.34 meters with a resistivity value of 0.26-4.70 Ωm. Finally, at a distance of 300 m from the shoreline is free of seawater intrusion. Meanwhile, the physical parameter well water as water consumption was also conducted to monitor well water quality for the settlement around the area. The amount of dissolved solids (TDS) are 74.9 – 230.9 mg/L with an average of 124.03 mg/L, so it is still meet health requirements. The level of turbidity is 0.47 – 13.68 NTU with an average of 5.80 NTU, so it does not meet the health requirements. The pH value is 5.14 – 7.75 with an average of 6.80, so it still meets health requirements.

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Impact of *Elaeidobius kamerunicus* population in F1 hybrid-single generation families of oil palm on Malaysia profound peat-soil

Senesie Swaray[1,2], Mohd Din Amiruddin[3], Mohd Rafii Yusop[1,4*], Syari Jamian[5], Mohd Firdaus Ismail[1], Oladosu Yusuff[4], Foday Turay[2], Momodu Jalloh[1,2*],Umaru Mohamed Gassama[6], Marhalil Marjuni[3], Bello Sani Haliru[4]

[1]Department of Crop Science, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 UPM Serdang, Selangor, Malaysia.
[2]Tree Crops Unit, Sierra Leone Agricultural Research Institute (SLARI), P.M.B 1313 Freetown, Sierra Leone.
[3]Advanced Biotechnology and Breeding Centre, Malaysian Palm Oil Board, 6 Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia.
[4]Laboratory of Climate-Smart Food Crop Production, Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia (UPM), 43400 UPM Serdang, Selangor, Malaysia.
[5]Department of Plant Protection, Faculty of Agriculture, Universiti Putra Malaysia (UPM), 43400 UPM Serdang, Selangor, Malaysia.
[6]Department of Crop Science, School of Agriculture and Food Sciences, Njala University, Sierra Leone.
*Corresponding authors: Mohd Rafii Yusop: mrafii@upm.edu.my

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Abstract**—** *Elaedobius kamerunicus (EK) is the most effective oil palm pollinator, and has positively improved the rate of pollination and oil yield. However, the decline in the oil palm fruit set and oil yield is alarming in oil palm industries. Therefore, this study investigated the EK population abundance and its impact on the oil palm fruit set. A significant variation in EK population was observed among the biparental families and a decline in its population abundance. The highest mean number of EK per palm was recorded on Day-three and family ECPHP500 recorded the highest (2367.94 ± 140.74). The total population means of EK was 36830.14 ± 851.68 per hectare and ECPHP550 recorded the highest at 52,189.64 weevils per hectare.A simple linear regression and correlation coefficient (r) analysis indicated declines in the efficiency of the weevil and it accounted for 31% of the variation in fruit to bunch, 25% in average bunch weight, 37% infertile fruit, and 33% of the total variation in oil palm fruit set ratio. The oil palm traits analysed, had a positive and highly significant moderate correlation with the weevil effectiveness. A strong perfect relationship was established between Day-three anthesis with EK population per inflorescence (r = 0.99, df = 3, 23, P<0.0001). Moderate evaporation rate, rainfall, wind velocity, and sunshine duration with temperature (29ºC) will increase the weevil population and efficiency. Future research and good management practices should be considered to improve the population and pollination effectiveness of EK, enhancing the livelihoods of farmers.*

Keywords**—** ***Elaeis guineensis, pollinator, Efficiency, Fertile fruit, Biparental, yield traits.***

I. INTRODUCTION

The African oil palm (*Elaeis guineensis*Jacq.) is one of the extensively cultivated perennial crops and the most significant industrial crop in Malaysia. It produces unisexual inflorescences of males and females separately (Adam et al., 2011) and is entomophilous, or pollinated by insects (Syed, 1979;Daud and Ghani, 2016). For many crops, insect pollination is vital (Jalloh et al., 2018; Fatihah et al., 2019). Souza et al. (2017) reported that, for every pollination process affected in flowering plants, more than 80% are done by biotic pollinators. Among biotic pollinators, the African oil palm weevil commonly known as *Elaeidobius kamerunicus* (EK) from the order Coleoptera of Curculionidae family,has been considered as the most efficient oil palm pollinator (Meléndez and Ponce 2016, Meijaard et al., 2018) and it has been introduced

globally. However, fluctuating populations in oil palm plantations have led to anxieties on yield and resilience (Li *et al*., 2019). Weevils significantly determine the yield of palm oil for industrial oil palm producers in which adequate weevils, 30% to 60% of flowers grow into fruit and fresh fruit bunch weight of 60% to 70% (Yousefi et al., 2020).

Oil palm is well known as a specific host plant for the weevil EK, and this weevil is incapable to carry out its normal life on any other kind of plant (Syed, 1984). *Elaeidobius. kamerunicus*, is extremely dependent on spikelets of the male inflorescence where they breed, feed, and animate. Its visitation depended on the aroma produced by the male inflorescence ascribed as estragole or P-methoxyally benzene (Muhammad et al., 2016). The female and male inflorescences of oil palm emit sequentially in the form of a cycle and two dissimilar inflorescences do not overlap at the time of sexual maturity and therefore transfer of male pollen grains is required for pollination. The proportion of oil palm fruit sets is strongly associated with the population density of the pollinating weevils (Kouakou et al., 2018).

In the 1980s, *E. kamerunicus* was introduced into Malaysia from Cameroon at Pamol estates in Kluang Johor and Ladang, Pamol in Sabah. This increased the rate of pollination and fruit set from 20 to 30% thereby resulting in the lower fresh fruit bunches abortion and greatly reduced the need for hand pollination or assisted pollination (Syed, 1982). Moreover, a 30% reduction in production cost (Basri et al., 1983) and approximately 43% of the kernel to bunch ratio were attained (Dhileepan, 1994). Similarly, Ponnamma (1999) revealed that a 36.9 to 78.3% bunch fruit set was achieved while Basri et al. (1987) reported a higher yield of fresh fruit bunches after the introduction of *E. kamerunicus* in oil palm plantations. This indicated a strong relationship between oil palm production and *E. kamerunicus* population as compared with several other crop species (Atibita et al., 2016, Posho-Ndola et al., 2017).

However, continuous decline in the oil palm fruit set has been reported and it has been constantly associated with the decline in *E.kamerunicus* population and efficiency (Swaray et al., 2021). Prasetyo et al. (2014) reported that the oil palm bunch fruit set has recently declined as a result of a decrease in *E. kamerunicus* population. Also, according to Fatihah et al. (2019), it is confirmed that the fruit set has recently decreased. For Malaysia's oil palm industry, the most challenging year was 2018 with a record of low fresh fruit bunch (FFB) production at 19.52 tons/ha resulting in low export earnings (Kushairi et al., 2019). The decline in EK population has been associated with several contributing factors which is not limited to its natural enemies and use of chemicals for the control of pest and diseases. According to Prasetyo et al. (2014), Yue et al. (2015), and Li et al. (2019), Predators such as rats, birds, ants, mites, and spiders have all been identifiedto feed on EK population levels at all life stages.

Despite the efforts of the Malaysia Palm Oil Board (MPOB) in the expansion of oil palm plantations across the country, poor fruit set due to the inadequate pollinator insects has been a major drawback (Frimpong and Adjaloo, 2012; Sisye, 2018). According to Latip et al. (2018), the yield output of oil palm has declined recently with several contributing factors, and perhaps a decline in the population and effectiveness of *E. kamerunicus* could be no exception. Fatihah et al. (2019) reported a low population abundance of EK in *dura* × *pisifera* (D×P) palms, and they suggested that to determine the relationship of various planting materials of oil palm and the EK population for fruit set, further study is required. Accordingly, we hypothesised that there is a decline in EK population abundance and its efficiency in oil palm D×P families. Therefore, this current study aims to assess the EK population abundance and its effectiveness in oil palm D×P biparental F1 hybrid-single generation families on oil palm fruit set yield.

II. MATERIALS AND METHODS

2.1.Planting materials

A total of 24 F1 hybrid-single generation (D×P415, D×P618, D×P4118, D×P4841, D×P4679, D×P4465, D×P550, D×P500, D×P4674, D×P4651, D×P4648, D×P4621, D×P4504, D×P4482, D×P4474, D×P4591, D×P4570, D×P4550, D×P4535, D×P4529, D×P4505, D×P4548, D×P4540, D×P4539) oil palm biparental families of the genus *Elaeis*derived from closed pollinated hybridization of four male *pisiferas* (Nigeria, Cameroon, Yangambi and AVROS) and six female *duras* (Angola, Deli-Banting, Tanzania, Deli-Johor Labis, Deli-Ulu Remis, Deli-Serdang) parental origins were utilized in this study. The current planting materials were planted in 2008 at Field 6B1-Trial 0.502,Teluk-Intan (3.49˚N, 101.06˚E), Malaysiaby MPOB.

2.2. Experimental design and data collection

The oil palm D×P derivative families were laid down in an Independent completely randomized design (ICRD) in four replications, 16 palms/family/replicate (16×4 = 64 palms/family) of 24 families, planted in 8.5 meters equi-lateral tri-angular design.Experimental sample palms of 288 (12 × 24) were selected from 1,520

experimental palms of 9.5 ha through systematic random sampling selection within the family group (1520 /288 = 5.23 palms), i.e three palms/family by four replications (3 × 4 = 12) and the same selected plants were sampled at each round.

In this research, the procedure established by Basri and Norman (1997) was followed every month for 12 months (February 2019 – January 2020). The oil palm male inflorescences at the anthesis phase for each month were randomly selected based on families. For each anthesizing day, three spikelets from the male inflorescence were harvested, making a total of 18 spikelets. However, in determining the EK population abundance, the first three days of anthesis, i.e nine spikelets (three spikelets/day) were randomly harvested at different portions from the anthesizing male inflorescence between the hours of 8 a.m. and 10 a.m. The number of EK was counted on each harvested spikelet and based on Basri and Norman's (1997) formulation, the mean of EKpopulation abundance per ha was determined.

i. $$PA/EK = \frac{(MEK/S \times NMF/A \times SM/MF)}{NFF/A}$$

Where:

PA/EK = Population abundance of *E. kamerunicus* per palm

MEK/S = Mean of *E. kamerunicus* per spikelet

NMF/A = Number of male inflorescences at anthesis per palm

SM/MF = Spikelet mean of male inflorescence at anthesis

NFF/A = Number of female inflorescences at anthesis per palm

ii. $$PA/EK\ (ha) = \frac{(MEK/S \times NS/MF \times TMF/A)}{Npalm\ per\ plot} \times Npalm\ (ha)$$

Where:

$PA/EK_{(ha)}$ = Population abundance of *E.kamerunicus* per hectarage

MEK/S = Mean of *E. kamerunicus* per spikelet

TMF/A = Total number of male inflorescences at anthesis per palm per replication

NS/MF = Number of spikelets per male inflorescence

Npalm/plot = 64 palms (16 palms/plot)]

Npalm/ha = 160 palms/ha

The effectiveness of the *E. kamerunicus* (EK) in the derivative oil palm families was measured based on oil palm average bunch weight (ABW), fruit to bunch (FTB) fertile fruit (FF), parthenocarpic/infertile fruit (PCF), inflorescence sex ratio (ISR), and fruit set ratio (FSR). One anthesizing female inflorescence per palm per round was selected and observed until the ripening stage, and the efficiency of EK was determined using the "S-shape" method as described by Rao et al. (1983). The 1st selection of the anthesizing female inflorescences was done in February 2019 and its efficacy in the 1st round was determined in June 2019, 2nd selection was in April 2019 and its efficiency was determined in September 2019, 3rd selection was in July 2019 and its productivity was determined in December 2019 and the final selection was done in October 2019 and its efficiency was determined in March 2020. The monthly population force of EKassessment was carried out among the 24 families from February 2019 to January 2020 as described by Basri and Norman (1997).

*Elaeidobius kamerunicus*population force data were collected on a monthly interval for 12 months. Whereas, data on oil palm traits were collected at 15 to 24 weeks intervals for four consecutive rounds. Environmental data on monthly rainfall (MRF mm), monthly wind velocity (MWV km/hr), monthly sunshine hour/duration (MSH Wm^2), monthly evaporation rate (MER mm), and monthly temperature (MT ^oC) were sourced from the local meteorological department in the experimental research station beginning from February 2019 to January 2020.

a. Statistical analysis

The number of *E. kamerunicus* captured during anthesis periods, average bunch (ABW), fruit to bunch (FTB) fertile fruit (FF), parthenocarpic/infertile fruit (PCF), inflorescence sex ratio (ISR), and fruit set ratio (FSR) was calculated based on individual palms and the means by progeny were precisely used for analysis using Statistical Analysis System (SAS) vision 9.4. The analysis of variance (ANOVA) was determined using the general linear model (PROC GLM) of SAS due to missing palms by families and Tukey's Studentized Range Test ($P < 0.05$) was used for mean separation. Variance component [genetic variance (σ^2_g), error variance (σ^2_e), and phenotypic variance (σ^2_{ph})], and simple statistics (mean and standard error) were calculated.

The relationship of the weevil density and its efficiency in respect of ABW, FTB, FF, PCF, ISR, and FSR were analysed using simple linear regression and Pearson's product correlation analysis using SAS vision 9.4. Thus, each of the traits was used as a response variable against the explanatory variable (*Elaeidobius. kamerunicus*).To acquire models for a functional relationship between dependent variables (FTB, ABW, FF, ISR, and FSR) and independent variables (PF/EK), Type two of the regression model was used since both of the

variables (response and explanatory) were measurable and were subjected to error. The simple linear regression with a linear model form of $Y = \beta_0 + \beta_1 X_1 + \varepsilon$ was used as delineated by (Ngo et al., 2012), where Y = response variable, β_0 = intercept (value of Y, when X is 0), $\beta_1 x_1$ = slope (change in Y, for each unit change in X) known as the explanatory variable and Ɛ= random error.

The equations of interest are as follows;

1. $FTB = \beta_0 + \beta_1(\mathrm{PF/EK}) + \varepsilon$
2. $ABW = \beta_0 + \beta_1(\mathrm{PF/EK}) + \varepsilon$
3. $FF = \beta_0 + \beta_1(\mathrm{PF/EK}) + \varepsilon$
4. $ISR = \beta_0 + \beta_1(\mathrm{PF/EK}) + \varepsilon$
5. $FSR = \beta_0 + \beta_1(\mathrm{PF/EK}) + \varepsilon$

Note: The variables, fruit to bunch (FTB) in the 1st equation, average bunch weight (ABW) in the 2nd equation, fertile fruit to bunch (FF) in the 3rd equation, inflorescence sex ratio (ISR) in the 4th equation, and fruit set ratio (FSR) in the 5th equation are the response variables at a time, respectively, while β_0 is the intercept and β_1 (PF/EK) is the slope and Ɛ is the random error.

III. RESULTS AND DISCUSSION

3.1. Population mean of Elaeidobius kamerunicus that visited the male inflorescence each day of anthesis among D×P families

The population abundance of *E. kamerunicus* on male anthesizing inflorescence showed highly significant differences among the biparental progenies, while no significant effect was seen among the replications (Table 1). According to Swaray et al. (2021), the EK population density exhibited significant differences amid the hybrids of D×P genotypes. Results on the variance component exhibited that genetic variability (σ^2_g) had more influence on the number of spikelets per male inflorescence (NS/MF), spikelet length (SPL cm) and population abundance of *E. kamerunicus* (PA/EK ha.), whereas, error variance (σ^2_e) had a greater influence on the anthesizing male inflorescences due to anthesis phases (Table 1). Optimal pollination could be achieved based on the pollinating insect's activity when adjusted to flower physiology (Auffray et al., 2017). According to Tandon *et al*. (2001), as supported by Auffray et al. (2017), the inflorescences of both sexes in oil palm became functional during the morning hours of 8:00 to 10:00 a.m. The male inflorescences on anthesis will emit pollen and transmit to the anther of the stigma of the female inflorescence flowers by the actions of pollinating insects or wind.

Table 1. The mean square and variance components for population abundance of Elaeidobius kamerunicus that visited male inflorescenceon each day of anthesis

S/V	DF	EK-D1P	EK-D2P	EK-D3P	EK-D4P	EK-D5P	EK-D6P	NS/MF	SPL (cm)	PA/EK (ha)
Replications (R)	3	695.97^{ns}	11792.13^{ns}	75441.66^{ns}	27469.21^{ns}	511.10^{ns}	31.37^{ns}	54.60^{ns}	0.15^{ns}	14936072.00^{ns}
Progenies (G)	23	2528.43**	60.829.65**	278671.88**	60630.07**	13733.42**	142.67**	431.97**	2.02**	180054129.00**
Error (e)	60	553.59	11492.55	49782.38	18400.32	4068.64	48.30	34.98	0.33	20700947
Variance Component										
σ^2_g		517.32	12932.90	59754.70	11263.10	2682.3	26.33	107.4	0.47	40800545.00
		(48.58) $^+$	(53.16)	(54.77)	(38.03)	(40.86)	(35.74)	(75.52)	(58.86)	(66.76)
σ^2_e		547.51	11395.50	49353.60	18353.30	3882.20	47.33	34.82	0.33	20314477.00
		(51.42)	(46.84)	(45.23)	(61.97)	(59.14)	(64.26)	(24.48)	(41.14)	(33.24)
σ^2_{ph}		1064.83	24328.40	109108.30	29616.40	6564.50	73.66	142.22	0.79	61115022.00
Mean		149.80	917.87	1853.66	1058.24	476.59	11.21	137.51	10.96	36830.14
SE		3.53	16.84	35.85	18.50	8.67	0.92	1.29	0.09	851.68

Notes: S/V = source of variation, DF = degree of freedom, EK-D1P = *Elaeidobius kamerunicus*day-1 population force per inflorescence (palm^{-1}day^{-1}), EK-D2P = *Elaeidobius kamerunicus*day-2 population force per inflorescence (palm^{-1}day^{-1}), EK-D3P = *Elaeidobius kamerunicus*day-3 population force per inflorescence (palm^{-1}day^{-1}), EK-D4P = *Elaeidobius kamerunicus*day-4 population force per inflorescence (palm^{-1}day^{-1}), EK-D5P = *Elaeidobicus kamerunicus*day-5 population force per inflorescence (palm^{-1}day^{-1}), EK-D6P = *Elaeidobius kamerunicus*day-6 population force per inflorescence (palm^{-1}day^{-1}), NS/MF = number of spikelet per male inflorescence (palm^{-1} yr^{-1}), SPL = spikelet length (cmpalm^{-1}yr^{-1}), PA/EK =population abundance of *Elaeidobius kamerunicus* (ha),ns = non-significant $P > 0.05$, ** = highly Significant at $P< 0.01$, ()$^+$ = phenotypic variance in percentage, σ^2_g = genotypic variance, σ^2_e = error variance, σ^2_{ph} = phenotypic variance, SE = standard error

Table 2. The mean population abundance and standard error (±) of Elaeidobius kamerunicus per progeny that emerged on male inflorescence on each anthesis day, number of spikelets, and spikelet length

F/code	EK-D1P	EK-D2P	EK-D3P	EK-D4P	EK-D5P	EK-D6P
ECPHP415	134.88^{bc} ± 21.33	997.02^{a-d} ± 73.83	2182.00^{a-c} ± 209.21	1061.03^{a-c} ± 109.14	470.73^{a-c} ± 29.64	16.61^{ab} ± 5.62
ECPHP500	157.94^{bc} ± 4.29	1171.35^{a} ± 44.98	2367.94^{a} ± 140.74	1257.35^{ab} ± 116.87	544.69^{ab} ± 34.87	9.04^{b} ± 4.51
ECPHP550	230.96^{a} ± 18.07	1154.75^{ab} ± 68.02	2321.70^{ab} ± 142.45	1281.30^{a} ± 66.35	595.30^{a} ± 33.52	29.71^{a} ± 3.60
ECPHP618	141.81^{bc} ± 10.07	945.13^{a-d} ± 82.85	1792.80^{a-e} ± 131.12	1048.62^{a-c} ± 80.33	478.25a-c ± 25.38	10.13^{ab} ± 4.11
PK4118	160.81^{bc}± 16.28	1112.67^{a-c} ± 75.00	2175.70^{a-d} ± 103.54	1208.03^{ab} ± 32.55	529.58^{ab} ± 16.39	13.53^{ab} ± 3.38
PK4465	155.44^{bc} ± 3.21	930.32^{a-d} ± 39.67	1839.96^{a-d} ± 85.29	964.40^{a-c} ± 38.69	420.84^{a-c} ± 18.25	16.52^{ab} ± 3.77
PK4474	157.75^{bc} ± 19.47	990.56^{a-d} ± 18.08	2044.51^{a-d} ± 41.35	1144.59^{ab} ± 88.25	534.04^{ab} ± 63.01	7.49^{b} ± 3.06
PK4482	133.02^{bc} ± 6.02	848.73^{b-e} ± 63.87	1842.30^{a-d} ± 154.14	934.36^{a-c} ± 144.16	422.68^{a-c} ± 50.54	2.00^{b} ± 0.07
PK4504	154.56^{bc} ± 13.42	908.24^{a-e} ± 64.27	1879.30^{a-d} ± 111.62	1117.39^{ab} ± 73.48	556.37^{ab} ± 19.61	21.29^{ab} ± 2.07
PK4505	147.97^{bc} ± 3.83	919.46^{a-e} ± 34.64	1897.90^{a-d} ± 51.15	1122.22^{ab} ± 68.15	495.24^{a-b} ± 31.21	13.64^{ab} ± 6.97
PK4529	124.07^{bc} ± 8.41	771.22^{de} ± 26.22	1625.00^{c-e} ± 85.51	1014.43^{b-c} ± 37.24	485.46^{a-c} ± 19.11	9.15^{b} ± 2.47
PK4535	138.64^{bc} ± 7.57	845.61^{b-e} ± 51.74	1713.30^{b-e} ± 92.99	1017.90^{a-c} ± 79.16	457.55^{a-c} ± 31.44	11.37^{ab} ± 3.66
PK4539	129.38^{bc} ± 4.93	777.33^{de} ± 20.62	1533.70^{de} ± 65.21	933.03^{a-c} ± 31.96	420.03^{a-c} ± 19.94	8.03^{b} ± 5.23
PK4540	122.45^{bc} ± 8.32	824.01^{c-e} ± 23.41	1693.70^{b-e} ± 45.41	1014.54^{a-c} ± 50.04	493.78^{a-c} ± 53.23	5.50^{b} ± 2.90
PK4548	133.48^{bc} ± 8.12	777.94^{de} ± 15.83	1589.37^{c-e} ± 59.63	884.91^{bc} ± 38.33	402.20^{bc} ± 11.51	8.56^{b} ± 2.57
PK4550	166.81^{ab} ± 12.18	920.44^{a-e} ± 36.25	1872.72^{a-d} ± 143.49	1080.30^{a-c} ± 86.72	482.90^{a-c} ± 41.32	8.38^{b} ± 2.26
PK4570	141.68^{bc} ± 15.81	840.52^{c-e} ± 44.48	1674.10^{c-e} ± 33.81	944.89^{a-c} ± 36.69	435.60^{a-c} ± 30.35	3.95^{b} ± 0.48
PK4591	159.28^{bc} ± 9.55	873.07^{a-e} ± 53.03	1752.80^{a-e} ± 63.74	1068.33^{a-e} ± 24.21	438.16^{a-c} ± 37.75	2.24^{b} ± 1.33
PK4621	94.25^{c} ± 6.05	619.78^{e} ± 51.69	1175.70^{e} ± 82.75	719.98^{c} ± 44.86	309.59^{c} ± 9.61	6.84^{b} ± 1.32
PK4648	182.63^{ab} ± 14.18	1003.35^{a-d} ± 70.8	2138.20^{a-d} ± 202.93	1224.31^{ab} ± 93.82	539.97^{ab} ± 47.53	17.89^{ab} ± 4.57
PK4651	146.70^{bc} ± 4.41	954.28^{a-d} ± 42.70	1968.80^{a-d} ± 98.81	1101.96^{a-c} ± 71.70	488.58^{a-c} ± 24.13	6.53^{b} ± 1.69
PK4674	152.11^{bc} ± 5.81	942.02^{a-d} ± 167.14	1835.37^{a-d} ± 270.09	1050.51^{a-c}± 131.34	422.67^{a-c} ± 22.34	9.37^{b} ± 1.45
PK4679	151.56^{bc} ± 12.13	956.46^{a-d} ± 30.34	1824.87^{a-d} ± 51.62	1101.50^{a-c} ± 18.36	474.75^{a-c} ± 17.18	12.83^{ab} ± 2.91
PK4841	170.96^{ab} ± 16.70	897.57^{a-e} ± 72.22	1695.56^{b-e} ± 115.52	1008.67^{b-c} ± 72.93	462.12^{a-c} ± 39.84	10.93^{ab} ± 4.09
Mean ± SE	149.80 ± 3.53	917.87 ± 16.84	1853.66 ± 35.85	1058.24 ± 18.50	476.59 ± 8.67	11.21 ± 0.92

Notes: F/code = family code,*Elaeis guineensis* crossing program Hulu Paka, PK = Porim Kluang, EK-D1P = *Elaeidobius kamerunicus*day-1 population force per inflorescence ($palm^{-1}day^{-1}$), EK-D2P = *Elaeidobius kamerunicus*day-2 population force per inflorescence ($palm^{-1}day^{-1}$), EK-D3P = *Elaeidobius kamerunicus*day-3 population force per inflorescence ($palm^{-1}day^{-1}$), EK-D4P = *Elaeidobius kamerunicus*day-4 population force per inflorescence ($palm^{-1}day^{-1}$), EK-D5P = *Elaeidobicus kamerunicus*day-5 population force per inflorescence ($palm^{-1}day^{-1}$), EK-D6P = *Elaeidobius kamerunicus*day-6 population force per inflorescence ($palm^{-1}day^{-1}$), Stderr = standard error, Tukey's Studentized Range (HSD) = honestly significant difference Test at $P< 0.05$,

Tukey's Studentized Range Test at ($P < 0.05$) determined that the population abundance of *E. kamerunicus* on anthesizing male inflorescence among the D×P progenies was significantly different on each phase of anthesis (Table 2). On the first day of anthesis, fewer weevils were found on the male inflorescence across the progenies with a trial mean of 149.80 ± 3.53 weevils per inflorescence. The weevil population on Day-1 ranged from 94.25 ± 6.05 to 230.96± 18.07 weevils per inflorescence, whereas, the highest was recorded in ECPHP550 and PK4621 had the least population. Based on a 50% opening of the florets with an increase in its odour, the population of the weevil on male inflorescence increased on the second day of anthesis with a trial mean of 917.87 ± 16.84 weevils.

Among the progenies in the present study. the second-day population ranged from 619.78± 51.69 to 1171.35± 44.98 weevils per inflorescence and the least was recorded in PK4621. The highest weevil population for Day-2 of anthesis was found in ECPHP500 and ECPHP550 at 1171.35 ± 44.98 and 1154.75 ± 68.02 weevils per inflorescence, respectively. On the alter stage (Day-3) of anthesis when all the florets opened, the weevil population increased and had a maximum trial mean value of 1853.66 ± 35.85 weevils. Syed (1982), Ponnamma (1999) and Yue et al. (2015) reported that on the male inflorescence flowers, the *E. kamerunicus* were higher in their population on Day-3 of anthesis. Therefore, more comprehensive observations were carried out in this current study and the results obtained were similar to those of former researchers' findings. It was observed that ECPHP500 recorded the highest weevils per inflorescence on Day-3 followed by ECPHP550 and PK4621 which continued to have the least population (Table 2).There was a progressive declined in the EK population on the fourth and fifth days in all the families. There were very few non-EK found on the sixth day of anthesis. This rise-and-fall trend in EK population abundance occurred across the families.

Experimental results on means for Day-1 to Day-3 per inflorescence showed that the EK population abundance was highly significant when correlated with EK Day-1 population force (EK-D1P), EK-D2P and EK-D3P with the correlation coefficient of r = 0.68, df = 3, 23, $P < 0.0001$; r = 0.97, df = 3, 23, $P < 0.0001$ and r = 0.99, df = 3, 23, $P < 0.0001$, respectively. Accordingly, any positive increase in NS/MF and SPL triggered an increase in EK population abundance per inflorescence. Understanding the interactions between the pollinator and its host provides an important benefit for management strategy and conservation of the weevils in palm plantations (Li et al., 2019). Thus, progenies with the characters such as producing huge and lengthy spikelets could be selected for future oil palm breeding programs.

The number of spikelets per male inflorescence (NS/MF) and spikelet length (SPL) and EK population abundance per ha. are presented in Figure 1.

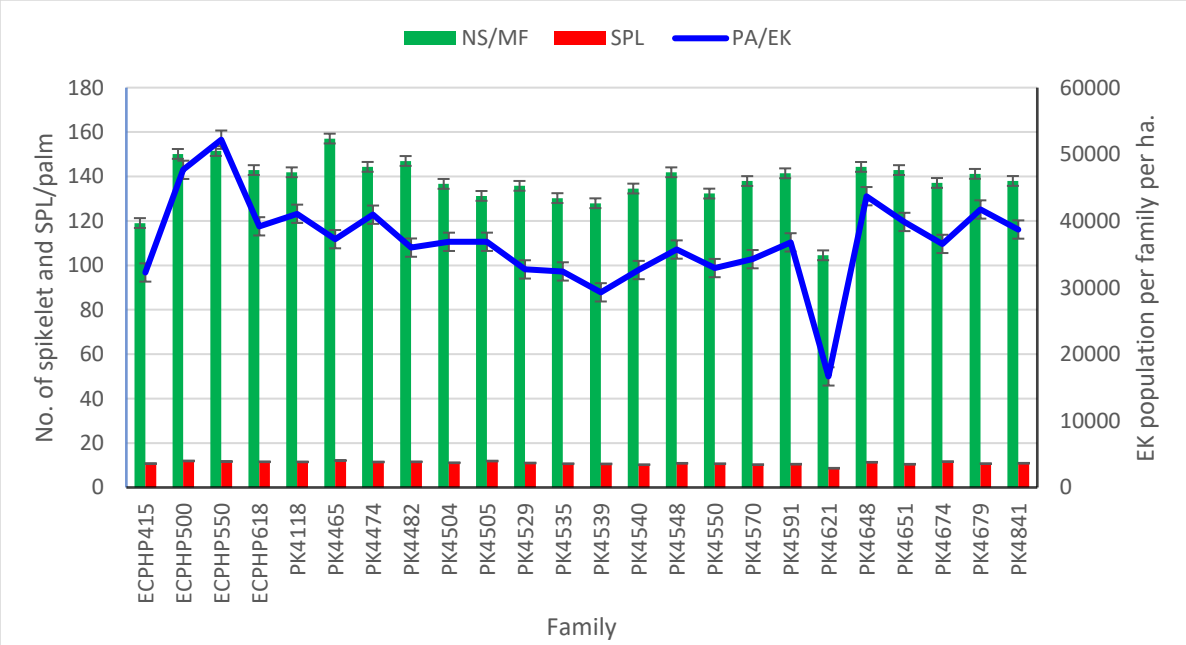

Fig. 1. Population abundance of Elaeidobius kamerunicus (PA/EK) per ha in biparental D×P families, number of spikelets per male inflorescence (NS/NF) and spikelet length (SPL)

Tukey's test (P= 0.05) showed that the number of spikelets per male inflorescence (NS/MF) 58.33% or 14 out of 24 progenies was above the trial mean value of 137.51 ± 1.29spikelets. Among the families, NS/MF ranged from 104.52 ± 1.06 to 157.07 ± 3.46 spikelets and family PK4465 had the highest quantity of spikelets per male inflorescence followed by families ECPHP550 (151.47 ± 2.81) and ECPHP500 (150.16 ± 2.46), with the least in family PK4621 (Fig. 1).The results obtained in the present study noted that all the families were within the range reported by Jacquemard and Baudouin (1998) that the male inflorescence was made up of 100-300 spikelets. The population abundance of the EK on individual progenies on anthesizing male inflorescence was based on the NS/MF coupled with the strong odour produced. Therefore, D×P families with these outstanding attributes could be used to develop future elite families.

A significant difference was found among the families for spikelet length (SPL cm) and 50% of the families were above the trial mean of 10.96 ± 0.09 cm. family PK4465 had the highest length at 12.14 ± 0.27 cm and the shortest SPL was found in family PK4621 at 8.65 ± 0.06 cm. However, findings in the present study were contrary to what was reported by Jacquemard and Baudouin (1998), that male inflorescences bore several cylinder-shaped spikelets of length 15 to 25 cm. The difference could be due to the genetic nature of the planting materials, location, and climate. Hence, SPL was found to be positively associated with EK-D1P (r = 0.39, df = 3, 23, $P < 0.0002$), EK-D2P (r = 0.49, df = 3, 23, $P < 0.0001$) and EK-D3P (r = 0.46, df = 3, 23, $P < 0.0001$). These experimental findings indicated that positive growth in SPL hastened the increase in the number of EK per anthesizing male inflorescence from Day-1 to Day-3.

In cultivated oil palm plantations, *E. kamerunicus* is the most dominant flower-visiting insect (Rizali, et al., 2019). The abundance of the population of EK per hectare in the present study had a trial mean of 36830.14 ± 851.68 and 50% of the families were above the trial mean. The mean population abundance of EK per hectare ranged from 16665.77 ± 786.86 to 52189.64± 2736.32 weevils per ha. Among the family, ECPHK550 recorded the highest population abundance of EK followed by ECPHP500 (47664.84 ± 3595.21), while the least was found in PK4621 (Fig.1). The study revealed that an increase in EK population abundance per ha occurred as a result of an increase in the production of male inflorescences at anthesis. The NMF/A showed positive and highly significant relationship with PA/EK (r = 0.81, df = 3, 23, $P < 0.0001$). A positive increase in the number of male inflorescences propelled anincrease in PA/EK.The observation was in agreement with Fatihah et al. (2019), who cited that the number of anthesizing male inflorescence increased the population of EK per ha. Similarly, Dhileepan (1994) supported that the abundance of EK strongly hinged on the male inflorescence availability.

The *E. kamerunicus* population abundance per ha recorded in Trial 0.502, for all the 11 years old D×P families indicated that there was a satisfactory number of *E. kamerunicus* to pollinate the entire female inflorescences produced, for the achievement of high fruit set (>60%). Dhileepan (1994) earlier reported that in India, to achieve a 60% fruit set, only 7,000 *E. kamerunicus* were needed. Donough et al. (1996) reported that 20,000 to 80,000 EK population per ha was needed to achieve 55% of the oil palm fruit set. Basri and Norman (1997) reported that a very low quantity of EK at 4,711 EK per ha could achieve an oil palm fruit set of more than 60%. There were conflicting statements made by earlier researchers regarding the population of EK needed per ha in achieving a good fruit set. Latip et al. (2018) reported that the lowest and highest number of EK per ha in D×P oil palm plantation was 6,435 and 83,676 weevils, respectively.

For oil palm clonal materials, the lowest and highest EK population abundance required was 9,318 and 141,431 weevil per ha respectively (Latip et al., 2018). When compared to those reported by Latip et al. (2018), it was evident that there was a decline in population abundance of EK per ha. These may perhaps be due to differences in the physiology of the hybridized D×P materials. Nevertheless, the population abundance of EK per hectare (PA/EK ha) was positively related and highly significant with NS/MF, SPL, EK-D1P, EK-D2P, EK-D3P, and population force were r = 0.80, df = 3, 23; $P < 0.0001$; r = 0.69, df = 3, 23, $P < 0.0001$; r = 0.63, df = 3, 23, $P < 0.0001$; r = 0.78, df = 3, 23, $P < 0.0001$; r = 0.73, df = 3, 23, $P < 0.0001$, and r = 0.91, df = 3, 23, $P < 0.0001$, respectively. The correlation outcomes indicated that any optimistic increase in NS/MF, SPL, EK-D1P, EK-D2P, EK-D3P, and population force would cause an increase in population abundance of *E. kamerunicus*per ha.

3.2. Relationship between Elaeidobius kamerunicus and oil palm traits on dura and pisifera biparental families

The outcome of the regression analysis for each response variable against the independent variable (PF/EK) is presented in Table 3. In assuming the fit of the regression model, the Adjusted (Adj) R-Square and R-Square are used and they are considered to be two statistics, and values near to one exhibited a better fit (Ngo et al., 2012). Nevertheless, the parameter estimates contained the intercept (β_0), slope (β_1), t-statistics

including their corresponding p-values for each regression as to whether each of the parameters is significantly different from zero (Table 3). However, the *P*-values for each regression indicated that the intercept for each of the dependent variables (FTB, ABW, FF, ISR, and FSR) and the independent variable (PF/EK) was significant with the exception for ABW and FF where significant intercept was observed (Table 3).

In the overall model for Equation one, F-value was significant (F = 9.87, P < 0.05), indicating that a significant portion was explained by the model for the variation. The R-square for equation one was 0.31 indicating that PF/EK accounted for 31% of the variation in FTB. In the total model for Equation two, the F-value was significant (F=7.23, df = 1, df error = 22, P < 0.05) which implied that the realistic portion was elucidated by the model in terms of variation. Hence, the R-Square in twoequations of 0.25 showed that PF/EK was responsible for 25% of the variation in ABW.

Table 3. Analysis of variance and other parameters of regression analysis for the relationship between Elaeidobius kamerunicus and oil palm traits

1. **FTB**	Source	DF	SS	MS	F Value	Pr > F
	Model	1	11715	11715	9.87	0.0047
	Error	22	26099	1186.332		
	Total	23	37814			
		Root MSE	34.443	R-Square	0.3098	
		Dep. Mean	333.359	Adj R-Sq	0.2784	
		Coeff Var	10.332			
	Variable	DF	Para Estimate	Std Error	F Value	Pr > F
	Intercept	1	171.178	52.087	3.29	0.0034
	PF/EK	1	0.1668	0.053	3.14	0.0047
2. **ABW**	Source	DF	SS	MS	F Value	Pr > F
	Model	1	38.323	38.323	7.23	0.0134
	Error	22	116.556	5.298		
	Total	23	154.879			
		Root MSE	2.302	R-Square	0.2474	
		Dep. Mean	7.425	Adj R-Sq	0.2132	
		Coeff Var	31.000			
	Variable	DF	Para Estimate	Std Error	F Value	Pr > F
	Intercept	1	-1.851	3.481	-0.53	0.6002
	PF/EK	1	0.010	0.004	2.69	0.0134
3. **FF**	Source	DF	SS	MS	F Value	Pr > F
	Model	1	15153	15153	12.86	0.0016
	Error	22	25913	1177.844		
	Total	23	41066			
		Root MSE	34.320	R-Square	0.369	
		Dep. Mean	169.162	Adj R-Sq	0.340	
		Coeff Var	20.288			
	Source	DF	SS	MS	F Value	Pr > F
	Intercept	1	-15.290	51.900	-0.29	0.7711

	PF/EK	1	0.190	0.053	3.59	0.0016
4. **ISR**	Source	DF	SS	MS	F Value	Pr > F
	Model	1	190.757	190.757	7.71	0.0110
	Error	22	544.624	24.756		
	Total	23	735.381			
		Root MSE	4.976	R-Square	0.259	
		Dep, Mean	83.724	Adj R-Sq	0.226	
		Coeff Var	5.943			
	Source	DF	SS	MS	F Value	Pr > F
	Intercept	1	104.419	7.524	13.88	<.0001
	PF/EK	1	-0.021	0.008	-2.78	0.0110
5. **FSR**	Source	DF	SS	MS	F Value	Pr > F
	Model	1	389.538	389.538	10.62	0.0036
	Error	22	807.264	36.694		
	Total	23	1196.802			
		Root MSE	6.05754	R-Square	0.326	
		Dep Mean	49.96625	Adj R-Sq	0.295	
		Coeff Var	12.12327			
	Source	DF	SS	MS	F Value	Pr > F
	Intercept	1	20.392	9.161	2.23	0.0366
	PF/EK	1	0.030	0.009	3.26	0.0036

Note: DF = degree of freedom, ISR = inflorescence sex ratio, FSR = fruit set ratio, PF/EK = population force of *Elaeidobius kamerunicus*, Adj R-sq = adjusted R-square, Coeff var = coefficient of variation, Dep. Mean = dependent variable mean, SS = sum of squares, MS = mean square, MSE = mean square error

Also, in the inclusive model for Equation three, its F-value was significant (F= 12.86, df error = 22, P < 0.001) indicating that a significant portion was likewise explained by the model for the variation. Therefore, the R-Square for FF in Equation three was 0.37 indicating that model for Equation five had a significant F-value (F= 10.62, df =1, df error = 22, P < 0.001), exhibiting that there was a significant portion of variation that was explained by the model in Equation five. It was observed that the R-Square for the 5th equation of 0.33 revealed that the population force of EK accounted for 33% of the total variation in the oil palm fruit set ratio.

The fitted model from the parameter-estimates from Models one to five were as follows:

1. $FTB = 171.178 + 0.167\ (\mathrm{PF/EK})$
2. $ABW = -1.851 + 0.010\ (\mathrm{PF/EK})$
3. $FF = -15.290 + 0.190\ (\mathrm{PF/EK})$
4. $ISR = 104.419 - 0.021\ (\mathrm{PF/EK})$
5. $FSR = 20.392 + 0.030\ (\mathrm{PF/EK})$

According to (Ngo *et al*., 2012), the Adj R-Square increases when the MSE decreases, hence, the smallest MSE or the largest Adj R-Square indicates the best fit for the model. Therefore, based on the Root MSE (Table 3), indicated the best fit for Models two, four, and five, whereas MSE of 34.44 and 34.32 was high in Models one and three, respectively, which did not best fit the models.

To determine the degree of the response variables as against the explanatory variables to which extent they are related, the Pearson's product correlation was used to determine their significance levels at $P \leq 0.05$ and $P \leq 0.01$, in which the correlation may well be positive or negative.Koo et al.'s (2016) estimation for determination of correlation coefficient was adopted, where $r < 0.5$ was estimated as weak correlation, $0.5 \leq r \leq 0.75$ was estimated as moderate, $0.75 \leq r \leq 0.9$ was estimated as strong and $0.9 < r = 1$ was estimated as a perfect relationship. The FTB, ABW, M, FF and FSR were positive and significantly correlated with PF/EK at (r = 0.56, F = 3.14, df = 1, df

error = 22, $P < 0.0047$), (r = 0.50, $F = 2.69$, df = 1, df error = 22, $P < 0.0134$), (r = 0.54, $F = 3.04$, df = 1, df error = 22, $P < 0.0061$), (r = 0.61, $F = 3.59$, df = 1, df error = 22, $P < 0.0016$) and (r =0.57, $F = 3.26$, df = 1, df error = 22, $P < 0.0036$), respectively.

The effective fruit development of the oil palm hangs on EK population abundance (Yousefi et al., 2020).The relationships of FTB, ABW, FF, and FSR with PF/EK, were found to be moderate. However, as the population of EK increased, FTB, ABW, FF, and FSR increased. Similarly, as the male flower production increased, the population force of the EK increased, vice versa. PCF had a weak negative and non-significant relationship with PF/EK (r = -0.15, $F = -0.71$, df = 1, df error = 22, $P > 0.4881$), indicating a decline in PCF when there was an increase in EK population force. Conversely, ISR had a moderate significant negative correlation with PF/EK at (r = -0.51,$F = -2.78$, df = 1, df error = 22, $P < 0.0110$). The ISR relationship with PF/EK implied that the higher the ISR, the lower the population force of the EK, which could diminish the fruit set ratio. In conclusion, based on the results obtained, it signified a decline in the population and efficiency of the EK and hence, the fruit set ratio was influenced by EK.

The efficiency of EK is believed to have declined in Malaysia oil palm plantations (Swaray et al, 2021; Prasetyo et al, 2014), especially the male EK (Swaray et al, 2021). The inefficiency of the *E. kamerunicus* was due to the declinein the male *E. kamerunicus* population. This result was supported byYousefi et al. (2020), who reported that in India and Malaysia, in both peat and mineral soil conditions, the male *E. kamerunicus* could carry more pollen.Norman et al. (2018) reported that for both male and female inflorescences including soil types, the pollen viability remainedinsignificant.The alteration in the favourable pattern of environmental factors as against the weevil population and efficiency could have contributed to the low fruit set formation.

Major palm oil exporters (Indonesia, Malaysia, and Thailand) worldwide were no exception to the fruit set problem. Kushairi et al. (2019), reported that the utmost challenging year with lower crude palm oil production, counting its prices and exports for the Malaysian oil palm industry was 2018. They reported that a 2.0% decline of crude palm oil to 19.52% million tons in 2018 was recorded as against 2017 of 19.91 million tons of crude palm oil. The decrease in fresh fruit bunch (FFB) yield could have occurred as a consequence of the fruit set gap which could have finally led to a decline in crude palm oil production. The fresh fruit bunch of oil palm could commence yielding at year five, however, between 8 to 18 years, the FFB peak yields were obtained (United States Department of Agriculture (USDA) 2019) and this can only be realized when the efficiency of the pollinator was high to attain substantial fruit set. Hence, the sustainability of the palm oil sector had been a prime focus and concern for Malaysia as a country (USDA 2019).

2.3. Relationship between pollinator weevil (Elaeidobius kamerunicus) and environmental factors on dura and pisifera families

There has been a continuous decline in the oil palm fruit set which has been reported by several researchers. Therefore, improved yielding genetic materials of oil palm that are robust to endure the threats of key pests and diseases could be vital in improving oil palm yield and for better economic returns during its production lifespan (Swaray et al., 2020). Also, due to restrictions in the rooting area, nutrient deficiency or toxicity, anaerobic conditions, and following poor growth and development, extreme soil moisture may be a limitation on crop production especially at the phase of the rainy season (Lahai et al., 2013; Johnson et al., 2017). Most researchers believed that the decline in fruit set was due to the low population of *E. kamerunicus*. The monthly trend, (taken between February 2019 to January 2020) between the most efficient oil palm pollinator weevil (*E. kamerunius*) and environmental factors [monthly precipitation/rainfall (MRF mm), monthly wind velocity (MWV km/hr), monthly sunshine hour/duration (MSH Wm^2), monthly evaporation rate (MER mm) and monthly average temperature (MAT ^oC)are shown in Fig.2.

The figure (Fig. 2) shows that the lowest and highest *E. kamerunicus* were recorded in August and September, and January, respectively. The highest MWV was recorded in May at 1,152.16 km/hr/month followed by March (1,143.50 km/hr/month), while February recorded the least at 753.20 km/hr/month. The lowest MSH was recorded in November (161.65 Wm^2) and March (255.10 Wm^2) recorded the highest followed by August at 231.12 hrs/decimals.

The highest MER (mm) was recorded in December (188.02 mm) with the least in November (85.80 mm). The MRF varied from 40.30 to 286.96 mm/month and it was observed that the lowest MRF was recorded in February, while the highest was recorded in December followed by November at 274.40 mm). The MAT varied from 27.10^{o}C to 30.78^{o}C and it was observed that the highest was recorded in January 2020, and the lowest in December 2019.

The illustration further shows that the highest PF/EK recorded in January could have been due to the environmental factors, such as the incidence of moderate

MSH, MWE, MRF, MER, and with a MAT of 28.48°C. However, the low EK population recorded in August and September 2019 could be due to very low rainfall, high wind velocity, high sunshine duration. The months with a decline in EK population and efficiency could be due to a combination of the genetic makeup of the progenies and some environmental factors in which wind velocity, sunshine duration, rainfall, including the growing medium were no exception. Yousefi et al. (2020) reported that the circumstances of change in climate with varying quantity in environmental factors and readiness of male inflorescence, influenced*E. kamerunicus's* performance in the loading of pollen and pollen viability. Planting materials, soil types, including other management practices could similarly affect weevil population and efficiency (Norman et al., 2018) thereby resulting in adecline in the oil palm fruit set.

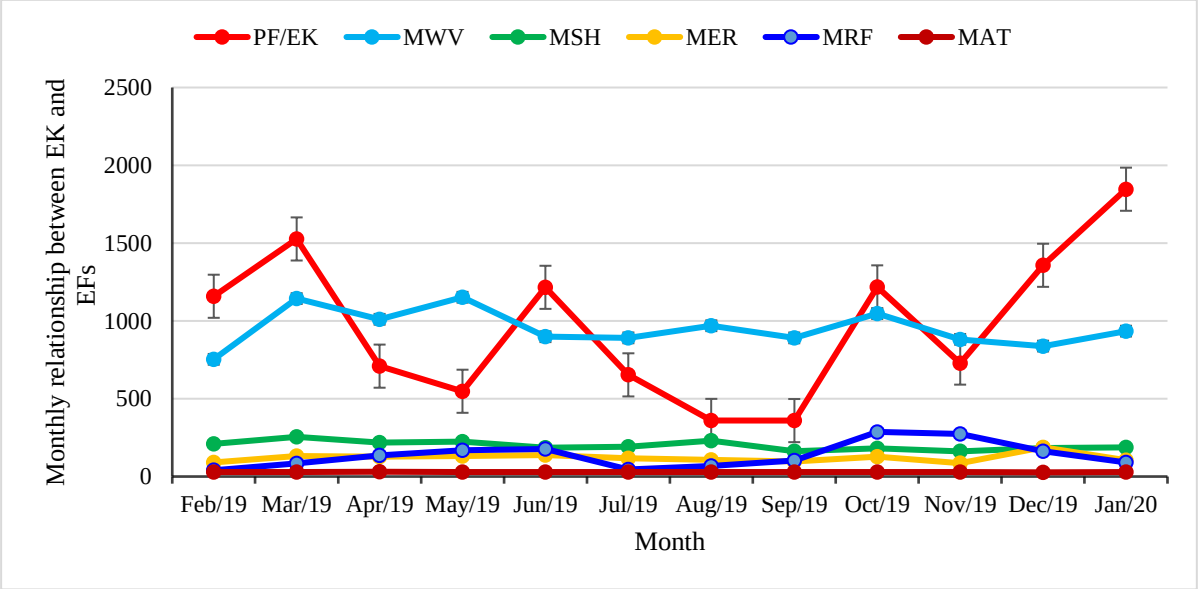

Fig. 2. Monthly relationship between Elaeidobius kamerunicus and environmental factors (precipitation, wind velocity, sunshine hour, evaporation, and temperature) on dura and pisifera genetic origins.

Note: (PF/EK) – monthly population force of *Elaeidobius kamerunicus*, (MRF) – monthly rainfall (mm), (MWV) – monthly wind velocity (km/hr), (MSH) – monthly sunshine hour/duration (Wm^2), (MER) – monthly evaporation rate (mm), (MT) – monthly temperature (°C).

IV. CONCLUSION

The analysis revealed that the genetic effect had a greater impact on the number of spikelets per male inflorescence, the length of the spikelet, and the population abundance of *Elaeidobius kamerunicus*. The highest population abundance of EK on anthesizing days was recorded on Day-3 and ECPHP500 was observed to record the highest weevils per inflorescence at 2367.94 ± 140.74 weevils on Day-3, followed by ECPHP550 at 2321.70 ± 142.45 weevils per inflorescence. However, on the fourth, fifth, and sixth days, a gradual decrease in population abundance of EK in all the progenies was noticed.A strong perfect relationship was established between Day-3 of anthesis with population abundance of EKper inflorescence of r = 0.99, $P < 0.0001$. The trial means and standard error of EK obtained from this study was 36830.14 ± 851.68 per ha with a range of 16,666.00 to 52,189.64 weevils per ha and ECPHP550 reported the highest population abundance of EKper ha. A decrease in the EK population was observed in Trial 0.502, but the productivity should have been able to hit above 60 percent of the fruit set despite the decline.

Also, the traits of the oil palm families and the population force of the *E. kamerunicus*were not significantly correlated, but fruit to bunch and fruit set was positively and significantly correlated. The relationship between the weevil and the oil palm traits indicated that Models two, four, and five had the best fit models among others. In general, the pollinator's effectiveness of this present study was low, based on the performance of the oil palm traits, as a result of population decline and its poor performance in pollination activities. It was further noticed that moderate rainfall and temperature will increase the weevil population and efficiency. However, to introduce additional pollinators into the existing oil palm plantations to overhaul the efficiency of EK is not required, but the

factors that influence the population and the effectiveness of EK should be highly considered.

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Authors contributions: MDA, MRY, S.J,MFI, MM, and SS developed the concept; SS carried out the research, SS,MM, OY, BSH, FT, and MJ, analysed the data; SS,wrote the draft of the manuscript; MDA, MRY, SJ,MFI, MM, BSH, FT, OY, UMG, and M.Jvalidation; MRY,OY, BSH, FT, UMG, and MJ, reviewed the final manuscript; MDA, MRY, SJ,MFI, FT, UMG,MJ, and MM, provided extensive guidance on the implementation of the research;All authors contributed and approved the published version of the manuscript.

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Data Availability: Datasets used and analysed throughout the existing study are encompassed in this article.

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Floristic diversity and carbon stock in the Agrosystem of *Persea americana* Mill (Lauraceae) in the high Guinean savannahs of the Adamawa Cameroon

D. Dongock Nguemo[1], M.S. Mandou Moucharou[2], Fawa Guidawa[1*], B. Dagavounanssou[1], P.M. Mapongmetsem[1]

[1]Department of Biological Sciences, Faculty of Science, University of Ngaoundéré.
[2]Department of Crop Science, Faculty of Agronomy and Agricultural Sciences (FAAS), University of Dschang.
Corresponding author: E-mail: fawaguidawa@gmail.com, PO Box: 454 Ngaoundéré Cameroon.

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Abstract— *The knowledge on the floristic diversity of Persea americana agrosystem and their contribution to carbon stock was evaluated in the high-Guinean savannahs of Adamawa Cameroon. Three sites of different ages were identified according to the age of plantation. The savannah zone was chosen as the witness treatment. Sampling was done along five transects of 20 x 100m² installed in each site giving a total of 20 transects. An inventory of shrubs with dbh ≥ 5 cm was carried out. The average estimates aboveground and belowground carbon stock in shrub biomass was calculated using the algometric equation. A total of 3296 individuals from 30 families, 53 genus and 61 species were counted. Comparative analysis was carried out to show that abundance, Shannon index and land area were significantly different in the different plots. Contrarily, Piélou equitability and ecology importance index do not vary much between pear trees and savannah. The total carbon stocks were estimated at 4.57t/ha (savannah) to 18.76 t/ha (others sites). Carbon sequestration ecological service value in the agrosystems was estimated to be more than 7126.6 dollars/ha with a liberation potential of about 712.66±2.11 tCO_2/ha. These data show the capacity of the agrosystem of Persea americana to sequestrate more carbon compared to savannah vegetation that is subjected to constant disturbance by anthropic activities. Ecological services related to carbon can be an opportunity for financial benefits if the credits from the development of mechanism improves incomes of rural populations who contribute in the management and the conservation of the ecosystem.*

Keywords— ***Floristic composition, agrosystem, Persea americana, carbon stock, Adamawa Cameroon.***

I. INTRODUCTION

Multistorey farming systems add considerable interspecific interaction, especially competition, to whatever existing intraspecific competition for water, nutrients, light, and CO_2, thereby creating a more complex agroecosystem (Rao *et al.*, 1999). Agroforestry is recognized as an integrated applied science that has the potential for addressing many of the land-management and environmental problems found in both developing and industrialized nations. From the 18th century, with the start of industrialization, there is an increasing rate of greenhouse gases in the lower atmosphere, causing the higher temperature on the earth. (Frederic, 2015). This alarming rate has brought about climate change, causing enormous irreversible damages to the environment and human society. The consequence linked to climatic variation include among others: rapid regression of ice caps, (3 million of km² from 1975 to 2010), polar cold waves, silting and eutrophication of the lake Chad (Volume ten times less than it was 40 years ago) accentuated inundation of terrestrial ecosystem during

heavy rains and many others (GIEC, 2014). Anthropics activities, the effect of industrial agriculture and energy supply contributes significantly to the pollution of the Earth and therefore constitute the main causes of the emission of greenhouse gases. (GIEC, 2007). Thus, the effective and economic engagement toward the reduction of greenhouse gases, carbon sequestration and stocking in order to avoid temperature increase of 4ºC or more by 2100 should be noted (Frederick, 2015).

The Cameroonian law of 1994 on forest, fauna and fishing provides a political and strategic framework on the conservation of biodiversity and sustainable management. Which it is articulated around points like sustainable management of forest, contribution to economic growth, participative management and the reinforcement of the public sector on essential functions (Fondemba, 2010). Therefore, it is important and necessary to know the carbon sequestration potentials of agroforestry systems which specifically offers goods and services (food, medicine, cosmetics, fuel and construction wood) to local populations. In Cameroon research has focused mainly on floristic diversity and carbon stock in parks and agroforestry systems (Frieden *et al.*, 2005; Peltier *et al.*, 2007; Mapongmetsem *et al.*, 2011; Zapfack *et al.*,2013 ; 2016; Noiha *et al.*, 2015 ; 2017).These works generally concerned only the agrosystem of forest zone. However, the savannah zones already weakened by climate change, abound with a fairly large flora which would also contribute to the sequestration of a significant amount of CO_2 contained in the atmosphere. Promoting agroforestry is one option perceived as a major opportunity to deal with problems related to land-use and CO_2-induced global warming. In this paper agroforestry is defined as any land-use system that involves the deliberate retention, introduction or mixture of trees or other woody perennials with agricultural crops, pastures and/or livestock to exploit the ecological and economic interactions of the different components (Albrecht and Kandji, 2003). The interest of this present study is to evaluate the biodiversity and carbon stock in agrosystem of *Persea americana* (ASPA) in Adamawa region for a greater importance to given to its conservation and sustainable management.

II. MATERIAL and METHODS

Presentation of the study zone

The study is carried out in Cameroon in the Adamawa region, Vina division. This zone covers an area of 63701km^2 between 6º to 8º North latitude and 11º and 15º East longitude (Table1).

Table 1: Geographical coordinates and direction of the sampling bands of the sites.

Sites Altitude Geographic Coordinate Area Direction

Sites	Altitudes	Geographicscoordinates	Areas	Directions
Ngadamabanga	1114	07°N 21’ 838’’013°E 35’ 779’’	1 ha	North-South
Mardock	1090	07°N 20’ 971’’013°E 34’ 162’’	1 ha	South-North
Nord-CIFAN	1120	07°N 19’ 219’’013°E 36’ 559’’	1 ha	North/West-South/East
Savannah	1075	07°N 26’ 225’’013°E 32’ 998’’	1 ha	South-North

It is made up mainly of highlands that crosses and stretches from West to East between the Federal Republic of Nigeria and Central African Republic. The Adamawa with its latitudinal extent has an extremely diversified landscape, ecosystems, geomorphological and climatic zones divided into two main agro-ecological zones with specific physical characteristics (Tchotsoua, 2006). The Adamawa plateau has an average altitudes of 1100m. The relief is very contrasting and compartmented with a vast block of a raised bed rock. The climate is the tropical type characterised by a short dry season (November to April) and a long rainy season (April to November) with peaks in September. The average monthly temperature does not go above 34ºC. The annual average rainfall varies between 900mm to 1500mm (PAN-LCD, 2007). Some patches of ferruginous soils are found on slopes with steep gradient, they are essentially ferraltic formed from different old rocks that dominate in this region (Humbel, 1966). The P^H is between 4 and 5.5 (Danboya, 2011). Agriculture, bush fire, mining, the search for fuel wood are the main causes of soil degradation (Danboya, 2011; Hamadou, 2017). The rivers of the zone flow into the Niger river, lake Chad and Atlantic Ocean. The Biographic homogeneity found in this region correspond to Sudano-guineen Shrubs or trees of *Daniella Oliveri* and *Lophira lanleolata* (Letounzey, 1968). The Mboum were the oldest population in the zone before Fulbe invasion. They are found especially on the Ngaoundéré plateau whereas the Peul, Dii or Dourou and the G’baya who came often occupies the North and East of the plateau respectively. The other ethnic groups were migratory.

2.2 Data collection

The sites were choosing based on the age of plantation and the representability of *Persea americana* in the area. Three plots were retained: < 10 years; 10-20 years and < 20 years. The witness site had not undergone dense anthropogenic activities for at least one year. The distance between the three sites was about 4 km while the witness plot was far at 10 km from the plots < 10 and 10-20 years, and from 13km from the plot >20 years.

Transects of 100m x 20m were constructed in each site and each of these transects was separated from another by a distance of 20m (Fig. 1). The sampling bands were established with the aid of compass and GPS. The circumferences (5≤ circumferences ≤155) for trees was measured at 1.30m above the ground and at 0.30m for small trees with the decameter. At the end of each bands, milestones were fixed at an equidistance of 20m, all the wooded plants were systematically counted.

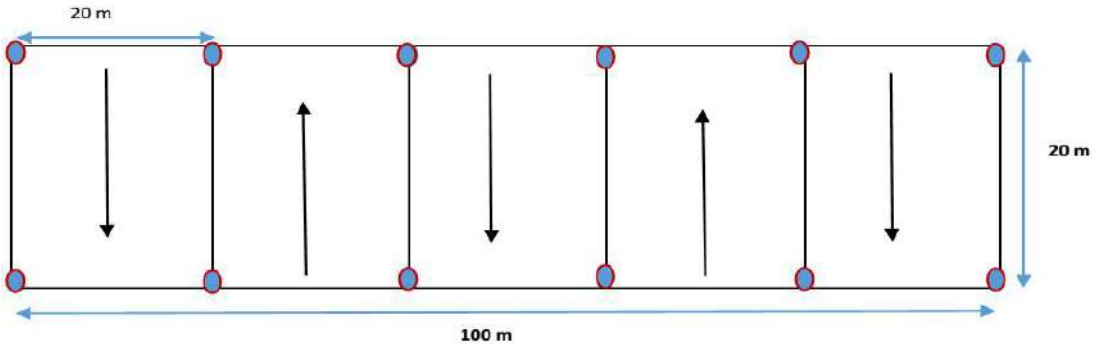

Fig.1: Plan of the device illustrating a sampling unit. (Legend: = milestones; → = sampling direction in 20 × 20 m² strips)

Floristic inventory

The dendrometric data concern only the dbh. The dbh obtained was divided into six classes of diameter:]0-10],]10-20],]20-30],]30-40],]40-50],]50-60]. The sampled trees were wounded on the bands delimited by the twins to avoid double counting. For the trees at the border of transect, they were taken into account those situated at the right in the direction of the transect.

The specific richness (S) was the total number of species from floristic inventory. The Relative abundance was calculated using the formula proposed by Doucet (2003): RA (%) = n/N×100

(RA= relative abundance; n= number of individual at the taxonomy level; N= total number of all the taxon considered).

The Shannon diversity index (ISH) was calculated using the Frontier and Pichod-viale (1991) method: ISH= -∑ (ni/N) Log_2(ni/N) (ni = numbers of the species, N= numbers of the total species).

The Piélou Equitability (EQ) according to Ngueguim *et al*. (2009) was calculated,

EQ = ISH/Log_2N ; N= number of species

The Sorensen Similitude Coefficient was calculated using the formula applied by Ngueguim *et al* (2009): K= (2c/a+b) x 100 (a= number of relieves 1, b= number of of relieves 2, c= number of species common in the two relieves).

Ecological importance index (IIE) $IIE = \left(\sum_{i=1}^{n} \frac{ni}{N} + \sum_{i=1}^{n} \frac{Si}{S}\right) x\ 100.$

(ni / N: relative frequency of individuals of a species; ni is the number of individuals of the species and N is the total number of individuals in the group. The Si / S ratio is the relative dominance of individuals for the species "i"; “Si” is the basal area of individuals of species i and S is the total basal area.

Diameter classes of species

The circumferences of all tree species are measured, the dbh obtained are divided into six classes of diameters. These allow to appreciate the behavior of the vegetation in general, and of the different dominant species in particular. The classes help to assess the dynamics of the formations studied. A distribution according to a decreasing exponential was a sign of ecological vigor.

Density and basal area

The density of a species was obtained by dividing the total number of individuals belonging to this species by the area of the sampling area (Jagoret *et al.*, 2011). This was the number of individuals per hectare. The following formula has been applied: D = n/S. (D: density (Trees/ha), n:

number of trees present on the surface considered and S: surface considered (ha)).

The basal area is the area of the cross section of a tree trunk. It is used to determine the relative importance of a species and is expressed by the following formula: $S = \pi (Di^2/4)$. It allows a better visualization of a forest ecosystem since it highlights the species and families that occupy the most space. It is a descriptor directly linked to the diameter and commonly used in forestry studies (Jagoret *et al.*, 2011). The basal area of the stand was: $S = \frac{\pi}{4} \sum_{i=1}^{n} d_i^2 = \frac{1}{4\pi} \sum_{i=1}^{n} C_i^2$(S: basal area (m²/ha), d: diameter (m), C: circumference (m)).

Carbon stock

The method used is the so called nondestructive method concerning the volumes of wood. It takes into account the diameters at breast height (dbh), it is less cumbersome to undertake and less expensive (Brown, 1997; Chave *et al.*, 2005).

Aboveground carbon

The Aboveground carbon (AGC) was evaluated by taking into account the diameters obtained during the floristic inventory, according to the allometric formula of Chave *et al.* (2005): AGB = α Exp [-1.499 + 2.148 * ln (dbh) + 0.207 * (ln (dbh)^2 - 0.0281* (ln (dbh))^3]. (AGB = aboveground biomass/kg, (dbh) = diameter (cm) above the ground; α = density). For species whose density has not been estimated, the value of the average specific density of wood for tropical forests: α = 0.58g/cm^3 was used. For the evaluation of specific densities of wood in all species, an online data item "Global Wood Density Data Base" was used (Zanne *et al.*, 2009).

From this biomass, the quantity of carbon (Kg/ha) was obtained by multiplying this biomass by a conversion factor equivalent to 0.47 (Zapfack *et al.*, 2013); then it is converted into tonnes of carbon per hectare (tC/ha).

Belowground carbon

After evaluating the biomass of the woody species surveyed, the allometric equation developed by Brown (1997) was necessary to deduce the belowground carbon (BGC), according to the following model: BGB = expo (-1, 0587 + 0, 8836 * ln (AGB)). (AGB and BGB in kg).

Total carbon of standing trees

The total biomass (TB/kg) of standing trees was estimated using the formula:

TB (kg) = AGB + BGB; then convert to t/ha (FAO, 1992) (AGB = aboveground biomass (kg); BGB = Belowground Biomass (kg))

Estimate of the ecological service

The ecological service was estimated by the 44/12 ratio corresponding to the CO_2/C ratio representing the molecular weight, used in this investigation to convert carbon stocks into the amount of CO_2 sequestered by the agrosystem. Subsequently, this quantity of CO_2 was evaluated in monetary value using the value of the ecological service estimated at 10 USA/t CO_2 (Kelley and Gallant, 2017).

Analysis of variance

A one-way ANOVA test is done using the XLstat (2017) and STATGRAPHICS plus 5.0 software to compare the quantitative data obtained in the different agroforestry systems.

III. RESULTS

Specific riches and taxonomies abundance

From the floristic inventory in the ASPA, a total of 2101 individuals were obtained, grouped into 24 species, 23 genus and 17 families. Taxonomic diversity varies with the age of the agrosystem (Table 2). The ASPA >20 age presents the highest diversity with 860 individual (28 species, 26 genus and 16 families), followed by the youngest (>10 years) with 689 individuals (23 species, 22 genus and 18 families). The witness site compared to ASPA presents a remarkable diversity with 1195 individual (36 species, 32 genus and 23 families). Six families dominate the floral of the plots and constitute 67.73% of the total number.

Table 2. Specifics richness and taxonomic abundance in the sites

Sites (years)	individuals	species	genus	famillies
< 10	689	22	22	18
10-20	552	23	22	18
> 20	860	28	26	16
Savannah	1195	36	32	23
Total	3296	61	53	30

The most represented families in terms of individuals were Lauraceae (33.07%), Myrtaceae (14.08%), Mimosaceae (7.97%), Sapindaceae (5.04 %), Anacardiaceae (3.85%) and Euphorbiaceae (3.72%). However, in the witness plot, 80.24% of individuals were represented by Hymenocardiaceae (34.47%), Caesalpiniaceae (21%), Combretaceae (9.37%), Annonaceae (7.03), Anacardiaceae (5.44 %) and Proteaceae (2.93%).

At the specific level, five species present a remarkable abundance in the undergrowth of the ASAP. These are *Persea americana*, *Psidium guajava*, *Citrus aurantifolia*, *Albizia zygia*, *Allophylus africanus*, which the cumulative total number represents 72.46% of the flora; while in the savannah, the densest species were *Hymenocardia acida*, *Daniellia oliveri*, *Piliostigma thonningii*, *Annona senegalensis* and *Terminalia laxiflora* with a relative density of 70.65%. The other species are poorly represented with 29.37% as a cumulative density.

Floristic diversity index

The floristic diversity index was summarized in the Table 3. The Shannon diversity index varies depending on the plots. It is significally high in witness plots (3.09) compare to ASPA (2.75, 2.54 and 2.31 respectively for the sites > 20 years, 10-20 years and < 10 years).It is showing a great diversity in the savannah compare to ASPA. The youngest sites (< 10 and 10-20 years) were lowest diversify. Concerning the floristic value, there was a great significant difference between those sites (P<5%).The individual plants were equally distributed within species in the ASPA and the savannah site (Piélou equitability is around 1 in all the sites).

Table 3. Diversity indexes in the sites.

Sites (Years)	Shannon index	Piélou equitability	Importance value (%)
< 10	2.54[a]	1[a]	200.11[a]
10-20	2.31[a]	1[a]	200.07[a]
> 20	2.76[a]	1[a]	200.02[a]
Savannah	3.09[b]	1[a]	200.22[b]

A total of 11 species have the highest importance value in the plots: *Persea americana* (113.46), *Hymenocardia acida* (38.89), *Psidium guajava* (24.48), *Citrus aurentifolia* (16.5), *Daniellia oliveri* (21.2), *Mangifera indica* (14.37), *Albizia zygia* (18.39), *Annona senegalensis* (8.85), *Terminalia laxiflora* (8.1), *Vernonia amygdalina* (7.97) and *Dacryodes edulis* (4.94). *Persea americana* is highly spread and predominates in the ASPA. The statistical analysis shows a significant difference between the ASPA and the whitness ($p > 0.05$) concerning the importance value.

The similitude coefficient varies from 60.09 in the site > 20 years to 68.33 in <10 years (Table 4). The similarity index are generally very high, not reflecting a significant difference between the plots of different ages. However, these four plots are more floristically similar, since they have floristic affinities between them greater than or equal to 60% which form the same plant community.

Table 4. Similitude coefficient in the sites.

Sites (Years)	**< 10**	**10-20**	**> 20**	**Savannah**
< 10	100			
10-20	66.66	100		
> 20	68.33	66.52	100	
Savannah	67.28	61.57	60.09	100

Diametric structure

The number of individuals by diameter reduces with the increase of diameter (Fig. 2). However, the plants with class diameter of the site <10 years were the most represented in all the sites and the witness plot. The general distribution of the plots studied presents a decreasing exponential form “L” with a high tendency in]0-10] and]30-40] classes. It is lowly represented in diameter between]40-50] and]50-60] and completely absent in the witness plot. This structure shows that the plots disposes many future individuals to assure the regeneration of forest species with many individuals of small diameter and few individuals of larges diameter.

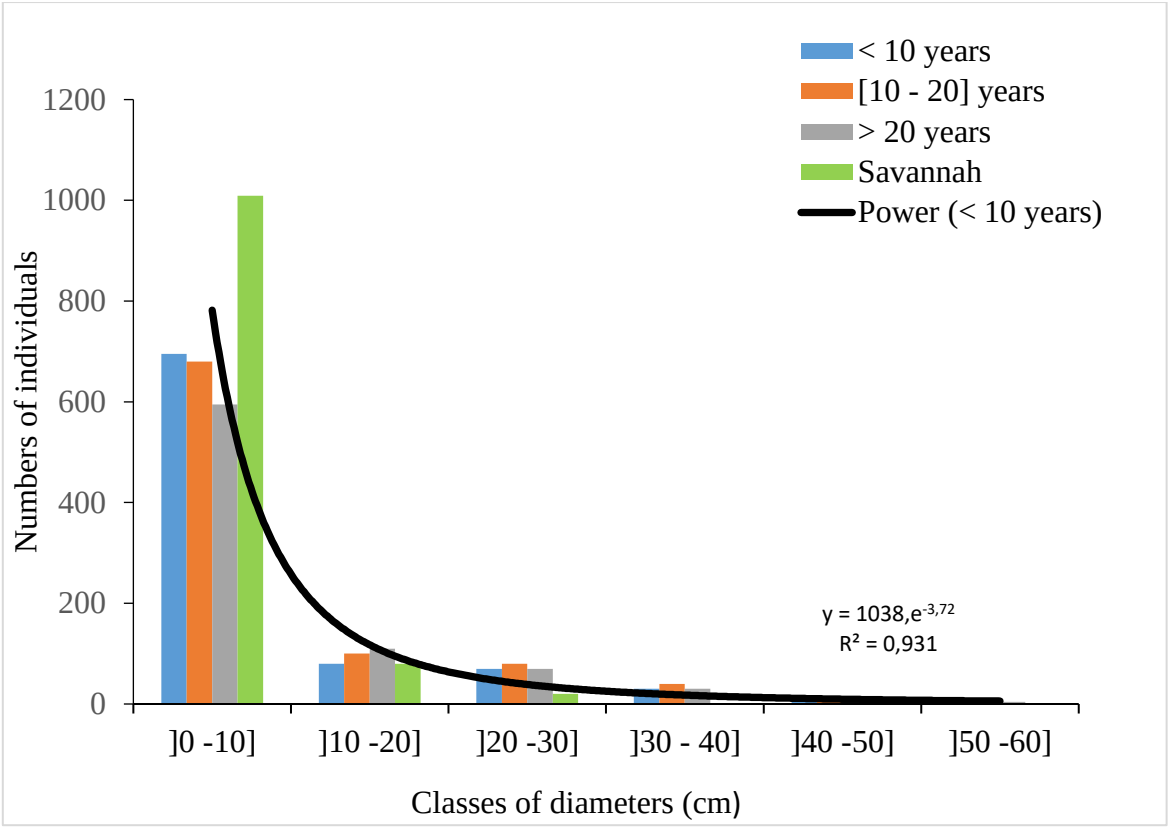

Fig.2: Distribution of individuals between the classes of diameters

Density

The density of species is highly significant between the witness site and the three ASPA ($F = 90.72$; $p = 0.00 < 0.05$) (Fig. 3). The value is maximum in the savannah with a significant rate of 1195±48.2 stems/ha. It gradually decreases by 860 in the plantations > 20 years, 689 stems/ha in that of < 10 years and to 552 in the sites of]10-20]. Six species are the most represented in the savannah with 910 inds/ha in the plots of > 20 years with 693 individuals, 588 individuals in that of < 10 years and finally 443 individuals for]10-20] years. Compared to the other plots, the control has the highest density. Of all these species, the highest value is for the witness site with *Hymenocardia acida* that has a density of 1246 inds/ha.

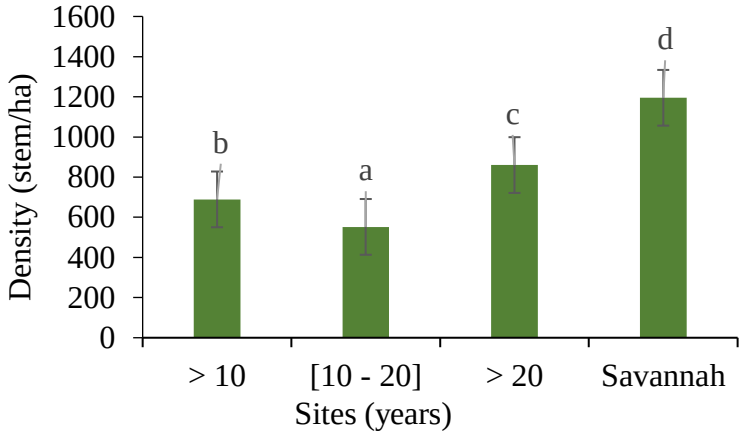

Fig.3: Variation in density between the different plots studied

(*Histograms with the same letters are not significantly different at the probability threshold of 0.05*).

Basal area

The basal area (Fig. 4) varies from 0.75 m²/ha for the savannah to 10.02 m²/ha for the site of site >20 years. The plots < 10 and]10-20] years has respectively the basal area of 0.32 and 5.36 m^2 /ha, this surface was maximum in the plot > 20 years (10.02±0.09 m^2 /ha). Statistical analysis shows that the basal area is highly significant between the savannah and the different ASPA studied (F = 92.89; p = 0.001 < 0.05). At the family level the basal area of the most represented six families was 0.66 m^2/ha in the savannah, 5.24 m^2/ha in the site <10 years, 7.07 m^2/ha in the site]10-20] years and 9.05 m^2/ha in the ASPA >20 years.

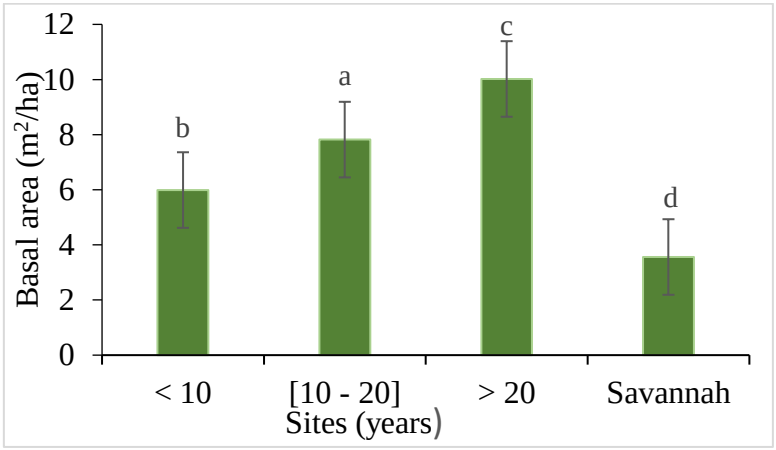

Fig.4: Variation of the basal area between the plots studied

(*Histograms with the same letters are not significantly different at the probability threshold of 0.05*).

Biomass and carbon stock

The largest AGB returns to the ASPA > 20 years with 59.31 tC/ha against 56.90 tC/ha for]10-20] and 15.98 Ct/ha for those < 10 years (Table 5). The savannah has a very low biomass with 2.93 tC/ha. There is a significant statistical difference for the aboveground carbon stocks between the different plots studied (F = 92.89; p = 0.001 < 0.05). The family with the highest amount of aboveground carbon stock was Lauraceae (31.87 tC/ha), followed by Anacardiaceae (2.55 tC/ha), Rutaceae (2.12 tC/ha) and Myrtaceae (0.55 tC/ha). The species with the highest amount of aboveground carbon stock was *Persea americana* (31.87 tC/ha), followed by *Mangifera indica* (2.56 tC/ha), *Citrus aurantifolia* (2.17 tC/ha), *Albizia zygia* (1.12 tC/ha). The others species stock are equal or than 4.29 tC/ha on average.

The ASPA > 20 years gives a highest BGB of 19.75 t/ha (Table 5), compared with 16.57 t/ha for that of]10-20], 2.78 t/ha for the plot of >10 years. The savannah reveals the lowest BGB (1.64 t/ha). The BGB seems to increase with the age of the area. Statistical analysis (p < 0.01) shows the significant difference between the belowground carbons stocks of the plots studied.

Table 5 : Carbon stocks and the economic value of ASPA (*AGB= Aboveground biomass, BGB= belowground biomass, QCO_2 = Quantity CO2*)

Sites (Years)	AGB (t/ha)	BGB (t/ha)	Stock (t/ha)	QCO_2 (t/ha)	EV (Dollars/ha)
< 10	15.98 ± 0.16[a]	2.78 ± 0.04[a]	17.76	28.49 ± 0.56 [b]	284.9
10 -20	56.09 ± 3.03[b]	16.57 ± 0.6[b]	75.47	287.99 ± 0.58 [a]	2879.9
> 20	59.31 ± 5.43[c]	19.75 ± 1.03[c]	83.06	304.82 ± 0.82 [d]	3048.2
Savannah	2.93 ± 0.03[d]	1.64 ± 0.01[d]	4.57	11.15 ± 0.17 [c]	913.6
Total	**128.12 ± 2.16**	**36.74 ± 0.42**	**180.86**	**712.66 ± 2.11**	**7126.6**

Values with the same letters are not significantly different in the column at the probability threshold of 0.05.

Carbon stock affected by diameter classes

The carbon stock varies depending of the diameter of trees and the age of the agrosystem (Fig. 5). In the ASPA > 10 years, carbon stock was highest in the diameter class of]20-30] cm and reduces slightly in the class of]30-40] cm but less represented in the other classes. In the plot with]10-20] cm of diameter, the quantity of carbon was very high in the diameter class]30-40] cm and]40-50] cm and low in the diameter class]0-10] cm. In the site >20 years, the sequestration of carbon is highly represented in three diameter classes]40-50],]30-40] and]20-30] with 25.03; 24.49 and 20.55 cm respectively, giving the total of 70.07 tC/ha. The small diameter classes store less carbon. The savannah generally was less represented in carbon stock. There is a significant difference in total carbon stocks between the different sites studied ($P < 0.01$). According to the result, it is convenient to note that carbon sequestration in different agrosystems is important in the large diameter classes whose evaluation depends significantly on dbh).

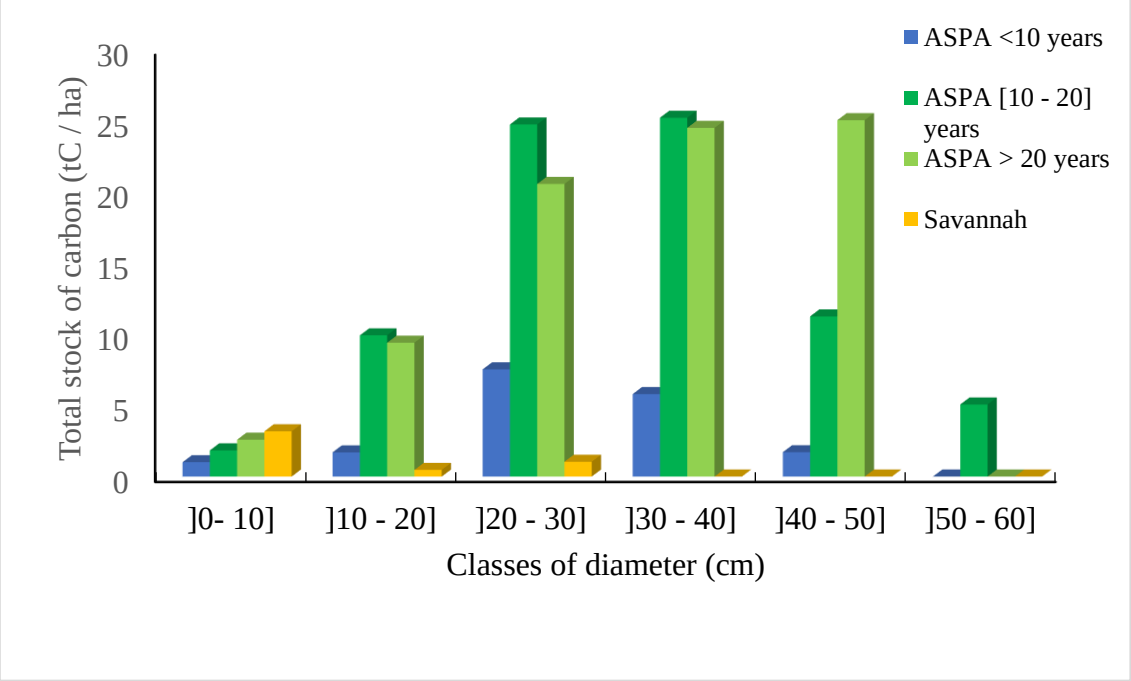

Fig.5: Stock of total carbon following classes of diameter in ASPA

Carbon stock in function of taxons

In ASPA, Lauraceae (53.32 tC/ha), Anacardiaceae (7.56 tC/ha), Rutaceae (3.6 tC/ha) and Myrtaceae (1.35 tC/ha) constitute the families which contributed significantly to the sequestration of total carbon. The families of the whitness site which contributed significally to the sequestered of total carbon were respectively Caesalpiniaceae (2.52 tC/ha), Hymenocardiaceae (0.82 tC/ha), Combretaceae (0.33 tC/ha) and Anacardiaceae (0.27 tC/ha) (Fig. 6). The species with the highest amount of total carbon stock was *Persea americana* with 53.32 tC/ha. It is followed by *Mangifera indica* (5.56 tC/ha), *Citrus aurantifolia* (3.6 tC/ha) and *Albizia zygia* (1.63 tC/ha). In contrast, the species with the highest amount of total carbon stock in the savannah is *Daniellia oliveri* (2.3 tC/ha), followed by *Hymenocardia acida* (0.75 tC/ha), *Piliostigma thonningii* (0.23 tC/ha) and *Terminalia laxiflora* (0.19 tC/ha) (Fig. 7).

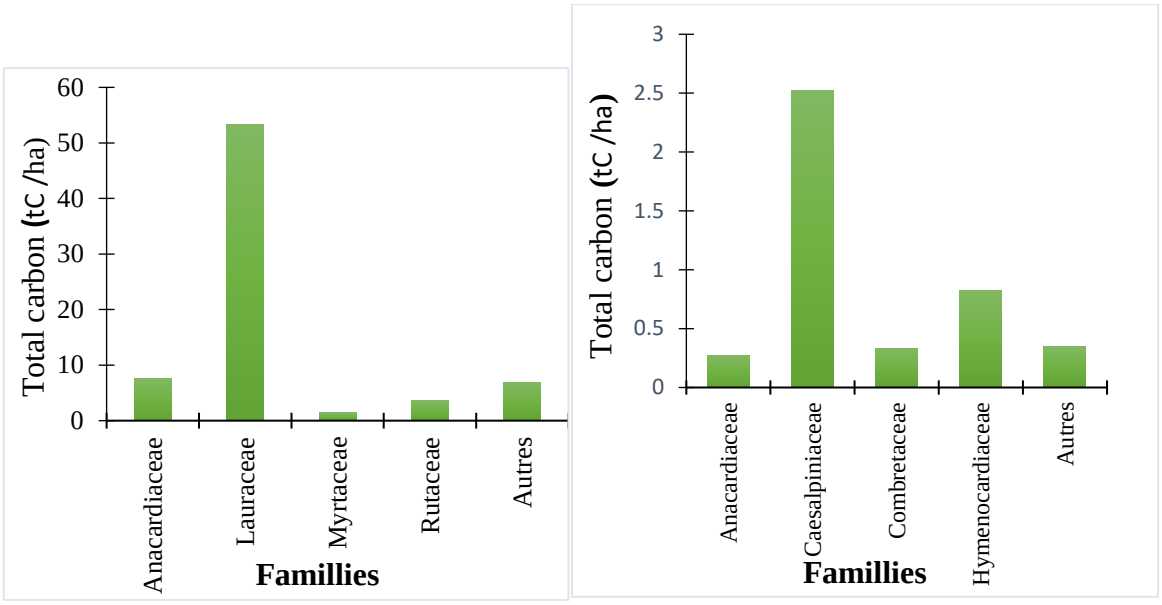

Figure 6: Total carbon of most represented families in the ASPA (A) and in the savannah (B).

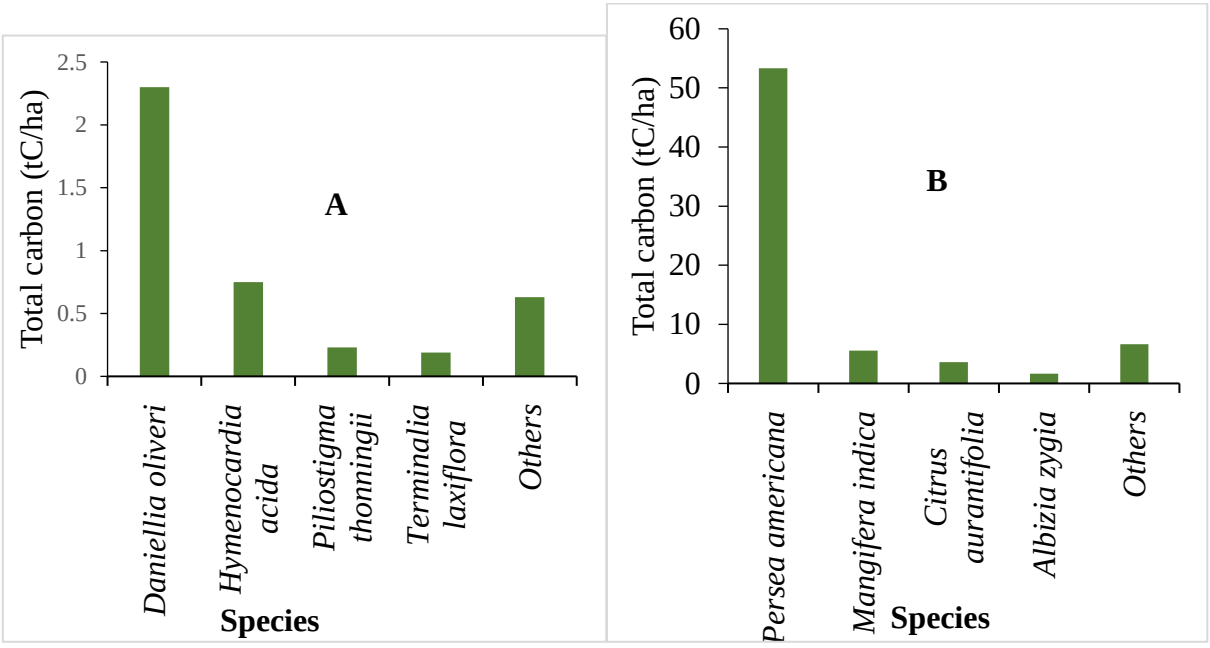

Fig.7: Total carbon of most represented species in the savannah (A) and in the ASPA (B).

Sequestration potentials and economic value

The potential for CO_2 sequestration is significantly different between the sites ($p= 0.001<0.05$). The highest stock of CO_2 was observed in sites of >20 years with 304.82 ± 0.82 tCO_2/ha). The economic value between the different sites also varies significantly ($p=0.001<0.05$). The greatest economic value is observed in the site of > 20 years (54153.28 ± 109.60 FCFA/ha).

Correlations

The correlation between carbon stocks and the number of species, the density or the basal area and the economic value is strong ($r > 0.5$). It is highly significant between carbon stock and the number of species for the aboveground carbon ($r = 0.831$; $p < 0.001$), belowground carbon ($r = 0.967$; $p < 0.001$) and total carbon ($r = 0.973$; $p < 0.001$). This means that carbon stocks were correlated with the numbers of species. There is also a strong and significant correlation between the carbon stock and the density for the aboveground carbon ($r = 0.978$; $p < 0.001$), belowground carbon ($r = 0.991$; $p < 0.001$) and total carbon ($r = 0.999$; $p < 0.001$). Thus a strong and significant correlation is also highlighted between the carbon stock and the basal area for the aboveground carbon ($r = 0.881$; $p < 0.001$), belowground carbon ($r = 0.835$; $p < 0.001$) and total carbon ($r = 0.999$; $p < 0.001$) and also between

carbon stocks and economic value where for the carbon aboveground ($r = 0.996$; $p < 0.001$), belowground carbon ($r = 0.998$; $p < 0.001$) and total carbon ($p < 0.001$) (Table 6).

Table 6: Correlation between the number of species, density, basal area, economic value aboveground carbon (AGC), belowground carbon (BGC) and the total carbon (TC).

	AGC (tC/ha)	BGC (tC/ha)	TC (tC/ha)
Numbers of species	r= 0.831	r =0.967	r =0.973
	p=0.0000	p =0.0000	p =0.0000
Density (stems/ha)	r =0.978	r =0.991	r =0.999
	p =0.0000	p=0.000	p =0.0000
Basal area (m^2/ha)	r =0.881	r =0.835	r =0.999
	p =0.0000	p =0.0000	p =0.0000
Economic value (dollar/ha)	r=0.996	r=0.998	r=0.888
	p =0.0000	p =0.0000	p =0.0000

(r = correlation coefficient, P= significance level)

Ascendant hierarchical analysis of species affected by total carbon stock

The hierarchical ascendant classification of the data obtain according to the similarity index confirms the different agroforestry systems sampled. At the threshold of the coefficient of similarity of about 98%, the analysis shows that the species forms five groups indicated in the dendrogram (Fig.8). Group 1 comprising 62 species, group 2 presents 5 species, groups 3 and 4 has one specie each, group 5 has three species. These species are grouped according to their diameter at breast height. The five groups form four complexes with different similitudes, (G4-G1): 07.5%; (G4-G5): 07.5%, (G1-G5): 49.51% and (G3-G2): 35.5% and are dependent on their carbon stock.

The principal component analysis (PCA) shows that the four plots are positively correlated with each other and the different species are also positively correlated with each other (Fig. 9A). The factorial correspondence analysis (AFC) shows that *Persea americana* was the most represented in the plots thus justifying pear agrosystem (Fig. 9B). The species dispersed in the sites were high represented, indicating a high frequency of finding them in all the four plots sampled. The other species that are less represented forms clouds around the two F1 and F2 axes (78.50%). The species represented in the form of clouds were less dense hence they cannot be found everywhere in the sampled plots. In the column function, the isolated species show correlation between the basal area, dbh, density and carbon stocks. From the ecological point of view, there species are accidental dotted in these plots.

IV. DISCUSSION

Vegetation

The agrosystems offers an important floristic diversity which varies with the maintenance technics and the climate of the region. This diversity in some areas is very different or close to that of a primary forest (Zapfack *et al*., 2002; Sonwa *et al*., 2007; Mapongmetsem *et al*., 2011; Noiha *et al.*, 2015; Dona *et al*., 2016). However, there is a high specific riche in the savannah. A total of 2101 individuals distributed in 17 families, 23 genus and 25 species have been inventoried in agrosystems, four species constituting 87.78% of the undergrowth were the most represented: *Albizia zygia*, *Allophylus africanus*, *Citrus aurentifolia* and *Psidium guajava*.

The savannah comprises 1195 individuals divided into 23 families, 32 genus and 34 species. Four species also, representing 98.56% of the total species, are the most represented. These are: *Hymenocardia acida*, *Gmelina arborea*, *Annona senegalensis* and *Allophylus africanus*, however there was a high specific richness in the savannah plot. The owners of ASPA clean the undergrowth during each rainy season where food crops are planted. The results of inventory in this agroforestry shows a low diversity compared to the cashew agrosystem in Northern Cameroon where Noiha *et al.*(2017) identified a total of 16488 taxa from 69 species, 58 genus and 31 families. In the other hand this result was closed to that obtained in Obala by Moneye (2004) who identified 26 species, 24 genus and 14 families. The ASPA woody biodiversity present different characteristics in relation with the geographical space considered, age and the agroforestry system. However, we have noted the significant biodiversity of our savannahs compared to the Sudanese

savannahs of the Tandjile area of Eastern Chad (Dona *et al.*, 2016).

The analysis of floristic diversity in agroforestry landscape in this study point to a consistent difference in the scale of the plots. Indeed, the comparison of the structural parameters (floristic composition by family, genus and species) of the plots, reflects their evolution compared to the witness plot. It emerges from this analysis that the savannah was densest (1195 individuals) than the others ASPA. Similarly, in terms of specific richness, the savannah system was more diversified than those in the agroforestry landscape. Despite the noticed difference in biodiversity between the agroforestry plots compared to the savannah, they are clearly more diverse and denser because the farmer promotes the development of fruit trees establishment for their economic and food importance to the detriment of non-fruit trees. So, the density of individuals according to the agroforestry practice gives them a structure close to the forest in the landscape. But taking into account the unfavorable ecological conditions and anthropic pressures, complete regeneration is hardly possible due to the exploitation of the undergrowth of avocado plantations.

In all of the plots studied, the value of the Shannon index of the avocado undergrowth is less to 3, indicating this low diversity and a strong homogeneity of the agrosystem. while it was a moderately diversified in the whiteness (3.9±1.85). These results are similar to those of Noiha *et al*. (2017) in cashew plantations in North Cameroon; Diedhiou *et al*. (2014) in Senegal in the *Faidherbia albida* park and in the *Faidherbia albida* and *Prosopis africana* park in south-central of Niger respectively. This can be explained by the ecological conditions which would be favorable or unfavorable for the development of the species.

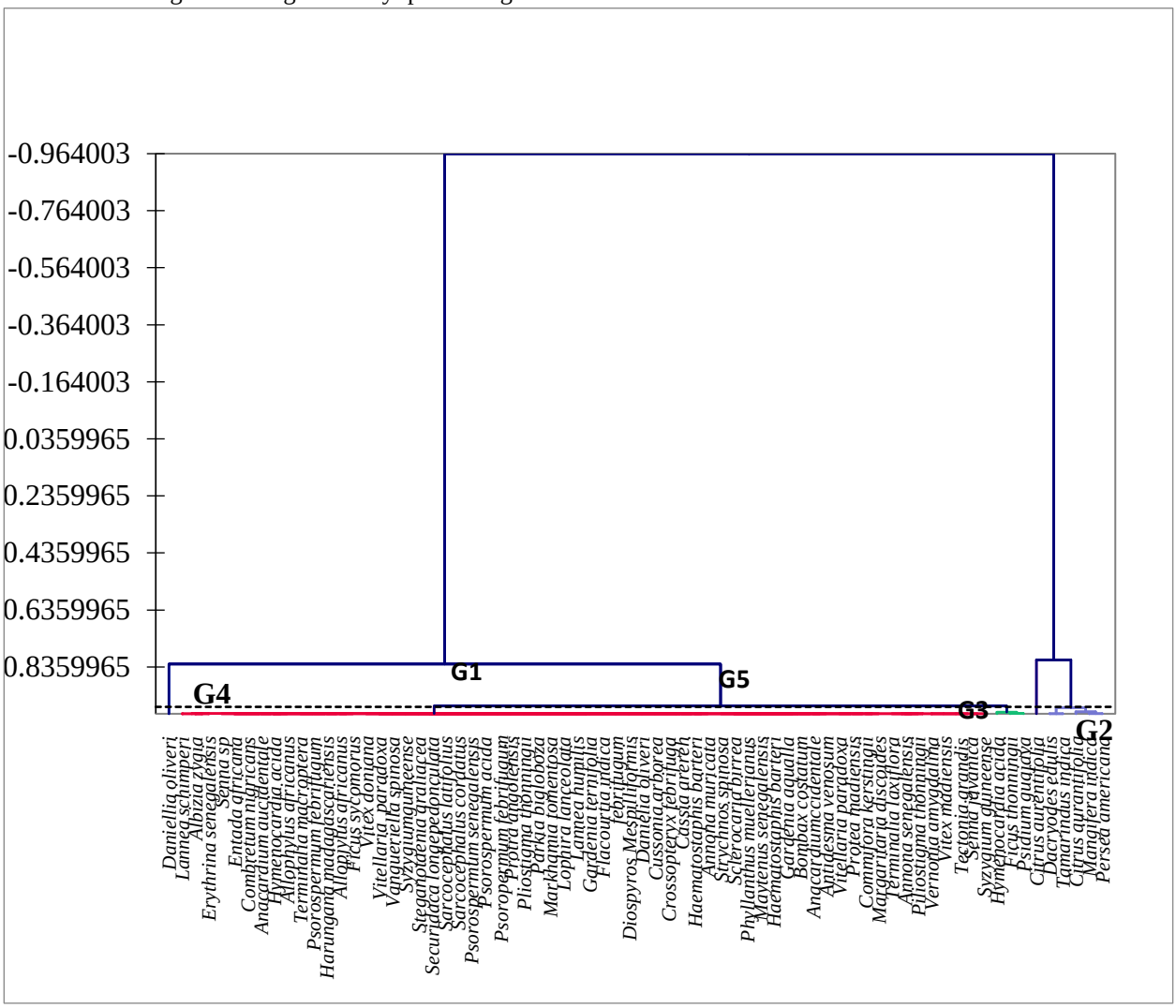

Fig.8: Dendrogramm of species in function of carbon stock in the sites

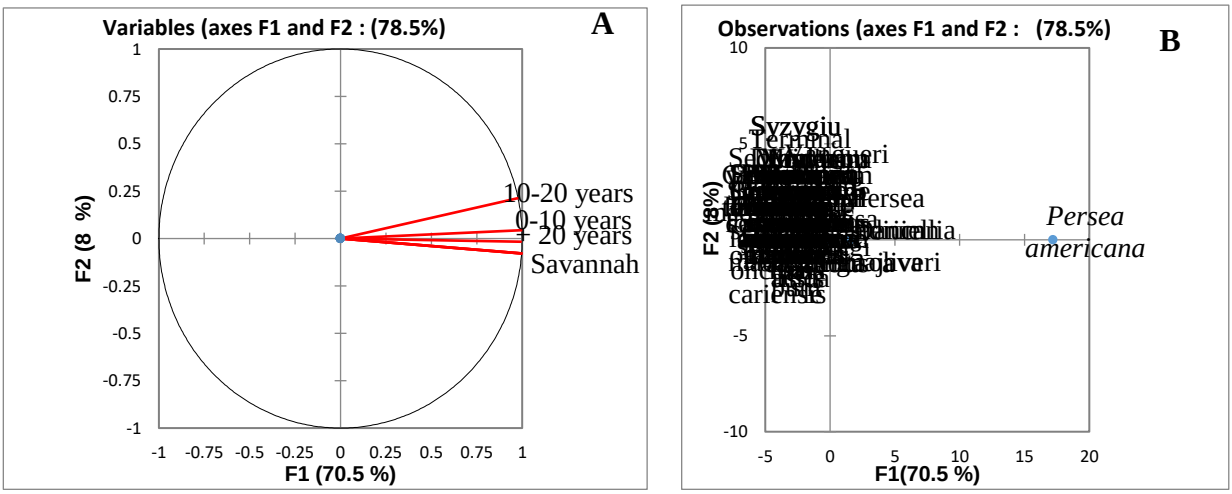

Fig.9 : Principal Component Analysis (PCA) (A) and Correspondances Factorial Analysis (CFA) (B) in the sites.

In the plots studied, the equitability of Piélou is equal to 1. This result is very close to that found by Noiha *et al.* (2017) in cocoa agrosystems in Cameroon and in cashew plantations in Cameroon between 2015 and 2017 respectively. This high value reflects a great diversity and a good reconstruction of the floristic diversity of the undergrowth, no doubt due to the favourable conditions set up by the agroforestry system. The importance value index (IIE = 200) was similar in all the sites studied. This result is substantially close (IIE = 214.52) to that found by Kabore *et al.* (2013) in the North-East of Burkina Faso. But remains higher than the value (IIE = 150) found by Noiha *et al*. (2017) in cashew plantations in North Cameroon. This could be due to the strong presence of tall crown trees in the plots studied. The result confirms the idea of Ngom *et al*. (2013) who state that trees with large crowns contribute more to the recovery and to a certain degree of recovery, they modify the ecological conditions by reducing the evaporating power of the air, by favoring the water balance of the soil and by improving soil fertility. A high similarity in species composition is observed in the population of *Persea americana*. It is due to the fact that the plots are located in the same agro-ecological zone, means that there are few differences between the three plots of different ages, hence a low beta diversity. These results are perfectly in accordance with those of Hamadou (2017) in the Eucalyptus plantations of Ngaoundéré (Adamawa-Cameroon).

The diametric structure has a decreasing exponential shape (L-shaped structure) with a strong slope of equation ($y= 1038e^{-1.14x}$ and $R^2= 0.931$) showing that the least represented stems are the stems of the future and regeneration, with a very large difference compared to other stems. This result corroborates those of Tchobsala *et al*. (2010), Noiha *et al*. (2015), Hamadou (2017), Zapfack *et al.* (2016) and Noiha *et al*. (2017).

The densities obtained in the different study plots vary from 552 ± 14.54 to 1195 ± 48.2 inds/ha with an average of 873.5 ± 31.37 inds/ha which would represent better regeneration. These results differ from those of Tayo Gamo (2014) and Durot (2013) in cocoa agroforestry systems respectively in Ngomedzap and Bokito (central Cameroon); from Ali *et al*. (2014) in the sacred forests of south-eastern Benin; Dorvil (2010) in tropical rain forests of Guadeloupe, Anobla *et al*. (2016) in the Agboville region (Côte d'Ivoire). The high density of trees in savannah considered as witness explains the opening of tree strata of savannah. This opening favors the development of woody plants facilitated by the penetration sun's rays to the ground. This is not the case with pear trees vegetation where there is competition between the species of the dominant stage for light. The difference in density of avocado population could be linked to the ecological characteristics of the study area, notably the growing of undergrowth (tomatoes, okra, peppers, parsley and peppers, etc.), soil types, topography, climate and recovery. The highest value of the basal area was 10.02±0.09 m²/ha obtained in the APSA of > 20 years which indicates the existence of large trees specimens. The low value of the basal area of the savannah population explains the impact of anthropic activities on this plot such as the slaughter of individuals during clearings for the agricultural and buildings activities or for firewood, uncontrolled bush fire etc.

Biomass and Carbon stock

The site >20 years sequestrated high carbon (59.31±5.43 tC/ha, with 31.87 tC/ha stocked by *Persea americana*) compared to the other sites. The difference observed can be explained by the presence of parameters such as the

density, the high basal area and the diameter (dbh) of tall trees. This result is largely superior to those obtained by Thiombiano (2010) in 22 years old cashew trees in Burkina Faso and by Noiha *et al*. (2017) in cashew plantations of >20 years in North Cameroon. However, these data remain largely inferior to those obtained by Zapfack (2005) in degraded secondary forests in the Center Cameroon region, but is appreciably close to those obtained by Mosango (1991) in young forests of Congo, according to Albrecht and Kandji (2003), the carbon storage capacity of an Agroforestry system varies between 12 and 228 tC/ha with an average value of 95 tC/ha. Indeed, the quantity of carbon sequestered by an agrosystem largely depends on the cropping system put in place, the structure and the function, the counting methodology, but also mainly on the variability of density of the undergrowth, which itself is also in function of the level of maturity of the secondary forest. In the Savannah, on the other hand, it was noted that the above-ground carbon stocks (2.93 tC/ha) are large inferior than those studied by Tchobsala *et al*. (2016) in the tree and shrub savannas of Ngaoundéré (Adamawa-Cameroon) and to those of Dona *et al.* (2016) in the Sudanese savannas of the Tandjile-East zone of Chad in the shrub savannah and the dry forest. This difference would be due to strong anthropic activities. The underground in avocado plantations of > 20 years (19.75±1.03tC/ha) was higher than the other plots studied. This value compared to those obtained by Traoré *et al*. (2004) in the shea park of Mali, Noiha *et al*. (2017) in cashew plantations in North Cameroon was higher. It is close to the value found by Ordonez *et al.* (2007 in the avocado plantation (13.6 tC/ha) in the Center of the Highlands of Mexico. The savannah, on the other hand, stocks 1.64tC/ha of underground carbon which is very different from the result found by Tchobsala *et al*. (2016) in the shrub savannah of Ngaoundéré (Adamawa-Cameroon). This difference would be due to the fact that in the control savannah, anthropic factors (bush fires, wood cuts, shifting and slash-and-burn agriculture) and biophysical factors (erosion, stripping of surface layers and oxidation of organic matter) destroy and reduce organic restitution from the environment to the soil. It should be noted that inappropriate agricultural practices in this area with intensive use of chemical fertilizers can also contribute to the destruction of organic matter to the detriment of mineralization. This stock is also different from that found by Traoré *et al*. (2004) in the Shea Park in Mali, probably due to the warm climatic conditions in the Sudano-Sahelian zone of Mali compared to the climate of the high-Guinean savannah of this study. The consequence was the rapid mineralization of organic matter in the Sudano-Sahelian zone and a decrease in the stock of organic matter in the soil.

The total carbon stock increases significantly (17.76 to 83.06 t/ha) with an average value of 58.76 t/ha in the avocado plantations but remains higher than the witness treatment (4.57 t/ha). The difference would be due to the higher diameter of the trees (dbh) and the basal area in the avocado plantations compared to those in the savannah. The highest total carbon stock was obtained in the plot of > 20 years. This result was much higher than those obtained by Kanmegne (2004) in the dense humid forests of South Cameroon in primary forest, banana plantation and old fallow; Ibrahima *et al*. (2002) in the tropical dance and humid forests of Southern Cameroon and Nolte *et al*. (2001) on land that has suffered the effects of slash and bush fire in Cameroon. In the savannah, carbon stocks (4.57 tC/ha) were lower than those of Mosango (1991) obtained in the Democratic Republic of Congo (6.63 tC/ha) were the total carbon in the three plots studies of different ages was 176.29 tC/ha. We can however note that our values were clearly lower than those obtained by Chavan and Rasal (2012) in the mango plantations (206.84 tC/ha) of Aurangabad in India and those of Deheza and Bellassen (2010) in the temperate forest (206.4 tC/ha) in France. This difference could be explained by the nature of the hypotheses adopted by the various researchers. Given these different results, we can deduce that ASPA are excellent carbon sinks.

Sequestration potential and economic value

In the context of this study, the CO_2 equivalent stock varies according to the different study sites, which determines the compensatory role of tree species in the emissions of carbon dioxide from anthropic activities that avocado trees can play. This variation is from 304.82 tCO_2/ha in plantations of > 20 years which constitutes the highest CO_2 stock, 287.99 tCO_2/ha in plantations of <20 years, 28.49 tCO_2/ha in that of < 10 years with a cumulative total of 621.3 tCO_2/ha and finally 11.15 tCO_2/ha lower in the savannah. However, the economic value being the value of Carbon, if it is sold on the international market, it is defined according to carbon sequestration. The larger the stock, the greater the economic value. The sale of carbon would make it possible to benefit from 66918.54±109.60 FCFA/ha to 4221851.58 FCFA/ha depending on the plots considered. These values are higher than those found by Noiha *et al*., 2017, but lower than of Hamadou (2017) in Adamawa. This difference is explained by the fact that avocado trees store more carbons compared to Neem and Cashew trees, but less carbon compared to Eucalyptus. The savannah considered as witness has low sequestration potential and value economic compared to the different

plots of avocado trees, these due to numerous anthropic disturbances, and, given the importance of these avocado systems in carbon sequestration (176.29 tC/ha), it can be deduced that they are excellent carbon sinks.

V. CONCLUSION

From this work, it emerges that the biodiversity of the Avocado Agroforestry Systems in Adamawa was relatively important. The plots of over 20 years ago were much diversified and have the highly significant basal area while the density of species was highly significant in the savannah. *Persea americana* and *Hymenocardia acida* were respectively the most dominants species of agrosystems and savannah. The plants with diameter of < 10 cm class were the most represented whatever the site. These agroforestry systems offer great potential for carbon sequestration compared to savannah. Especially the value of the ecological carbon sequestration service in the event of payment which has been estimated at more than $ 7126.6/ha in the agrosystems. To effectively combat global warming, it is imperative, at this stage, that pilot projects be initiated and developed.

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Organic dust exposure induced pulmonary damage among livestock workers

Dr. Anu Nag[1], Dr. R.S. Sethi[2], Dr. Akashdeep Singh[3]

[1]Dept. of Human Genetics, Punjabi university Patiala, Punjab
Naganu111@yahoo.co.in
[2]B.V.Sc & A.H., M.V.Sc, Ph.D., FIAVA, Professor and Head, Department ofAnimal Biotechnology, College of Animal Biotechnology, Guru Angad Dev Vety & Animal Sciences University, Ludhiana 141004, Punjab, India
Adjunct Professor, Department of Biomedical Sciences University of Saskatchewan, Canada
email: sethi116@gmail.com; rs.sethi@yahoo.com
[3]Professor & Head, Department of Pulmonary Medicine, DMC&H, Ludhiana.
drsinghakashdeep@gmail.com

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Abstract**—** *Livestock dust contains immunologically potent substances including allergens, endotoxins, microbial compounds, bacteria, fungi, viruses, pathogenic infectious organisms, particulate matter (PM), various poisonous gases such as ammonia, hydrogen sulphide (H_2S), methyl acetate, propanoic acid, heptane etc.It stimulates the immune system through inflammatory and allergenic microbial agents (molds, bacteria, virus and allergens) and microbial-associated molecular patterns (e.g., endotoxin, glucans and peptidoglycans), to result in inflammatory reactions. Farmers are at the risk of developing airway diseases resulting from repeatedly exposures on the livestock farms. There is a paucity of data on in vivo and in vitro cellular and molecular changes following multiple exposures to these livestock contaminants and their long-term impact on the environment as well as human health. The mechanisms of lung dysfunction are still largely unknown. So, there is strong need to look at the combined effect of all the components of livestock dust as stimulatory factors for respiratory hazards. The development of preventive strategies to reduce exposure will be required- in-depth and identification of factors that affect day-to-day variability in exposure.*

Keywords**— Organic dust, livestock dust, endotoxins, respiratory disorders, pulmonary health.**

INTRODUCTION

Livestock keeping is an age-old practice in India andit is the second income generating activity after crop in the agricultural economy of India. Livestock production and agriculture are intrinsically linked to each other and both are crucial for overall food security. About 20.5 million people depend upon livestock for their livelihood. This sector provides employment to about 8.8 % of the population in India and contributes 4.11% GDP of the total Agriculture GDP (25.6%). Unfortunately, livestock farmers are at the risk of developing various diseases associated with exposures to livestock dust.Livestock farming is one of the agricultural industries where farmers are at increased risk for respiratory health problems (Merchant et al. 1991).

Organic dust availability and its composition

In the field of occupational hygiene, airborne and settled particulate material of biologic origin is often referred as organic dust. Organic dusts contain particles of plant, animal and microbial origin (Douwes et al., 2003).Dust exists with heterogeneous composition and this is predominantly organic from animal confinement (Donham, 1986).Organic dusts found in agricultural environments display equally complex composition, although the primary sources may differ. Rylander(1994)reported in animal confinement buildings

some organic dust particles which originated from the animal feed, but the main sources of microorganisms, allergens, and toxins are animal dander, urine, and feces. Microorganisms are widespread in the environment and are often a major component of organic dusts because of the nutrients that the dusts contain. The microflora of organic dust depends on the source material, which depends in turn on a variety of factors, among them substrate composition, acidity, aeration, water availability, and temperature etc. (Lacey, 1994). The main agent in organic dust is endotoxin, a major component of the outer membrane of Gram-negative bacteria, but components of Gram-positive bacteria (peptidoglycans) and fungi (glucans) are also present. The organic fraction of these dusts may contain yeasts, molds, mesophilic and thermophilic bacteria (G-positive and G-negative), histamine, cow urine antigen, mite antigen, endotoxins and pharmaceutical compounds (Donham, 1986; Kullman et al. 1998; Kemper, 2008). Similarly, an "immunoallergic" and inflammatory reaction following the inhalation of organic dust contained in hay among dairy workers due to endotoxins has been proposed to explain this phenomenon (Dalphin et al., 1993; Eduard et al., 2009; Poole and Romberger, 2012). A large number of studies suggested that total dust is comprised of variety of factors such as particle size, concentration of bacterial products LPS and PGN etc. and revealed relevant assessment techniques for the measurement of mold spores, mycotoxins, bacteria, allergenic proteins, endotoxins, and microorganisms in the organic dust (Kirychuk*et al.* 2010 and Hawley *et al.* 2015).

Noxious Gases also act as potential health hazards along with these dust particles such as ammonia which is present inside unbedded dairy calf and hydrogen sulphide which is very poisonous is produced inside the farms during manure agitation (Eduard et al. 2017). Heedreik*et al.* 2007 and Guidry *et al.* 2018 also demonstrated that in animal production farms,the dusts from the animals, their feed, and their faeces contains high levels of poisonous gases such as ammonia (NH3) which comes primarily from the animal's urine and faeces, and hydrogen sulphide (H2S) from manure pits, especially during agitation and emptying. This fact is well supported by Eduard *et al.* 2017 and May *et al.* 2012 that livestock buildings may contain concentrations of contaminants that can negatively affect human health.

As mentioned,in table no. 1.The dust in livestock barns is comprised of molds, actinomycetes, dried fecal matter, pollens , insect parts etc. which means the dust is biologically active and will react to the defense system of the respiratory organs.

Table 1. Classification of dust inside the livestock barns:

Source of dust	**Type of dust**	**Cause of dust**
Grain	Molds, actinomycetes	Storage problem
Hay	Molds, actinomycetes	Poor conservation
Straw	Molds, actinomycetes	Combining/poor conservation
Silage	Molds	Poor conservation
Animal Debris	Faeces,urine,hair,skin,feathers Fungi,bacteria	Animal activity, barn, cleaniless, ventilation,etc.
Feeds	Numerous particles	Feed-distribution/poor ventilation

Source: Air Quality Inside Livestock Barns (gov.on.ca)

Epidemiological Studies

Respiratory disease is an important clinical problem for livestock farmers which significantly increased risk of their respiratory morbidity and mortality. Farmers and other individuals involved in livestock farming have an increased risk for acute and chronic respiratory disorders; their respiration is routinely challenged by intense exposure to several chemical and biological substances such as odorous gases, and organic and inorganic dusts (Schenker *et al.* 1998; Kirkhorn*et al.* 2000; Omland; 2002; Sigsgaard*et al.* 2010). The dairy farmers are exposed to high concentrations of organic dusts, this increased risk seems mainly driven by chronic exposure to these dusts (Basinas et al., 2014; Pfister et al., 2018).

Various studies involving large numbers of exposure measurements which have been published previously for dairy and swine confinement industries have shown that organic dust exposures may vary qualitatively as well as quantitatively from one occupation to another but these dusts had stronger respiratory effects on the lungs of the farmers (Huy*et al.* 1991, Smid*et al.* 1992; Preller *et al.* 1995; Kullman 1998). Kouimintzis *et al.* 2007 and

Szczyrek*et al.* 2011 found a strong association between developing bronchitis, COPD and lung reduced force expiratory volume among livestock farmers who are exposed to high levels of organic dust in confined buildings. Dalphin*et al.* 1989 studied the prevalence of bronchitis and reduced respiratory function among livestock dairy farmers. He further concluded that dairy farmers are at a greater risk of developing respiratory disfunction. A large number of studies also supported and found a strong potential association between animal farming and non-malignant disorders, like asthma, chronic bronchitis organic dust toxic syndrome and hypersensitivity pneumonitis (Zejda*et al.* 1993; Omland 2002; Hoppin*et al.* 2003) as shown in table 2.

Table 2. Respiratory conditions due to occupational exposure

OCCUPATION	EXPOSURE	RESPIRATORY CONDITIONS
Dairy farmers	Organic dust Feed additives Thermophilic bacteria and fungi Fungi Microbial toxins Storage mites Irritant gases	Chronic Bronchitis, Organic dust toxic syndrome Asthma Allergic alveolitis (farmer's lung) Bronchiolitis Toxic pneumonitis (silo filler's lung) Rhinitis COPD (chronic obstructive pulmonary disease

Source: Merchant JA et al. Textbook on Clinical Occupational and Environmental Medicine. Eds. Rosenstock L, Cullen, 1994.

Various studies demonstrated that organic dusts present particularly ina Concentrated Animal Feeding Operations (CAFOs)i.e., is a system of farming which concentrates a large number of animals into a small space for maximum efficiency, may cause lung inflammation and assessed the respiratory health of the workers by testing dust mitigation strategies and further reported that organic dust and its components may be a deciding factor in understanding inflammatory response among livestock farmers who are exposed to the environment (Senthilselvan et al. 1997; Schnebergeret *al.* 2016 and Hawley *et al*. 2015) as shown in fig. 1.

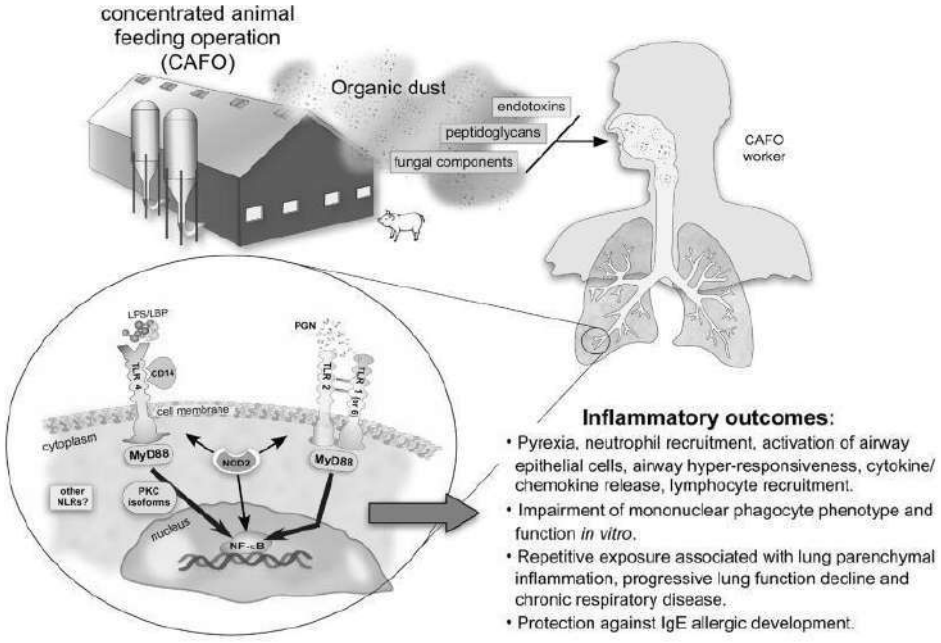

Fig.1: Poole, J. A., &Romberger, D. J. (2012). Immunological and inflammatory responses to organic dust in agriculture. Current opinion in allergy and clinical immunology. Diagrammatic presentation of the agents and immunologic and inflammatory consequences of organic dust exposure in the agriculture industry in large, concentrated animal feeding operations (CAFOs).

Exposure studies found a strong association between COPD, dust and endotoxins in confined livestock buildings and revealed the fact that livestock farmers had significant higher mortality rates due to their respiratory illness (Monso*et al.* 2004; Szczyrek*et al.* 2011). Van *et al.* 2016 and Sigsgaard*et al.* 2020 also recently investigated the impact of livestock farming on lung health of farmers in their epidemiological studies and reported the risk of developing chronic bronchitis and bronchial obstruction/COPD among livestock farmers. They concluded the higher prevalence of lower respiratory tract infections in the area with a high density of livestock farms. Dairy farm dusts are complex mixtures that contain both toxic and immunogenic compounds. Dust exposure is a major source of respiratory morbidity and mortality among agricultural workers (American Thoracic Society, 1998; Schenker, 2000; Linaker and Smedley, 2002; Cleave *et al.* 2009; Reynolds *et al.* 2013). A large number of studies indicated that dairy workers, in particular, have increased risks for **asthma, rhinitis, sinusitis, mucus membrane inflammation syndrome, bronchitis, chronic obstructive pulmonary disease (COPD), hypersensitivity pneumonitis, and organic dust toxic syndrome** (Kullman*et al.* 1998; Gainet*et al.* 2007; May *et al.* 2012; Reynolds *et al.* 2013).

Taluja, *et al.* 2019 also reported that occupational exposure of dust causes respiratory hazards to farm workers and concluded that dust adversely affects the respiratory function by deteriorating the lung function parameters. Similarly, number of exposure studies reported a range of respiratory and other symptoms including bronchitis, chest tightness, nasal congestion, organic dust toxic syndrome, occupational asthma, mucus membrane irritation, nausea, headache, mood changes, altered immunity among workers who are exposed to organic dust (Sahlander*et al.* 2012; Viegas*et al.* 2013; Iowa Concentrated Animal Feeding Operations Air Quality Study, 2018) and increased risks of lung cancer (Peters *et al.* 2012).

Various studies indicated health hazards and recognized a number of syndromes among workers in intensive livestock production (Donham *et al*.1995; Hartung and Schulz,2008). Organic dust toxic syndrome recognized in workers is predominantly a severe flu-like syndrome originally described in farmers and other persons who are occupationally exposed to dusty conditions. (Donham *et al.* 2002; Hartung and Schulz,2008) again reported the prevalence of ODTS ranges from 10 to 30% in workers, depending on the type of intensive animal production and use of facilities.Several studies have indicated that the prevalence of persistent restriction of airflow and pulmonary disordersare higher among dairy farmers than in the general population (Stoleski et al., 2015; Guillien et al., 2016; Marescaux et al., 2016; Guillien et al., 2019).As dairy farmers are exposed to high concentrations of organic dusts, this increased risk seems mainly driven by chronic exposure to these dusts (Basinas et al., 2014; Pfister et al., 2018).These findings suggest that presence of multiple microbial and non-microbial factors in OD can cause broad-range of health effects upon exposure which is a significant public health concern.

Mechanism involving lung inflammation

Cytokines play an important role in determining pulmonary diseases which includes **platelet-derived growth factor (PDGF),Interleukln-1 (IL-1), transforming growth factor-p (TGF-P), tumor necrosis factor-a (TNF-a), Insulin like growth factor I (IGF-I), Interleukin-& (IL-&) 1** (Kelley, 1990). Alterationsin cytokine production, secretion, and action represent determining forces in the destructive and inflammatory lung disorders as shown in fig. 2.

Recognition of micro-organisms is an important function of the innate and adaptive immunity and pattern recognition receptors (PRRs) recognize a variety of pathogen-associated molecular patterns (PAMPs) from viruses, bacteria, fungi and parasites (Takeda *et al.* 2003). Toll-like receptors (TLRs) comprise a group of PRRs which are expressed by most immune cells. When binding to PAMPs, immune responses including expression of proinflammatory cytokines and type I interferons (IFNs) are mediated through activation of the transcription factor **NF-kB and interferon regulatory factors (IRFs).** Currently, eleven TLRs have been identified in humans of which TLR2 and TLR4 are the most studied. Toll-like receptor 4 is activated by the endogenous molecules or danger signals released during tissue injuries in addition to bacterial endotoxins (Akira *et al.* 2006; Tsan and Gao 2004). Thus, TLR4 is the prototypical sensor of infection or injury that arranges the innate response via a sequential activation of both cell surface and endocytic signaling pathways (Ghosh *et al.* 2015). The increased expression of TLR4 has been associated with the lung dysfunction and elevated TLR4 subsequently activates nuclear factor kappa-light-chain-enhancer of activated B cells (NF-kB) which in turns directs the expression of various chemokines and pro-inflammatory cytokines including Interleukins-1β and tumor necrosis factor TNF-α (Strieter*et al*. 2002).

Lipopolysaccharides (LPS) is a major component of the outer membrane of gram-negative bacteria, (Sugiyama *et al.* 2008) is associated with the development and progression of various lung diseases characterized by chronic inflammatory conditions (Vernooy*et al.* 2002). Single LPS exposure is sufficient to rapidly recruit

neutrophils to the lung and to produce pro-inflammatory cytokines and chemokines (Deetz *et al.* 1997). The recognition of LPS is modulated by soluble factors, such as LPS binding protein and surfactant proteins that are present in airway lining fluid and influence the presentation of LPS to membrane-bound CD14 (Skerrett *et al.* 2004). Binding of LPS to CD14 triggers intracellular signaling that is mediated by Toll-like receptor 4 (TLR4) in association with a secreted cofactor, MD-2 (Akira *et al.* 2003). TLR2 recognizes PAMPs from Gram-positive bacteria like peptidoglycans (PGN) and lipoproteins and binds LPS from special bacteria strains and PAMPs from fungi (Takeda *et al.* 2003 and Akira *et al.* 2006). Zahringer*et al.* 2008 reported that TLR 2 is typically associated with the detection of peptidoglycans, lipoteichoic-acid, lipoproteins, lipopeptides and zymosan. (Oliveira-Nascimento *et al.* 2012; Kang *et al.* 2009; Oosting*et al.* 2014) further demonstrated the dimerization property of TLR2 with TLR1, TLR6 or TLR 10 which makes it to detect increased range of possible ligands. These studies have shown that TLR2 may be even more important than TLR4 in determining the response to these organic dusts. (Martin *et al.* 1996) also supported in their study that TLR2 may be more important than TLR4 in determining the response during organic dusts exposure. Whereas other studies supported the role of protein kinase C (PKC), TLR9 (Schnebergeret *al.* 2016); TLR2 (Poole *et al.* 2011); MyD88 (Bauer et al 2013) in several innate signaling pathways in response to organic dust exposure.

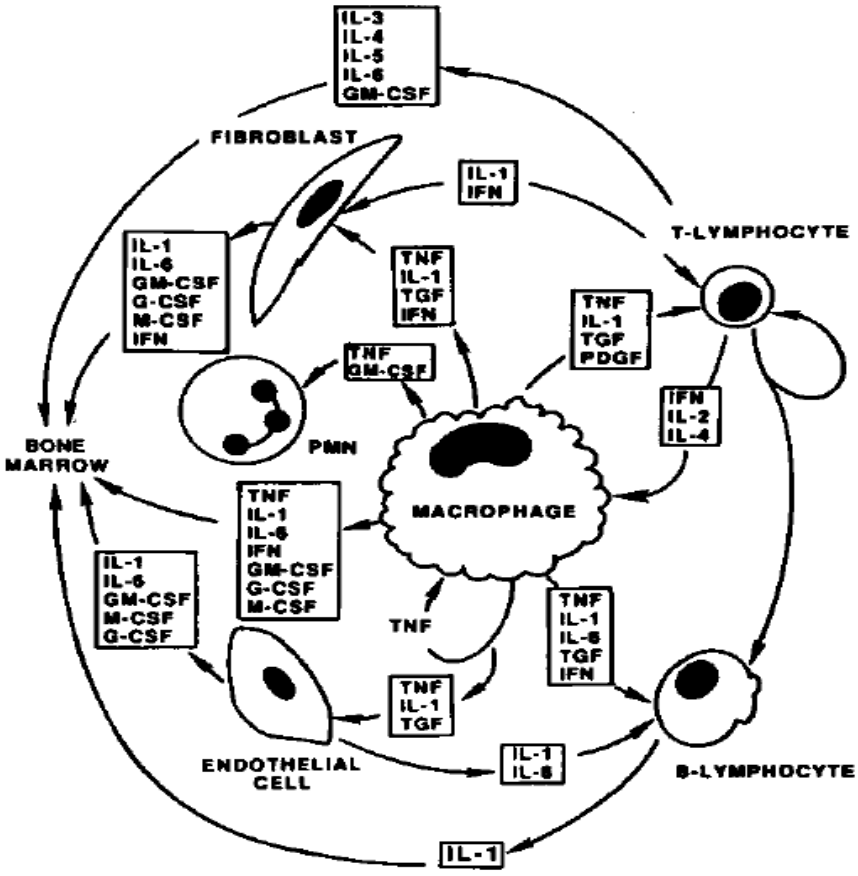

Figure 2. **Kelley, J. (1990). Cytokines of the lung. *Am Rev Respir Dis*, *141*(3), 765-788.**

Schematic showing multiple potential cellular interactions involving cytokines.

Interleukin-1β is a potent pro-inflammatory cytokine that is crucial for host-defense response to infection and injury (Lopez *et al.* 2011). Interleukin-1β, encoded by the IL-1β gene, has been associated with chronic inflammation and plays an important role in lung inflammatory diseases including lung cancer. Elevated levels of IL-1 proteins, in particular IL-1β greatly enhance the intensity of the inflammatory response (Bhat et al. 2014).(Zahringer*et al.* 2008) reported that TLR2 is associated with the detection of peptidoglycans, lipoteichoic acid, lipoproteins and zymosan. Senthilselvan*et al.* 2009 revealed the association of TLR4 gene and its ligand LPS as an important factor in

lung dysfunction after barn exposure in humans. (Sahlander*et al* 2010) studied association between T-helper (th) cell, cytokine *profile* and acute response to pro-inflammatory stimuli as markers. Whereas (Kang *et al.* 2009 and Oosting*et al.* 2014) reported that TLR2 can dimerize with TLR1, TLR6, TLR10 and can detect various range of possible ligands. Rombergeret *al.* 2015 discovered **proteolytic properties that can stimulate protease activated receptors (PARs) 1 and 2** in the bronchial epithelium and focused on the contribution of proteases to lung inflammation and pathways which contribute to the lung inflammatory response to dust exposure. These proteolytic properties of organic dusts require further investigations because some chemokines are also produced on cleavage although study suggested main effect is through PAR receptors.

Surfactant proteins (SP) are also important constituents of pulmonary defense and are a lipoprotein complex of phospholipids and apoproteins which is a complex critical component in lung immune host defense (Pastva et al. 2007).Surfactant, a lipoprotein. Pulmonary SPs are also involved in the pathophysiology of lung injury following exposure to pesticides (Gil et al. 2007).Although surfactants appear not to have been studied extensively in terms of organic dust whereas Schneberger et al. 2018 examined the role of the immune surfactant or collectin surfactant protein D (SP-D) in lungs induced prolonged exposure to organic barn dustsand concluded that organic barn dust can reduce lung SP-D, thus leaving workers potentially at risk for a host of pathogens.Sethi et al. 2017 also found SP-A and SP-D reductions in A549 lung cell linesexposed to hog barn dusts. This further suggests that some of the inflammatoryresponse generated in lungs to these dusts might beattributable to reductions in these immune surfactants.

In- vivo studies

Multiple researches identified organic dusts as a major problem in lung inflammation and have shown that organic dust exposure on human subjects and animals are helpful in accessing the pulmonary health of the occupational workers (Senthilselvan*et al.* 1997; Charavarymath*et al.* 2005; Schenebergeret *al.* 2016). Various animal models have been designed by the researchers which helped in understanding the molecular and cellular mechanisms of lung inflammation following exposures to livestock dust (Sethi *et al*. 2013 and Charavaryamath and singh 2006).

Charavaryamath*et al.* 2005 designed first rat model of human exposure to barn air which was mimicked human exposure of fulltime barn workers (8h/day, Monday to Friday) and found that single and multiple exposures to endotoxin rich-swine barn air induce lung inflammation characterized by infiltration of inflammatory cells, increased mucus positive-epithelial cells in addition to the presence of endotoxins, dust, ammonia, microorganisms, aeroallergens.

Charavarymath*et al.* 2006 supported that PIMMS cells are important because they have shown to produce both pro and anti-inflammatory cytokines to regulate lung inflammation.Further Gamage *et al.* 2007 demonstrated the role of pulmonary intravascular monocytes /macrophages (PIMMS) recruitment and their functions in lung inflammation induced following exposure to the barn air by using a rat model. Further interactions between PAR2 and TLR4 were also well demonstrated by Rallabahndi*et al.* 2008. Lundin and &Checkoway, 2009 reported altered TLR expression among livestock farmers who were probably exposed to organic agents and concluded that reduced TLR expression may be related to the increased prevalence of respiratory disorders among livestock farmers.

Sahlander et al. (2010) hypothesized that T-helper (Th) cell cytokine profile and acute response to pro-inflammatory stimuli as immune response among pig farmers and smokers. After in vivo exposure, altered TLR expression was only observed in controls and the ex vivo stimulations showed an attenuated response in farmers compared to the control group. The inflammatory systemic response to pro-inflammatory stimuli is altered in farmers probably because of adaptive mechanisms arising from chronic exposure to organic material and microbial compounds, have an increased number of inflammatory cells in peripheral blood and an increased proportion of circulating Th2- type lymphocytes which, among pig farmers, were positively related with the duration of work in pig confinement buildings.

Sethi *et al.* 2013 revealed a decrease in Clara cells and an increase in numbers of mucus producing goblet cells in the airway epithelium in exposed knockout TLR9 $^{-/-}$ animals after chronic barn exposure. Schneberger*et al.* 2016 reported that in TLR9 knockout mice no stronger responses has been detected as compared to TLR2 and TLR4 mice when exposed to the barn environment. Sethi *et al.* 2017 further demonstrated the role of innate inflammatory mechanism, especially TLR4 and TLR9 following exposure to dust and other pollutants in agriculture environments by using in vitro models and laboratory animals.

Nath *et al.* 2018 illustrated the association between the exacerbated inflammation upon persistent barn organic dust exposure, pathogenesis of lung inflammation and lung function decline. He investigated the inflammatory effects of Barn Dust Extracts on human lung epithelial **(BEAS2B)**

and macrophage (THP-1 monocyte derived) cell lines on a kinome array to determine phosphorylation events in the inflammatory signaling pathways. Further he concluded that workers exposed to persistent barn air are at occupational risk of developing a range of respiratory illnesses and there is a critical need to understand the mechanisms behind those illness.

Kaur and Sethi, 2020 concluded that multiple exposures of poultry barn air resulted in lung damage and damage is more severe when combined with LPS. Multiple exposures in combination with LPS significantly altered the mRNA and protein expression of TLR-4 and IL-1β. Expression of TLR4 and IL-1β showed a synergistic effect when combined with LPS.Woldeamanuel*et al*. 2020 and Soumagne*et al*. 2020 reviewed that dairy farmer could be exposed to various potentially hazardous exposures that can cause respiratory symptoms due to higher inflammatory markers such as such as TNFα, fibrinogen, IL-6 and CRP

In vitro studies

Poole et al. 2008 found that repetitive organic dust exposure significantly decreases markersof antigen presentation and host defense function in monocyte-derived macrophage (MDMs). Bacterial cell components appear to be driving these impaired responses**.Expression of HLA-DR, CD80, and CD86;** phagocytosis; and intracellular bacterial killing were significantly decreased with organic dust exposure (ODE)-challenged versus control MDMs. Responses were retained after marked depletion of endotoxin. PGN, LPS, and PGN plus LPS significantly reduced MDM surface marker expression and, except for LPS alone, also reduced phagocytosis. ODE-challenged MDMs had significantly diminished cytokine responses **(TNF-α, IL-6, and IL-10)** after repeat challenge with high-dose **ODE** and concluded that organic dust–induced macrophage dysfunction might be important in respiratory disease development.

Viegas*et al*. 2017 chosemacrophagesfor the in vitro assessment because they are known to be responsible for first-line protection and also for triggering the inflammatory response via secretion of signaling molecules.The cell viability and the inflammatory response, as measured by the production of pro-inflammatory cytokines tumor necrosis factor-α (TNFα) and interleukin-1 β (IL-1β), are determined in human macrophages derived from THP-1 monocytic cells. This study emphasizes the importance of measuring the organic dust/mixture effects in occupational settings and suggests that differences in the organic dust content may result in differences in health effects for exposed workers.

Nordgren and Charavaryamath in 2018 demonstrated the application of a kinome array to delineate key inflammatory signaling pathways activated upon swine barn dust extract SBDE exposure in vitro. They concluded that SBDE-mediated pro-inflammatory effects are predominantly due to the induction of neutrophilic chemokine IL-8. Differentially phosphorylated peptides implicated in IL-8 induction in BEAS2B cell line include, **TLR2, 4, 5, 7, 8, 9, PKC, MAP kinases (p38, JNK), inflammasomes (NLRP1, NLRP3), NF-κB and AP-1** due to persistent barn organic dust exposure which is a key contributor to the pathogenesis of lung inflammation and lung function decline.

Nordgren*et al*. 2013identified the role of mediators derived from polyunsaturated fatty acids exhibit anti-inflammatory, pre-resolving actions and tested the potential of one of these mediatorsi.e.,**maresin-1 (MaR1)**.As bronchial epithelial cells (BECs) playpivotal role in initiating organic dust-induced inflammation and they investigated the invitro effects of MaR1 on a human BEC cell line (BEAS-2B)in reducing organic dust-associated airway inflammation. Again Nordgren*et al*. 2015 supported the previous study that the specialized proresolving lipid **mediator maresin-1 (**MaR1) reduced proinflammatory cytokine release and **intracellular adhesion molecule-1 (ICAM-1)** expression in bronchial epithelial cells exposed to extracts of organic dust (DE) derived from swine confinement facilities in vitro. The data suggested that MaR1 might contribute to an effective strategy to reduce airway inflammatory diseases induced by agricultural-related organic dust environmental exposures.

Occupational lung diseases caused and aggravated by various organic and inorganic inhaled dust, fumes, and mist.Therefore, occupational history of livestock farmers should be considered when evaluating respiratory symptoms. The best way to treat OLDs as early as possible are prevention and early detection by controlling the working environment and conducting regular surveillance of workers (Lee, 2011).

There is an urgent need to improve knowledge on several topics, including 1) understanding thenature and pathophysiology of respiratory diseases, 2) diagnostic approaches, 3) disease behaviorand natural history, and 4) therapeuticapproaches. Key questions onpathophysiology includes geneticsusceptibility and both host andenvironmental factors. For diagnosticapproaches, important needs include thevalidation and standardization ofquestionnaires, BAL lymphocytosisthreshold, specific antibodies, andbiomarkers.In addition, new techniques

likegenomic classifiers and artificial intelligenceto improve diagnosis and prognosis need tobe assessed. For example;adiagnosis of hypersensitivity pneumonitis (HP) and distinguishing it from other forms of interstitial lung diseases.The diagnosis of HP relies on the integration of multiples domains such as clinical assessment of exposure, imaging, bronchoalveolar lavage lymphocytosis and histopathological findings. Among patients with fibrotic HP, the MUC5B (mucin 5B) promoter polymorphism is more prevalent than in the general population and is associated with shortened survival (Ley, 2017).Among sensitized individuals, the immune reaction after exposure to an antigen appears to consist of both humoral (i.e., antigen-specific IgG antibodies) and T-helper cell type 1 (Th1) cellular immune responses (Hisauchi-Kojima, 1999). These responses lead to a predominantly lymphocytic inflammatory pattern and granulomatous inflammation (Vasakova et al. 2019). Neutrophilic inflammationmay play a role early in the disease whereas impaired function of T regulatory cells may play a role in the exaggerated immune response(Pardo et al.2000). Similarly other pulmonary diseases can be detected by analyzing cytokines production, presence of IgG and IgE antibodies. Manyother antigens in organic dusts associated with these diseases have not been adequatelycharacterized and better understanding of the mechanisms by which thesematerials cause clinical disease is necessary.

CONCLUSION

From this review it has been concluded that pulmonary damage risk is associated with raising livestock animals due to organic dust exposure. Once the lung is damaged by organic dusts, regeneration of lung to normal state is almost impossible. Thus, prediction and early diagnosis of lung diseases are important and imperatively necessary. In spite of advanced technologies overall level of organic dust exposure of livestock workers is very high which poses a serious health threat. Exposure to organic dust and its health effects among workers have been investigated in numerous epidemiological and exposure-assessment studies during the last three decades.Further multiple components within the dust such as endotoxins, LPS and peptidoglycans bind to a wide variety of innate immune receptors but we still have no clear definition of the potential determinants of personal exposures in livestock farming environments. Work related respiratory diseases are major contributors to the global burden of respiratory diseases. This review is focused on the findings which suggested that livestock farmers are exposed to high levels of dust and endotoxin consistent with an increased risk of developing respiratory symptoms and diseases.

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Development of Nutrient Rich Value-added Biscuit through Incorporation of Orange-fleshed Sweetpotato Puree

M.M. Hossain[1], S. Heck[2], D. Chanda[1], E.H.M.S. Rahaman[1], S. Mahmood[3] and M.H. Kabir[4]

[1]International Potato Center, Banani, Dhaka, Bangladesh,
[2]International Potato Center, Nairobi, Kenya,
[3]Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh
[4]Sher-E-Bangla Agricultural University, Sher-E-Bangla Nagar, Dhaka, Bangladesh
Corresponding author: monower.hossain@cgiar.org

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Abstract— *In Bangladesh bakery and confectionery industry has become almost self-sufficient in meeting the local demand. But the products produce from the factories cannot fulfill nutritional demand of the people of Bangladesh as wheat flour is the main ingredient of the bakery products. Orange Fleshed Sweetpotato is a promising root crop due to high beta carotene content and other vitamins and minerals could be used to reduce the gap of nutritional demand. The experiment was conducted with four BARI (Bangladesh Agricultural Research Institute) released orange fleshed sweetpotato varieties and a local cultivar at the GUK's 'Super Tasty Food' Products Factory, Nashratpur, Gaibandha, Bangladesh during 2020-21 cropping season. The aim of the study was to develop nutrient rich value-added biscuit for the consumers. Eleven treatments (formulations) were used to develop biscuit. The highest amount of beta carotene content was recorded in T_4 treatment (1.67 mg/100g) followed by T_9 treatment (0.84 mg/100g) and the lowest was obtained from T_{11} treatment (0.01 mg/100g). Maximum amount of vitamin C detected in T_5 treatment (1.81 mg/100g) which was statistically similar to T_1 treatment (1.74 gm/100g) and no Vitamin C was found in T_{11} treatment. Zinc content found maximum in T_{11} treatment (2.04 mg/100g) while the lowest was observed in T_5 treatment (1.12 mg/100g). The highest amount of iron was recorded in T_3 treatment (6.52 mg/100g) which is significantly similar to treatment T_2 (6.43 mg/100g) and T_8 (6.09 mg/100g), respectively. The entire sensory attributes of value-added biscuit were accepted as fair to very good and have no remarkable difference from traditional biscuits (T_{11}). The overall acceptability of the biscuit was found to be highest in T_9 treatment (good to very good).*

Keywords— ***Sweetpotato puree, sweetpotato biscuit, nutrient analysis, sensory evaluation.***

I. INTRODUCTION

Malnutrition is a common phenomenon in Bangladesh. The children, especially of low-income households/families (both in rural and urban) suffer from high rates of micronutrient deficiencies, particularly vitamin A, iron, iodine and zinc deficiency. Though the country has made some significant progress in reducing vitamin A deficiency (VAD) among preschool children over the past 15 years, consumption of vitamin A rich foods is still low, suggesting that the underlying causes of VAD require further attention and support. Anemia is also highly prevalent among children

in Bangladesh and few programs have been initiated to improve their iron status.

Sweetpotato (*Ipomoea batatus*) is an important staple crop in many parts of the world (Rahaman *et al.* 2016). Orange fleshed sweetpotato (OFSP) contains a diverse array of vitamins and minerals with potential nutritional benefits to meet easily the intake needs and reduce VAD and under-nutrition (Van Jaarsveld *et al.,* 2006). However, the utilization is very low and commonly consumed in the limited form like boiled and cooked meals in traditional dishes of Bangladesh. There is limited information on processing of OFSP to other products or considering it as an additional ingredient for baked foods (Assefa *et al.,* 2007) which is also a limiting factor for OFSP consumption. Numerous studies have been conducted to develop nutritious food products from OFSP and other supplementary food sources (Coronel *et al*., 2005). Snack foods such as biscuits and crackers are widely consumed, with relatively longer in shelf life, good in eating quality and highly palatable foods that can be modified to suit specific nutritional needs of any target population (Okoye *et al.,* 2008; Vitali *et al.,* 2009).

The production of biscuit is mainly based on wheat flours. In recent studies, new ingredients were included in the production of biscuit products such as black gram flour (Hooda and Jood, 2005), mustard flour (Tyagi *et al*., 2007), soy flour (Vitali *et al.,* 2009), fibers from different cereals and fruits (Sudha *et al.*, 2007; Bilgicli *et al*., 2007) to study changes on nutritional and organoleptic characteristics of biscuits. Biscuits can also be prepared by combining sweetpotato flours to wheat flour (Srivastava *et al.,* 2012).

The sweetpotato could be considered as an excellent novel source of natural health-promoting compounds such as β-carotene, zinc and iron, for the functional food market. Also, the high concentration of β-carotene in OFSP, combined with the high stability of the color extract make it a promising and healthier alternative to synthetic coloring agents in food systems. Bread prepared from OFSP puree can create new economic and employment opportunities for farmers and rural households and can add nutritional value to food systems. However, the introduction of foods is to be made with caution, and issues such as safety, acceptability and nutrient bioavailability need to be considered. The demand for bakery products and import of wheat are increasing. Adding appropriate proportion of OFSP puree to wheat flour could have an advantage on the nutritional and economical aspects. Therefore, the aim of this study was to develop nutrient rich value-added biscuit through incorporation of OFSP puree.

II. MATERIALS AND METHODS

The experiments were carried out at Super Tasty Food Product Factory, Gana Unnayan Kendra (GUK), Nashratpur, Gaibandha district in 2021. The biscuits were developed through incorporation of sweetpotato puree. Four orange-fleshed sweetpotato (OFSP) varieties viz. BARI SP-4, BARI SP-8, BARI SP-12, BARI SP-15 and a popular white flesh local Sweetpotato variety were used in this study. Eleven treatments were used for making biscuits following Completely Randomized Design (CRD). The treatments were as follows , T_1=40% BARI SP 4+60% Wheat Flour, T_2=40% BARI SP 8 +60% Wheat Flour, T_3=40% BARI SP 12+60% Wheat Flour, T_4=40% BARI SP 15+60% Wheat Flour, T_5=40% Local Variety+60% Wheat Flour, T_6=20% BARI SP 4+80% Wheat Flour, T_7=20% BARI SP 8+80% Wheat Flour, T_8=20% BARI SP 12+80% Wheat Flour, T_9=20% BARI SP 15+80% Wheat Flour, T_{10}=20% Local Variety+80% Wheat Flour and T_{11}=100% Wheat Flour. The following steps were followed for making biscuits:

Step-I: Processing of orange-fleshed sweetpotato roots into puree

Initially, four BARI released OFSP varieties viz., BARI SP 4, BARI SP 8, BARI SP 12 and BARI SP 15 were collected from Development and Delivery of Biofortified Crops at Scale (DDBIO) project areas of Gaibandha district. Local variety of sweetpotato was collected from a farmer's field of Gaibandha. The roots were washed to remove all soil and dust particles and then boiled. After boiling, the skins of the roots were removed, and purees were prepared from each variety using an electric mixer.

Step II: Development of baking products

For preparation of biscuits, treatment wise basic ingredients were used. Other ingredients were used the same amount in every baking product for making biscuits. The standard procedures for making biscuit were followed as per GUK's Super Tasty Food Product Factory protocol.

Table 1. Ingredients used in biscuits

SL No.	Name of Ingredients	Amount
1	Sugar	600 gm
2	Oil	250 ml
3	Egg	60 ml
4	Salt	10 gm
5	Flavor	10 gm
6	Dalda	350gm

Nutrient Analysis of Biscuits:

Beta-carotene and vitamin C analyses of biscuits were done at the Food Processing and Preservation Laboratory of Hajee Mohammad Danesh Science and Technology University, Dinajpur and, Zinc and Iron content of bakery products were analyzed at the Soil Resources and Development Institute (SRDI), Dinajpur. β-carotene was determined according to the method of Nagata and Yamashita (1992). Vitamin C content of the products was estimated by titration method (Ranganna, 1986) using 2, 6- dichlorophenol indophenol dye solution. Iron and Zinc content were determined by Atomic Absorption Spectrophotometric methods directly in the undiluted filtrate following analytical method described by Petersen (2016).

Sensory Evaluation:

The biscuits developed through OFSP puree were subjected to sensory evaluation by a 15-members, semi trained panel made up of individuals who are familiar with the quality attributes of the products and do taste testing of the products regularly (factory experts, technical persons and students). The evaluations were done on 13 June 2021. Panelists were evaluated biscuit samples presented in a random order for appearance, color and taste, using scale 5=Very good, 4=Good, 3=Fair, 2=Bad and 1=Very bad and crispiness was evaluated using scale 5= Much more crunchy than I like, 4=More crunchy than I like, 3 = The way I like it; 2=Less crunchy than I like and 1 = Much less crunchy than I like). Overall acceptability was also measured using scale 5= Highly acceptable, 4=Acceptable, 3=Neutral, 2=Less acceptable and 1= Not acceptable.

Method of Data Analysis:

Data on different parameters were analyzed following Statistical Tools for Agriculture Research (STAR) software. Sensory evaluation results were expressed as the mean ± standard error (SE).

III. RESULTS AND DISCUSSION

Determining the beta-carotene, vitamin C, zinc and iron content are important for identifying and recommending acceptance and preference of the biscuits for the potential end users. The result of beta-carotene, vitamin C, zinc and iron content are shown in Table 2 and Table 3. The beta-carotene, vitamin C, zinc and iron content of biscuit, bread and cake varied significantly ($p<0.05$) depending on the formulations (treatment).

A) Beta carotene, vitamin C, zinc and iron content of biscuits

Considering beta carotene content, significant variation was observed in biscuits regardless of treatments. The highest beta carotene content was found in T_4 treatment (1.67 mg/100g) followed by T_9 (0.84 mg/100g) and T_1 (0.80 mg/100g) and the lowest was recorded in T_{11} treatment (0.01 mg/100g) (Table 2). This may be happened due to varietal characteristics of sweetpotato (SP) puree used in the treatments, as higher beta carotene content was recorded in the treatments where OFSP varieties puree was used, on the other hand, lowest beta carotene was recorded in T_{11} treatment where white fleshed SP variety puree was used.

The vitamin C content in biscuit products also varied significantly among the treatments. The vitamin C in biscuits was found the highest in T_5 treatment (1.81 mg/100g) which as statistically similar to T_1 (1.74 mg/100g) and no vitamin C was recorded in T_{11} treatment (Table 2). This may be also observed due to the variation of vitamin C content of the used sweetpotato varieties in different treatments.

Zinc content in biscuits was varied significantly in different treatments. In all the treatments, T_{11} treatment (biscuit made from 100% wheat flour) exhibited the highest zinc content (2.04 mg/100g) followed by T_3 treatment (1.84 mg/100g) and the lowest was recorded in T_5 (1.12 mg/100g) (Table 2). This may be happened due to the presence of higher amount of zinc in wheat flour.

Iron content also showed significant variation among the treatments. The treatment T_3 showed the highest iron content (6.52 mg/100g) which is statistically similar to T_2 (6.43mg/100g) and T_8 (6.09 mg/100g) (Table 2). The lowest iron content was recorded in T_4 treatment (2.84 mg/100g) that was statistically similar to T_5 treatment (2.95 mg/100g) (Table 2).

B) Sensory Evaluation of Biscuits

Sensory quality of any food products measures degree of acceptance (Muresan *et al.*, 2012). Sensory characteristics such as appearance, flavor, taste, crispiness and overall acceptability were considered for this study.

The entire sensory properties of biscuit are presented in Table 3. Appearance is the primary key attributes for accepting any food products by the consumers. Appearance score of the biscuits was ranged from 3.07±0.18 to 4.47±0.17. Biscuit made by T_4 formulation scored the highest compared to other formulations. The result revealed that appearance of biscuits of all formulations were varied from fair to very good.

Table 2. Beta carotene, Vitamin C, Zinc and Iron content of biscuit made from different formulations OFSP puree and wheat flour

Treatments	Beta carotene (mg/100g)	Vitamin C (mg/100g	Zinc content (mg/100g)	Iron Content (mg/100g)
T_1	0.80 b	1.74 a	1.30 e	4.31 b
T_2	0.19 f	1.26 c	1.32 e	6.43 a
T_3	0.59 c	1.55 b	1.84 b	6.52 a
T_4	1.67 a	1.61 b	1.15 f	2.84 d
T_5	0.02 h	1.81 a	1.12 f	2.95 d
T_6	0.40 d	0.91 de	1.22 ef	3.70 c
T_7	0.10 g	0.66 g	1.71 bc	4.37 b
T_8	0.30 e	0.82 f	1.53 d	6.09 a
T_9	0.84 b	0.84 ef	1.63 cd	3.62 c
T_{10}	0.02 h	0.95 d	1.53 d	4.06 bc
T_{11}	0.01 h	0.00 h	2.04 a	3.83 c
CV (%)	3.76	2.30	3.37	3.47

Note: T_1=40% BARI SP 4+60% Wheat Flour, T_2=40% BARI SP 8 +60% Wheat Flour, T_3=40% BARI SP 12+60% Wheat Flour, T_4=40% BARI SP 15+60% Wheat Flour, T_5=40% Local Variety+60% Wheat Flour, T_6=20% BARI SP 4+80% Wheat Flour, T_7=20% BARI SP 8+80% Wheat Flour, T_8=20% BARI SP 12+80% Wheat Flour, T_9=20% BARI SP 15+80% Wheat Flour, T_{10}=20% Local Variety+80% Wheat Flour and T_{11}=100% Wheat Flour; Means with the same letter are not significantly different.

Table 3. Sensory properties of biscuits made from different formulations of OFSP puree and wheat flour

Treatment	Appearance	Flavor	Crispiness	Taste
T_1	3.27±0.25	3.40±0.21	2.87±0.19	3.40±0.19
T_2	4.13±0.24	3.87±0.13	3.53±0.17	3.87±0.19
T_3	3.60±0.16	3.40±0.27	3.87±0.19	3.80±0.22
T_4	4.47±0.17	4.20±0.24	3.27±0.33	3.93±0.25
T_5	3.73±0.18	3.27±0.18	3.67±0.23	3.67±0.21
T_6	3.67±0.21	4.00±0.17	3.87±0.22	3.93±0.18
T_7	4.00±0.10	3.80±0.20	3.80±0.17	3.93±0.12
T_8	4.20±0.17	3.60±0.21	4.07±0.21	4.07±0.18
T_9	4.13±0.09	3.93±0.18	4.33±0.16	4.00±0.14
T_{10}	3.07±0.18	3.93±0.15	3.87±0.13	3.93±0.21
T_{11}	3.91±0.07	3.59±0.11	3.88±0.13	3.75±0.13

Note: T_1=40% BARI SP 4+60% Wheat Flour ,T2=40% BARI SP 8 +60% Wheat Flour, T_3=40% BARI SP 12+60% Wheat Flour, T_4=40% BARI SP 15+60% Wheat Flour, T_5=40% Local Variety+60% Wheat Flour, T_6=20% BARI SP 4+80% Wheat Flour, T_7=20% BARI SP 4+80% Wheat Flour, T_8=20% BARI SP 4+80% Wheat Flour, T_9=20% BARI SP 12+80% Wheat Flour, T_{10}=20% BARI SP 15+80% Wheat Flour, and T_{11}=100% Wheat Flour; Overall Scale: 5-Very good; 4-Good; 3-Fair; 2-Bad and 1-Very bad

Flavor score of the biscuit was between 3.27±0.18 to 4.20±0.24 and it was also ranged from fair to very good of all formulations (Table 3).

Crispiness represents the key textural attributes of dry snacks products; denoting freshness and high quality, generally a crisp should be firm and snaps easily when bent, emitting a crunchy sound (Dueik *et al*., 2010). From the Table 3 shows that crispness score of the biscuits ranged from 2.87±0.19 to 4.33± 0.16. Biscuits made with T_9 formulation recorded higher crispiness (4.33± 0.16) followed by T_8 (4.07±0.21) while the biscuits made with T_1 formulation scored the lowest (2.87±0.19).

Regarding taste scores, the biscuits score ranged between 3.40±0.19 and 4.07±0.18 (Table 3). The taste acceptance score of all biscuits made from different formulations were more or less similar and treated as fair to very good (Table 3).

The overall acceptability score of biscuits was found the highest in T_9 formulation and it was 4.00 and the lowest acceptability score (3.20) was found in T_1 formulation. All the biscuits made from different formulations were accepted as fair to good by the panelist (Fig 1.).

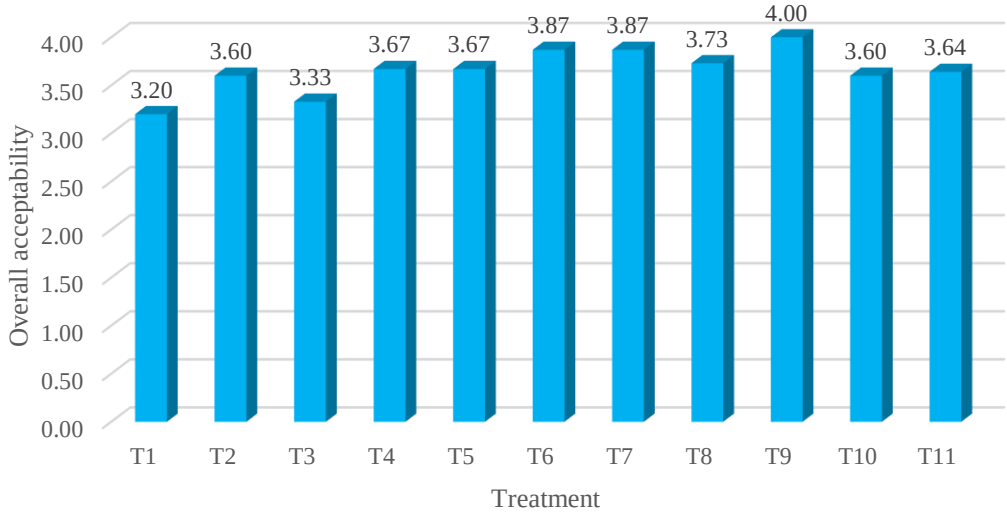

Fig. 1. Overall acceptability of biscuit made from different formulations of OFSP puree and wheat flour

Note: T_1=40% BARI SP 4+60% Wheat Flour T2=40% BARI SP 8 +60% Wheat Flour, T_3=40% BARI SP 12+60% Wheat Flour, T_4=40% BARI SP 15+60% Wheat Flour, T_5=40% local variety+60% Wheat Flour, T_6=20% BARI SP 4+80% Wheat Flour, T_7=20% BARI SP 8+80% Wheat Flour, T_8=20% BARI SP 12+80% Wheat Flour, T_9=20% BARI SP 15+80% Wheat Flour, T_{10}=20% Local Variety+80% Wheat Flour, T_{11}=100% Wheat Flour; Overall Scale: 5= Highly acceptable, 4=Acceptable, 3=Neutral, 2=Less acceptable and 1= Not acceptable

IV. CONCLUSION

According to the findings of the above study, it could be concluded that when orange fleshed sweetpotato puree is potentially used as food ingredient in biscuits preparation, it can enrich beta carotene, vitamin C and iron content but not enriches zinc content. Based on their overall nutrient contribution, T_4 formulation contributed the highest beta carotene content followed by T_9 formulation, T_5 formulation contributed the highest vitamin C and T_3 formulation contributed maximum iron content followed by T_2 and T_8 in the biscuits. The sensory attributes of the biscuits developed from OFSP puree accepted by the panelists as fair to very good, indicating that all are accepted but T_9 formulation are well accepted. Due to higher acceptability, T_9 formulation could be used for the development of nutrient rich value-added biscuits which may be the best substitutes for wheat flour and possibly for other baking products in Bangladesh.

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Phytochemical Screening of *Ricinus communis* and *Erigeron bonariensis*

Gajanan D. Wadankar, Manasi S. Khanzode, Bhagyashri K. Mahale and Anjali P. Gavhale

Post Graduate Department of Botany, R. A. Arts, Shri M. K. Commerce and Shri S. R. Rathi Science Mahavidyalaya, Washim-444505, Maharashtra, India.
E-mail: gdwadankar@gmail.com

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Abstract— *Ricinus communis and Erigeron bonariensis were selected and aimed to investigate the presence of phytochemicals in leaf and stem. Aqueous, Acetone and Methanol Solvents were used for phytochemical analysis. Our findings provides evidence, that aqueous and organic solvent extracts of these plants contain medicinally important bioactive compounds.*

Keywords— ***Ricinus communis, Erigeron bonariensis Phytochemicals screening, Qualitative.***

I. INTRODUCTION

Phytochemicals generally originated from the plant source are bioactive compounds also known as secondary metabolites. These are synthesized in almost all parts of plants and are used by the local peoples for healing of certain disorders [1-2].

Plants product have been part of phytomedicines since time immemorial. This can be derived from barks, leaves, flowers, roots , fruit, seeds. Knowledge of the chemical consitiuents of plants is desirable because such information will be value for synthesis of complex chemical substances [3].

Medicinal plants contain some organic compounds which provide definite physiological action on the human body and these bioactive substances include tannins, alkaloids, carbohydrates, terpenoids, steroids and flavonoids [4]. These compounds are synthesized by primary or rather secondary metabolism of living organisms. Secondary metabolites are chemically and taxonomically extremely diverse compounds with obscure function. They are widely used in the human therapy, veterinary, agriculture, scientific research and countless other areas [5]. A large number of phytochemicals belonging to several chemical classes have been shown to have inhibitory effects on all types of microorganisms in vitro [6].

Plant products have been part of phytomedicines since time immemorial. This can be derived from barks, leaves, flowers, roots, fruits, seeds [7]. Knowledge of the chemical constituents of plants is desirable because such information will be value for synthesis of complex chemical substances [8-10].

The present study was undertaken to evaluate the phytochemical analysis of *Ricinus communis* and *Erigeron bonariensis*, stem and leaves.

II. MATERIALS AND METHODS

Collection of plant material

Fresh plant material of *Ricinus communis* and *Erigeron bonariensis* were collected from different regions of Washim district, Maharashtra, India. It commonly occur in cultivated land, along with roadside, Shady & moist places. plant material washed under running tap Water 2-3 times to remove soil particles and dust. the plant material were shaded for 12 days. After drying plant materials grinded into fine powder using mechanical blender and

then transfer into airtight Container with proper labeling for further use.

Preparations of solvent Extracts

Stem and leaves of the *Ricinus communis* and *Erigeron bonariensis* were thoroughly washed with running tap water 2-3 times and then finally washed with distilled water followed by shade-dried for seven days and then dried in an oven below 50ºC. The dried plant materials were then powdered using mixer and grinder. 30g of plant powder were extracted with 100ml of aqueous, acetone and methanol. After 24 hours, it was filtered through a filter paper, filtrate was collected. Test can be Conducted then and there it self after Collection or Can be stored in refrigerator for Conducting test later.

Phytochemical screening

Extracts of stem and leaves of *Ricinus communis* and *Erigeron bonariensis* using aqueous, acetone and methanol were subjected to various chemical tests in order to determine the secondary plant constituents [11]:

Test for Alkaloids

Mayer's test

A few drop of Mayer's reagents was added the Turbidity of the resulting precipitate indicates positive test for alkaloids.

Test for Tannins

A few chops of 0.1% ferric chloride was added and observed blackish-blue or brownish green Coloration indicates the Presence of Tannins.

Test for saponins

Extract was mixed with 5 ml of distilled Water in a test tube and then it was shaken vigorously, formation of stable foam indicates presence of Saponins.

Test for Flavonoids

Extract were treated with few drops of lead acetate solution yellow Coloration indicates. The presence of flavonoids.

Test for phenol

Crude Extract were treated with 3-4 drops of ferric chloride solution. bluish black or blue green colour indicate positive test for phenol.

Test for Terpenoids

(Salkowski test)

Extract was mixed in 2 ml of chloroform and concentrated H_2SO4 (3ml) was carefully added to form a layer. A radish brow coloration of thin inter face was formed it indicates positive test for terpenoids.

Test for amino acids

Ninhydrin test

Crude extract when boiled With 2 ml of 0.2% Solution of Ninhydrin Violet color indicates the presence of amino acids.

Test for Carbohydrates

Benedict's test

2 ml of Benedict's reagent added and heated on boiling Water bath for 2 min. reddish brown precipitate indicates the presence of Carbohydrates.

Test for Glycosides

To known volume of extract 1 ml of distilled Water added and aqueous solution of NaOH was added formation of yellow color indicates positive test for Glycosides.

III. RESULTS AND DISCUSSION

Phytochemical analysis of aqueous, acetone and methanol extract of *Ricinus communis* and *Erigeron bonariensis* shows positive test for tannin. Alkaloids, saponins, carbohydrates and amino acids were absent in the all extracts of *Erigeron bonariensi.* Carbohydrates were present in methanol extract of leaf and stem of *Ricinus communis.* Amino acids were present in the aqueous extract of stem of *Ricinus communis*. Glycoside were present in all extracts of *Ricinus communis*. The results of phytochemical contents stem and leaf in Aqueous, Acetone and Methanol extracts of *Ricinus communis* and *Erigeron bonariensis* are reported in Table 1 (Fig. 1 to 3), Table-2 (Fig. 4 to 6) and Table-3 (Fig. 7 to 9), Table 4 (Fig. 10 to 12), respectively.

Table 1: Phytochemical analysis of stem of Ricinus communis

Test	Aqueous	Acetone	Methanol
Alkaloid	+	-	+
Tannin	+	+	+
Saponin	+	+	-
Flavonoid	+	+	-
Phenol	+	+	+
Terpenoids	+	-	+
Amino acid	+	-	-
Carbohydrate	-	-	+
Glycoside	+	+	+

Fig. 1 Phytochemical analysis of Aqueous extract of stem of Ricinus communis

Fig. 2 Phytochemical analysis of Acetone extract of stem of Ricinus communis

Fig. 3 Phytochemical analysis of Methanol extract of stem of Ricinus communis

Table 2: Phytochemical analysis of leaf of Ricinus communis

Test	Aqueous	Acetone	Methanol
Alkaloid	-	-	+
Tannin	+	+	+
Saponin	+	+	-
Flavonoid	+	+	-
Phenol	+	+	+
Terpenoids	-	-	+
Amino acid	-	-	-
Carbohydrate	-	-	+
Glycoside	+	+	+

Fig. 4 Phytochemical analysis of Aqueous extract of leaf of Ricinus communis

Fig. 5 Phytochemical analysis of Acetone extract of leaf of Ricinus communis

Fig. 6 Phytochemical analysis of Methanol extract of leaf of Ricinus communis

Table 3: Phytochemical analysis of stem of Erigeron bonariensis

Test	Aqueous	Acetone	Methanol
Alkaloid	-	-	-
Tannin	+	+	+
Saponin	-	-	-
Flavonoid	+	+	+
Phenol	+	+	+
Terpenoids	-	-	-
Amino acid	-	-	-
Carbohydrate	-	-	-
Glycoside	+	+	+

Fig. 7 Phytochemical analysis of Aqueous extract of stem of Erigeron bonariensis

Fig. 8 Phytochemical analysis of Acetone extract of stem of Erigeron bonariensis

Fig. 9 Phytochemical analysis of Methanol extract of stem of Erigeron bonariensis

Table 4: Phytochemical analysis of leaf of Erigeron bonariensis

Test	Aqueous	Acetone	Methanol
Alkaloid	-	-	-
Tannin	+	+	+
Saponin	-	-	-
Flavonoid	+	-	-
Phenol	+	+	+
Terpenoids	+	-	-
Amino acid	-	-	-
Carbohydrate	-	-	-
Glycoside	-	-	+

Fig. 10 Phytochemical analysis of Aqueous extract of leaf of Erigeron bonariensis

Fig. 11 Phytochemical analysis of Acetone extract of leaf of Erigeron bonariensis

Fig. 12 Phytochemical analysis of Methanol extract of leaf of Erigeron bonariensis

IV. CONCLUSION

The *Ricinus communis* and *Erigeron bonariensis* this plants are source of secondary metabolites and the solvent choice is very important for extraction of Phytochemical from plants. Medicinal plants are helpful for discovering and Manufacturing of new drugs. The research on *Ricinus communis* and *Erigeron bonariensis* plants which can be medicinally important.

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Estimation of true preceacal phosphorus digestibility of phytase supplemented groundnut cake in broiler chicken

Asiruwa, P.O*, Iyayi, E. A.

Department of Animal Science, Faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Nigeria
*Corresponding author: poasiruwa@gmail.com

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Abstract— *An experiment was conducted to investigate effect of phytase supplemented groundnut cake (GNC) on endogenous preceacal phosphorus loss (EPPL) and true preceacal phosphorus digestibility (TPPD) in broiler chickens using regression technique. A total of 300, one-day-old, unsexed broiler chickens were raised on standard commercial starter diet. At day 20, selection for 216 male broilers chicks was made and chicks were completely randomized and allotted to 6 dietary treatments in 3×2 factorial arrangement with 3 levels of P (1.40, 2.66 or 3.96 g/kg diet) obtained from varying proportions of GNC and 2 levels of microbial phytase (0 FTU/kg or 1000 FTU/kg), feeding trial lasted for 7 days. With inclusion of chromic oxide in experimental diets, the index method (Adeola, 2001) was used to calculate apparent preceacal phosphorus digestibility (APPD). Generated regression curve obtained from the relationship between preceacal digested P and dietary P intake was used to calculate EPPL and TPPD. Results showed that increasing P intake had linear effect ($p<0.05$) on body weight gain and feed to gain ratio. Neither P, phytase nor their interaction affected ($p>0.05$) feed intake, dry matter intake and tibia ash of the birds. Addition of phytase resulted in 44.1% reduction in preceacal P output, while levels of P, phytase and interaction linearly increased ($p<0.05$) digested P and retained P from GNC. From the regression curve, phytase improved TPPD of groundnut cake in birds by 34.48% with a 52.27% reduction in EPPL. True preceacal P digestibility of GNC in 28 days-old, broiler chickens improved with 1000units phytase supplementation of GNC*

Keywords— ***preceacal, digestibility, endogenous, phosphorus, groundnut cake.***

I. INTRODUCTION

Oil seed meals (OSM), which make up 25 to 35% of formulated diets for poultry feed usually, have high protein and P contents. Apart from soyabean meal, a closely ranked OSM commonly used in poultry feed is groundnut cake (GNC), a by-product obtained after oil extraction from groundnut seeds. According to Raboy (1997), about 65-80% of P in vegetative feed ingredients is bound as phytate-P complex. The poor utilisation of complexed P tends to limit amount of P from OSM available to poultry birds. Sequel to this, strategies have been documented to further improve available P from OSM for use by birds. One of such strategies have led to the need for continuous measure of available P in poultry feed ingredients (Rodehutscord,2009; Mutucumarana, 2014) and results expressed on "apparent digestibility" basis, without accounting for endogenous P loss. Although, endogenous loss of nutrients is well documented as an inevitable loss from the animal but contribution to such loss from dietary origin cannot be ignored and needs to be accounted for. According to Butt *et al,* (1993), ingredient specific factors constitute a portion of endogenous loss of nutrient. To circumvent this limitation, Currently, expressions for P is being canvassed on "true digestibility" basis. To this end, techniques that simultaneously estimate TPPD, true total tract retention and EPPL for P have been reported; radioactive labelled isotope technique (Al-Masri, 1995),

regression approach (Fan *et al*., 2001, Adeola and sands, 2006) and P-free diet method (Petersen and Stein, 2006).

The use of exogenous phytase to make more P available from phytate-P complex is another known strategy. To a large extent findings from research conducted on poultry and pigs have demonstrated benefits of microbial phytase to include improved digestibility of P, calcium and Zinc (Paiva *et al*., 2014). Studies of (Fan *et al*., 2001; Ajakaiye *et al*., 2003; Dilgner and Adeola, 2009; Iyayi *et al*., 2013; Mutucumarana, 2014). estimated TPPD, true total tract P retention and EPPL of feed ingredients in poultry and pigs. However, investigation on TPPD from phytase supplemented-GNC in broiler chicks is limited. Therefore, this study aims to estimate EPPL and TPPD of 28-day-old broiler chickens fed phytase supplemented GNC.

II. METHOD

2.1 Experimental diets

A total of six semi-purified diets containing; 210, 420 or 630g of GNC, with or without phytase at dose of 1000 *FTU*/kg were formulated (table 1). Adjustment for calcium: P ratio and energy were made using limestone and soy oil, respectively. Chromic oxide (Cr_2O_3) at a rate of 5g/kg of diet served as indigestible marker. Exogenous phytase was BASF Natuphos® phytase (3-phytase derived from *Aspergillus niger*) and inclusion was based on dosage recommendation to obtain dose rate of 1000 FTU/kg.

Table1. Gross composition of experimental diets (g/kg) (as-fed basis)

	PHYTASE (0 FTU/ Kg diet)			PHYTASE (1000 FTU/ Kg diet)		
Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
GNC	**210.00**	**420.00**	**630.00**	**210.00**	**420.00**	**630.00**
Cassava Starch	**588.50**	**334.20**	**105.90**	**578.50**	**324.20**	**95.90**
wheat gluten	130.00	130.00	130.00	130.00	130.00	130.00
Soy oil	2.00	44.00	60.00	2.00	44.00	60.00
Dextrose	35.00	35.00	35.00	35.00	35.00	35.00
Methionine	1.00	1.00	1.00	1.00	1.00	1.00
Lysine	1.00	1.00	1.00	1.00	1.00	1.00
Limestone	**2.50**	**4.80**	**7.10**	**2.50**	**4.80**	**7.10**
Vitamin-Premix	2.50	2.50	2.50	2.50	2.50	2.50
Salt	2.50	2.50	2.50	2.50	2.50	2.50
[1]Phytase premix	0.00	0.00	0.00	10.00	10.00	10.00
[2]Chromium oxide Premix	25.00	25.00	25.00	25.00	25.00	25.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated Nutrients (g/kg)						
ME (Kcal/Kg)	3173.21	3126.75	2964.13	3138.31	3091.85	2911.23
Crude protein	200.13	294.63	389.13	200.13	294.63	389.13
Calcium (Ca)	1.44	2.76	4.07	1.44	2.76	4.07
Phosphorus (P)	1.40	2.66	3.96	1.40	2.66	3.92
Ca : P (ratio)	1.03	1.04	1.04	1.03	1.04	1.04

[1]Phytase premix prepared by mixing phytase with maize. [2]Chromic oxide premix prepared by mixing 1g of chromic oxide with 4g of maize

Management of experimental birds

A total of 300, one-day-old, unsexed broiler chickens were raised on standard commercial starter diet. At day 20, selection for 216 male broilers chicks was made, each was tagged and weighed individually and were completely randomized before allotment to the six experimental diets in 3×2 factorial arrangement with 3 levels of P (1.40, 2.66 or 3.96 g/kg) arising from varying proportions of GNC and 2 levels of phytase (0 *FTU*/kg or 1000 *FTU*/kg). Six replicate cells were allotted to each dietary treatment and six birds per replicate cell. Allotment was done using an allotment programme of Kim and Lindemann, (2007). Birds were housed in metabolic cage containing 36 cells and during the 7 days feeding trial birds had access to clean water.

Data and sample collections

Feed intake was calculated on cell basis. Weighing at day 20 and 28 on cell basis to calculate average body weight changes. On day 28, birds were euthanized by carbon (IV) oxide for preceacal digesta collection from the two-third distal, end of the ileum using procedure of Rodehutscord *et al*., (2012). Preceacal digesta samples were milled and stored for analyses. Left tibiae from 4 birds were processed for determination of tibia ash.

Chemical analyses

Dry matter (DM) content for diets and preceacal digesta samples were analysed according to (AOAC International, 2005; method no: 930.15). Ashed samples for P and calcium were determined spectrophotometrically (FAO, 2011). Chromium (Cr) concentration in feed, preceacal digesta was determined by colorimetric method following digestion of ashed samples with nitric and perchloric acids with absorbance reading at 440ωm. Crude protein for GNC, diets and preceacal digesta samples were determined by total combustion method (AOAC International, 2005; method no: 968.06). Gross energy of GNC and diets was assayed using adiabatic bomb calorimetry standardized with benzoic acid.

Calculations

Apparent preceacal phosphorus digestibility (APPD) was calculated using index method according to Adeola, (2001)

$$\text{APPD (\%)} = 100 - \left(\left({}^{Cr_i}/_{Cr_o}\right) \times \left(\left({}^{P_o}/_{P_i}\right) \times 100\right)\right)$$

Cr_i is concentration of chromium in feed, Cr_o is chromium concentration in preceacal digesta, P_o represents phosphorus concentration from preceacal digesta and P_i denotes phosphorus intake from feed ingested. Analysed values were expressed as gramme per kg DM

Statistical analyses

Data were analysed using GLM procedure in SAS, (2004) and orthogonal polynomial contrasts were used to determine effects of P and phytase at 5% level of significance. Dietary P intake was expressed as P intake per kg DM intake. Preceacal digested P or total tract retained P (g/kg DM intake was regressed against P intake (g/kg DM) for (0 or 1000) *FTU* /kg, respectively, using the statistical linear regression model:

$$P_D = (TDP) \times P_I \pm EPPL$$

Where P_D represents preceacal digested P, EPPL represents intercept of regression curve. P_I represents P intake, slope estimates TPPD.

III. RESULTS

From tables 2 and 3, calculated CP values were higher than analysed values, while analysed calcium (Ca) values were higher than calculated values. Except for amount of P supplied at 210g of GNC, calculated P concentrations were higher than corresponding analysed values. Despite slight differences between analysed and calculated values, clear linear increase was obtained for CP, P and Ca.

Table 2. Analysed nutrient composition of GNC (as fed)

Composition	% (g/100g)
Dry matter	90.37
Crude protein	43.69
Ether extract	9.64
Calcium	0.09
Total phosphorus	0.36
Gross energy (kcal/kg)	4611.28

[1] each value is a mean of triplicate analysis

Table 3. Analysed nutrient composition of experimental diets

	Phytase, 0 FTU/kg			Phytase, 1000 FTU/kg		
	GNC 210g	GNC 420g	GNC 630g	GNC, 210g	GNC 420g	GNC 630g
Composition (%)						
Dry matter	93.00	91.58	92.68	92.62	93.09	90.37
Crude protein	19.25	23.10	36.75	17.15	25.90	35.35
Calcium	0.29	0.56	0.83	0.27	0.51	0.91
Total P (P)	0.17	0.22	0.29	0.16	0.27	0.29
Gross energy (kcal/kg)	4154	4126	3991	4137	4135	3887

[1] each value is a mean of triplicate analysis

Table 4. Selected growth performance indices and percentage tibiae ash of experimental birds

	Phytase (0 FTU/kg)			Phytase (1000 FTU/kg)				P-value						
											Without Phytase		With Phytase	
Measurements	GNC 210g	GNC 420g	GNC 630g	GNC 210g	GNC 420g	GNC 630g/	Pooled SEM[3]	Phytase	Phosphorus	Interaction	L^2	Q^2	L^2	Q^2
Feed intake (g/bird)	325.19	353.44	350.11	359.22	377.31	346.55	7.71	0.257	0.465	0.603	0.435	0.566	0.582	0.280
Dry matter intake(g/bird)	169.34	169.26	156.55	182.86	178.37	180.29	4.49	0.103	0.786	0.799	0.419	0.642	0.885	0.828
Body weight gain(g/bird)	59.57[a]	106.97[b]	139.08[c]	66.55[a]	105.39[b]	141.67[c]	6.49	0.746	<0.001	0.912	<0.001	0.601	<0.001	0.769
Feed : gain ratio	5.27[a]	3.38[b]	2.67[b]	5.15[a]	3.62[b]	2.47[b]	0.23	0.932	<0.001	0.792	<0.001	0.070	<0.001	0.406
Tibiae ash (%)	52.29[a]	47.66[ab]	44.95[b]	50.75[ab]	47.61[ab]	52.11[a]	0.95	0.309	0.198	0.125	0.025	0.902	0.557	0.946

[a b c] Means in a row with different superscripts are significantly different from each other (P<0.05) [1]Each value represents the mean of 6 replicates (6 birds/replicate) L^2 = Linear effect Q^2 = Quadratic effect (P=0.05) [3] Pooled standard error of mean, *P-Phosphorus

Table 5. Dietary P, P outputs and calculated phosphorus response criteria for experimental birds

Measurements	Phytase, 0 FTU/kg			Phytase, 1000 FTU/kg				P-value						
											Without Phytase		With Phytase	
	GNC 210g	GNC 420g	GNC 630g	GNC 210g	GNC 420g	GNC 630g	Pooled SEM[3]	Phytase	Phosphorus	interaction	L^2	Q^2	L^2	Q^2
P intake (g/kg DM)	1.82	2.35	3.16	1.71	2.94	3.26								
Preceacal P output (g/kg DMI)	0.38^{ac}	0.60^{a}	0.98^{b}	0.22^{c}	0.31^{cd}	0.57^{ad}	0.06	0.001	<0.001	0.435	0.003	0.523	0.001	0.743
Total tract P output	0.61^{a}	1.09^{b}	1.95^{c}	0.71^{ab}	0.73^{ab}	1.07^{b}	0.09	0.002	<0.001	0.006	<0.001	0.067	0.030	0.755
Preceacal Digested P	1.44^{a}	1.74^{c}	2.17^{c}	1.49^{b}	2.62^{d}	2.68^{d}	0.05	<0.001	<0.001	0.002	0.001	0.647	<0.001	<0.001
Total tract Retained P	1.21^{a}	1.25^{a}	1.20^{a}	0.37^{b}	2.20^{c}	2.18^{c}	0.12	0.006	<0.001	<0.001	0.281	0.344	<0.001	0.001
Apparent preceacal P digestibility (%)	79.14^{ab}	74.51^{ac}	68.91^{c}	87.27^{b}	89.42^{b}	82.49^{ab}	9.68	<0.001	0.061	0.636	0.093	0.917	0.354	0.223

$^{a\,b\,c}$ Means in a row with different superscripts are significantly different from each other (P<0.05) [1]Each value represents the mean of 6 replicates (6 birds/replicate)

L^2 = Linear effect: Q^2 = Quadratic effect (P=0.05) [3] Pooled standard error of mean, DM= dietary dry matter content, DMI = dry matter Intake, P-Phosphorus

Selected growth performance indices

As depicted in table 4, feed intake per bird showed no significant ($p>0.05$) response to either P or phytase supplementation levels, similar trend was observed for dry matter intake. Regardless of phytase, increasing dietary P intake influenced ($p<0.05$) average weight gain of birds. On comparison, average weight gain of birds fed with or without phytase for a specific graded level of GNC did not differ ($p>0.05$). Linear ($p<0.05$) increase in average weight gain of birds due to increasing P intake with corresponding better feed:gain ratios, were observed. Tibiae ash of birds showed no variation ($p>0.05$), values ranged between 47.61 to 52.06%.

Phosphorus digestibility and retention indices

From table 5, preceacal digesta P output of birds were significantly ($p<0.001$) affected by effects of P levels and phytase supplementation. As dietary P increased, lower preceacal digesta P outputs were observed for birds on phytase supplemented GNC diets in comparison with values obtained for birds fed GNC without phytase. Phytase addition accounted for 31.3% reduction in total tract P voided for birds on GNC diets with phytase. Preceacal digested and total tract retained P were not only affected ($p<0.05$) by main effects and interaction, but increased linearly ($p<0.05$) as GNC increased.

For GNC without phytase, (figure 1), TPPD coefficient (slope of regression curve) was 0.589 with corresponding EPPL value of 356.4mg of P/kg DMI. For phytase supplemented GNC (as shown in figure 2), TPPD coefficient was 0.793 and endogenous P loss of 170.1mg of P/kg DM intake

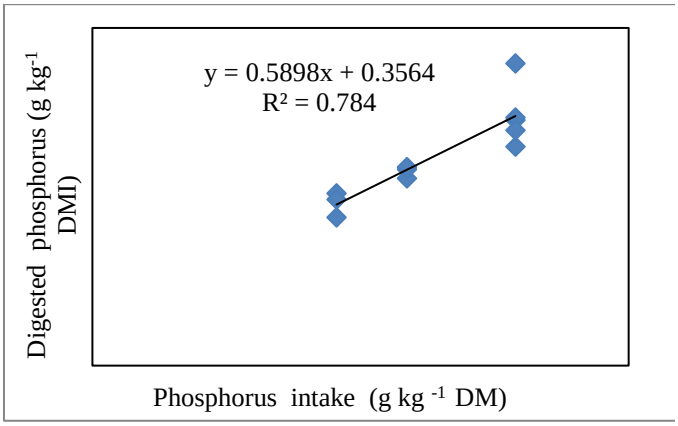

Fig. 1. Linear relationship between preceacal digested P and dietary P intake

Figure 1a. Regression curve for GNC without phytase supplementation

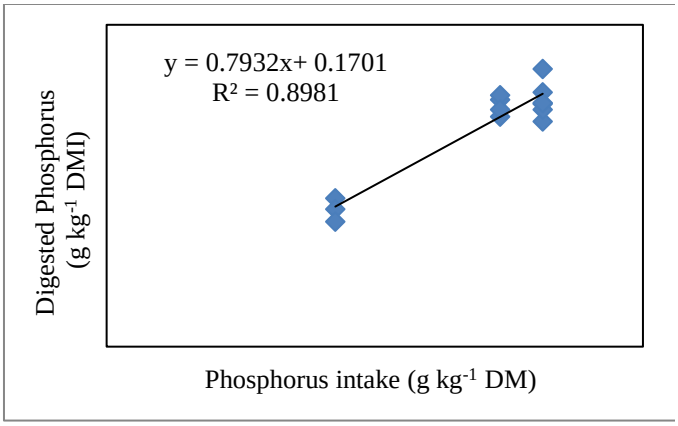

Figure 1b. Regression curve for phytase supplemented GNC

IV. DISCUSSION

Analysed dietary P in assay diets were close to calculated values except for P in diets containing 210g of GNC. Such differences between calculated and analysed values with regards to feeding P have been documented (Applegate and Angel, 2014). According to the authors, variations in ingredients nutrient profile, sampling and analytical procedures are usually associated with feeding P to broilers. It is important to note that despite the observed differences, graded proportions of GNC accounted for the increase in P across the diets, with latent increase in dietary protein supply to the birds even though research focus was not on dietary crude protein. From this study weight gain of birds increased as proportions of GNC increased. This observation indicates that at higher inclusions (430 or 645gm) of GNC, birds had more P available, for metabolic functions, skeletal development and body tissue growth. Lower body weight gain value was recorded for birds fed 210gm of GNC. Similar observation was also documented (Xue *et al*., 2016), who stated that low-crude protein diets decreased body weight gain and feed intake of experimental birds as well as compromising the absorption and utilisation of nutrients. Average weight gain values of birds fed 210g GNC mindless of phytase was 50-60% lower than those obtained for birds on 420 and 630g GNC. In addition, the dietary crude protein values at 210gm of GNC (17.5 or 19.2%) were lower than crude protein value range (22-24%) recommended for broiler starter chicks. Presumably, the extent to which birds fed 210gm of GNC were able to develop skeletal frame and body tissue growth seems affected by how much of P and protein are available in the diet. Such observation strongly indicates certain

relationship between P and protein. As described (NRC, 2012), there exist correlation between whole body content of N and P, stating that a reduction in one nutrient inadvertently affect deposition of the other. In support of this finding, studies (Mahan *et al.*, 1980; Carter and Cromwell, 1998) demonstrated that higher P is required to maximise nitrogen deposition in pigs. For Ferguson *et al*, (1998) feeding adequate or reduced CP and P to broiler chickens had significant interaction on growth performance. Regardless of phytase, body weight gain in birds was attributed to increasing P intake as GNC inclusion increased. Similar findings were also reported by Liu *et al*, (2013) and Mutucumarana *et al*, (2014). The better feed:gain ratio observed for birds at higher dietary P intake further affirms that increasing P intake closer to total P requirement (4.5 to 5g/kg diet) for broiler chickens, provides more P for growth and bone mineralization. Tibia ash, a sensitive indicator of bone mineralization was not influenced, despite phytase supplementation and increasing P intake. This finding is similar to those of Liu *et al.*, (2013) and Iyayi *et al.*, (2013) who reported no effect on tibia ash from their respective investigations. This observation could be due to the duration of feeding, which may not be adequate to induce significant changes in tibia ash. The simultaneous decrease in preceacal P concentration, as well as improved P digestibility coefficients for birds on phytase supplemented GNC further emphasizes the ability of phytase in hydrolyzing phytate-P complexes to release P even in non-conventional semi-purified diets. From the current study it was observed that APPD values obtained for birds fed 210gm of GNC, was not different from values observed for birds on 420gm of GNC, in contrast weight gain differed. This suggest that APPD might be independent of dietary crude protein but influenced by amount of P supplied in 210gm of GNC. This observation can probably be that hemostatic effect might play a role in helping the birds to retain P, even when dietary P intake was lower than dietary P intake at 430gm, birds on both inclusion levels of GNC recorded similar APPD values. Although the assay diets (cassava starch, wheat gluten diets) were different from the conventional cornstarch-casein based diets but phytase was able to improve P digestibility and retention of GNC in birds. This could probably be attributed to the favourable prevailing factors that influence phytase efficiency. According to Dersjant Li *et al*., (2014), the efficiency of feed phytases *in vivo* depends on interplay of phytase, dietary and animal- related factors. One key component of dietary related factors is Ca: P ratio. From the current study, estimate of Ca: P from analysed values (from 1.69:1 to 3.13:1) were higher than those obtained from calculated values (1.03:1 to 1.04:1) despite diets were formulated to ensure similar Ca: P across the diets. The high Ca:P could be attributed to the increasing proportion of limestone while trying to make adjustment for similar ratio across the diets. Though higher Ca: P were observed in the current study when compared with those of Liu *et al*, (2013) but these ratios seem not to have created an un-favourable condition for phytase activity based on the results obtained. From the results of this study, strong linear relationships were observed between preceacal digested P and dietary P intake, a basic requirement for the application of the regression technique in TPPD estimation. To achieve this, graded levels of test feedstuff assayed must triggers a gradual linear increase in levels of the nutrient under study. Other authors have reported strong linear relationship between; preceacal digesta P outputs and dietary P intake, total tract P outputs and dietary P intake (Fan *et al*., 2001; Akinmusire and Adeola, 2009). The relationship permits theoretical estimation of EPPL (intercept) and TPPD from regression curve. From regression curves obtained in this study, TPPD for phytase supplemented GNC was 79.32%, which was 4.48 points higher than estimate value obtained by (Iyayi *et al*., 2013), on feeding phytase supplemented peanut flour diets to broiler chicks. In most documented reports corn-starch and casein were mainly used in formulation of semi purified diets as against cassava-starch and wheat gluten used in the current study. It can be posited whether the composition of semi-purified assay diets for specific test feed ingredient have influence on estimate values for TPPD and EPPL, using regression technique remains to be investigated. Addition of phytase to GNC reduced EPPL by 52.27% at preceacal sampling section.

V. CONCLUSION

In a nutshell, supplementation of GNC with Natuphos at 1000(*FTU*)/kg improved TPPD of GNC with a subsequent reduction in endogenous phosphorus loss of 28 days old broiler chicken.

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A Review of options for speeding the adoption of climate smart varieties: what works and what does not work: Experiences from Tanzania

Atugonza Luta Bilaro[1], George M. Tryphone[2]

[1]Tanzania Agricultural Research Institute -IFAKARA Centre, Private Bag, Ifakara, Morogoro – Tanzania.
Email: Atugonza.bilaro@tari.go.tz
[2]Department of Crop Science and Horticulture, Sokoine University of Agriculture, P. O. Box 3005, Chuo Kikuu, Morogoro, Tanzania.
Email: muhamba@sua.ac.tz

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Abstract— *Given the efforts invested on addressing climate change adaptation particularly in agriculture, the adoption of climate smart varieties has not met the expectations. A number of crop varieties developed targeting drought prone areas largely remained un-adopted hence unknown to the majority of farmers or lack traits deemed special for adaptation to climate change in target areas. Variety adoption rate is highly dependent on its adaptation to particular environmental conditions including suitability to tolerate drought, salinity and acidity and ability to meet different livelihood needs such food, fodder and cash. Poor adoption emanates from lack of awareness and the volatility of the farming environment coupled with poor integration of seed business into private public partnership. Rapid adoption of climate smart varieties in Tanzania would require better policy intervention with a well-organized extension system and modifications in variety testing procedures, including the current guidelines for variety release. In this work the authors discuss some approaches that can be used to enhance the adoption of climate smart varieties in Tanzania and cite a few specific cases based on experience from Tanzania.*

Keywords— ***climate smart varieties, adoption, food security, drought***

I. INTRODUCTION

Climate smart varieties encompass crop varieties that are adapted to climate related challenges such as drought, salinity, flooding, pests and disease (World Bank, 2015). Apart from adaptation, these varieties are expected to produce reasonable yield under stress conditions. Lack or poor adoption of varieties adapted to these challenges result into low yields, which in turn leads to land degradation as farmers are forced to clear more land for food and household income. At the same time, agriculture in rainfall dependent areas, like Africa, is dominated by smallholder farmers who operate on small plots ranging between 0.5 and 5 acres (Kalungu et al., 2013). The majority of farmers use traditional varieties that are not adapted to climate change. As a result, food production is under threat due to increased incidences of drought caused by climate change (Khatri-Chehtri et al., 2017). Any attempt to sell food to meet other basic needs put further strains on household food budget and results in negative food balance (Connolly-Boutin and Smit, 2016).

While agriculture is regarded as the engine for poverty reduction in most of rural areas, in recent years, the growth of the agricultural sector has stagnated due to climate change worldwide (Readon and Zilbermann, 2017). Lack of crop varieties that can tolerate/resist to extreme conditions such as drought and flooding has resulted in increased number of households suffering frequent famine (Khtri-Chhetri et al., 2017). Low food production is aggravated by high population growth rate which limit the land available for farming (Muyanga and Jayne, 2014). At the same time

intensive land-use to meet food production results in severe land degradation particularly in marginal areas (FAO, 2014). One of the options for mitigating the climate change impacts in agriculture is the use of climate smart or resilient varieties. However, adoption of these varieties particularly in Africa is below the expectations (Pandey et al., 2012). For example, in the 2016, the alliance for green revolution for Africa (AGRA)'s country progress report, indicated that up to now there are over 251 released varieties out of which 205 are commercialized in East Africa; yet only 1,196 337 farmers are reported be using improved seeds. This shows that research efforts have not brought the desired results. Low adoption ability of the varieties suited to prone areas, suggests lack of awareness due to poor promotion or possible inefficiencies in seed delivery systems. In this paper, we examine the role of extension and government services in driving the adoption of new climate smart varieties using sunflower (*Helianthus annuus* L.) and pigeon pea (*Cajanus cajan* L.) in Tanzania. This will serve as a starting point towards formulating appropriate intervention in other regions and are discussed hereunder.

II. MECHANISMS OF ACCELERATING SPEEDY ADOPTION

2.1 Variety dissemination strategy and the role of extension services

Extension services play a great role in variety adoption by creating awareness The services act as a link between farmers and researchers by communicating their needs to research and demonstrating the innovations developed by research to them (farmers). Extension officers help to translate information and innovations generated by research into simple, user-friendly message suited to local circumstances. Better agricultural innovation services help farmer to make informed decision on the crop varieties to cope with climate variability (United Republic of Tanzania (URT), 2015). For it to be a better communication strategy, extension message must focus on aspects of content design, timing of the information and providing appropriate dissemination channels with consideration of different gender category (World Bank, 2015). The contents must be simple and easy to understand and follow with little external supervision taking into account of the education level of rural farmers. The time when the information is delivered should coincide with the crop calendar in target location i. e. time to establish demonstration plots. In addition, extension service must strive to reach large audience with less cost by choosing the right communication channel. In Kenya, for example, innovative ideas such as "Shamba Shape Up" (SSU), an agricultural reality TV show, have proved to be useful in disseminating new farming technologies and improved the crop agriculture. The TV and radio programmes in Tanzania also have been playing a vital role in the dissemination of improved cassava (Manihot esculenta Crantz) varieties. Similarly, the radio and TV programs are crucial especially in the areas where the number of extension personnel is very low but the famers need to be exposed to the technology. For a completely new technology adoption, demonstration plots are needed and must be designed in such a way that farmer participation is allowed so as to remove scientism and be able to get feedback before embarking on mass promotion (Paris et al., 2011).

2.2 The role of the government in variety adoption

In most cases, the traditional role of the state in the seed sector is regulatory, to ensure that standard procedures are followed. However, state monopoly in the seed business stifles competition and discourages private sector growth. The private sector involvement in seed business is important as it helps to reduce the inefficiencies resulted from government monopoly and therefore stimulate agricultural production (CTA, 2014; Mabaya, 2016). Therefore, the government should concentrate on creating an enabling environment for other actors along the seed value chain to function properly. For example, the governments need to revise variety release protocols by allowing quality declared seed (QDS) production scheme in remote areas. This exposes farmers to quality seed, which is a preliminary stage for formal seed systems (Langyintuo et al., 2008). In addition, governments must embrace policies that permit cross border seed trade through harmonization of seed policies (AFSA, 2017). Such initiatives when implemented better are likely to increase farmer access to improved seed and lower seed prices especially in countries with poorly developed seed system. Alternatively, farmers could be trained on seed purification and selection skills in areas where formal seed systems are lacking as in the case of beans in Uganda (Nasirumbi et al., 2008). Seed policies must support the growth and expansion of small seed companies operating at national level as in the case of Tanzania (International Trade Centre (ITC), 2016). Also policy incentives that will attract investment in the seed sector must be put in place. For example, policies that will improve access to credits as well as grain markets and retail networks are likely to improve variety deployment and its uptake due to assured markets (Langyintuo et al., 2009).

In Tanzania, an enabling environment to private sector has shown positive contribution in enhancing adoption of sunflower production in semi-arid regions where other tradition crops have been failing due to climate change. Sunflower in Tanzania is believed to grow well in almost all

regions including in drier areas of the central regions. Available data show that between 2000 and 2005 production was only 75000 to 100,000 tonnes but production has reached 2,995,500 tonnes in 2015/16 due to better policy intervention (Figure 1). Recent statistics from FAOSTAT show that, as of 2014 Tanzania is ranked 7th among the top sunflower seed producer in the world (FAO, 2014), as shown in Figure 1.

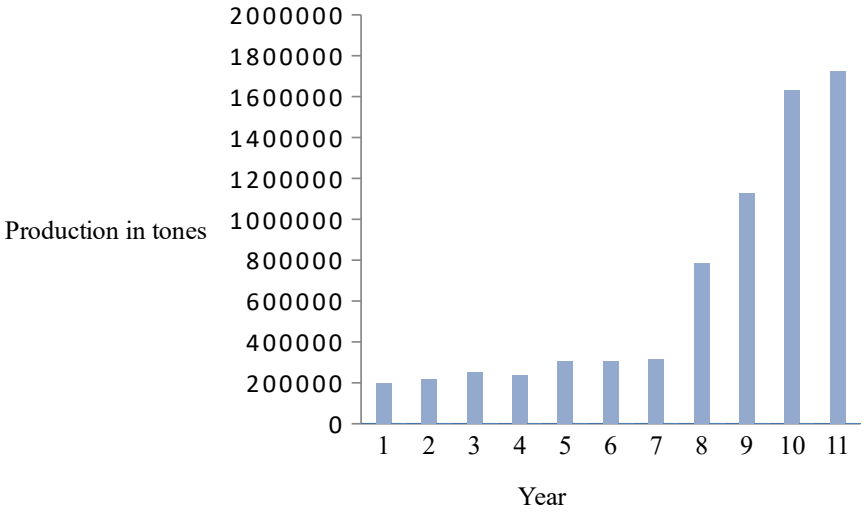

Fig.1: Sunflower seed production trends for Tanzania (2004 – 2014)

2.3 Factors for successful adoption of climate smart varieties

Sunflower was introduced in Tanzania many years ago but it has remained unpopular despite the huge market potential of edible oil in Tanzania. As a result, Tanzania has continued to import a large portion of edible oil due to poor local production. High incidences of drought forced the government to adopt a number of policy interventions to promote sunflower production in semi-arid areas of Tanzania. First the government initiated and supported the production of quality declared seed (QDS) at village level to ensure timely availability and at an affordable price. Also, agricultural reforms such as agricultural sector development programme (ASDP) ensured increased participation of private sector by providing start-up capital for the establishment of agro industries. For example, the government introduced the industrial development support loan with subsidized interest to promote local investment for agro-processing industries through the Tanzania Investment Bank (TIB) in partnership with Rural Livelihood Development Cooperation (RLDC). The government also initiated credit guarantee scheme for agro-processing and agro-business sector through small industry development organization (SIDO). Such incentives increased the participation of NGOs and other financial institutions such as RLDC working with government to increase the profit among sunflower producers (SARECA/KIT, 2014). RLDC also helps sunflower farmers to gain access to agro inputs and reliable markets and processors by supporting contract farming where processor association works with 300 to 700 farmers. The voucher system and warehouse receipt system supported by RLDC enable farmers to deposit sunflower seed in the warehouse and sell later when the prices are better; while stored seed serves as a guarantee for the RLDC business partners to give credits to farmers. As a result, currently in Singida region alone, central Tanzania there are more than 64 small scale sunflower oil processing factories and one (1) large scale processing factory. Sunflower production is rapidly spreading to new regions such as Morogoro (South-east) and Tabora (North-west) where new small oil mills are also being established involving women and youth groups which are supported through district development fund. Following these successes in sunflower adoption the number of foreign seed companies dealing with seed business has been increasing Market opportunities also act as an incentive in the adoption of drought tolerant (DT) varieties. Guaranteed market has been a driving force in the adoption of Pigeon peas in Tanzania. Using this model Tanzania has been able to increase the production of pigeon pea production thus overtaking Malawi as the third world leading producer (Table 1).

Table 1: World's Pigeon pea production - India and its main suppliers 2009-11

Country	2009		2010		2011	
	Production (Mt)	Proportion of world supply (%)	Production (Mt)	Proportion of world supply (%)	Production (Mt)	Proportion of world supply (%)
India	2,270,000	64.1	2,460,000	63.9	2,860,000	64.9
Kenya	46,474	1.3	103,324	2.7	84,313	1.9
Malawi	184,156	5.2	193,005	5.0	195,516	4.4
Burma	765,000	21.6	772,999	20.1	837,385	19.0
Uganda	91,000	2.6	93,000	2.4	94,861	2.2
Tanzania	**120,870**	**3.4**	**166,130**	**4.3**	**272,608**	**6.2**
Total India and suppliers	3,477,500	98.2	3,788,458	98.3	4,344,683	98.6
Total World Production	3,542,598	100.0	3,852,110	100.0	4,405,984	100.0

Source: FAOSTAT (2014)

Pigeon pea is a drought tolerant crop that is currently widely grown in northern regions of Tanzania. It is an important source of income among farmers in Arusha, and Manyara regions (North-east) with market opportunities in Kenya, the Middle East and the European Union (Mponda et al., 2013; ICT, 2016). About 70 percent of Pigeon pea produced in Tanzania is exported (Mponda et al., 2013). Originally, Pigeon pea production was confined to high rainfall areas due to lack of early maturing and drought tolerant varieties (Mussa et al., 2012). The assurance in market has increased the number of farmers growing the crop. As a result, Pigeon pea production is rapidly spreading in other semi-arid areas particularly Dodoma, Morogoro (central) and southern regions such as Mtwara and Lindi. Availability of better varieties with short duration maturity and farmer preferred traits such as high grain yield, intercropping compatibility, photoperiod insensitivity and maturity, high yield potential during ratoon and climate resilience have contributed to increase Pigeon pea production (Figure 2).

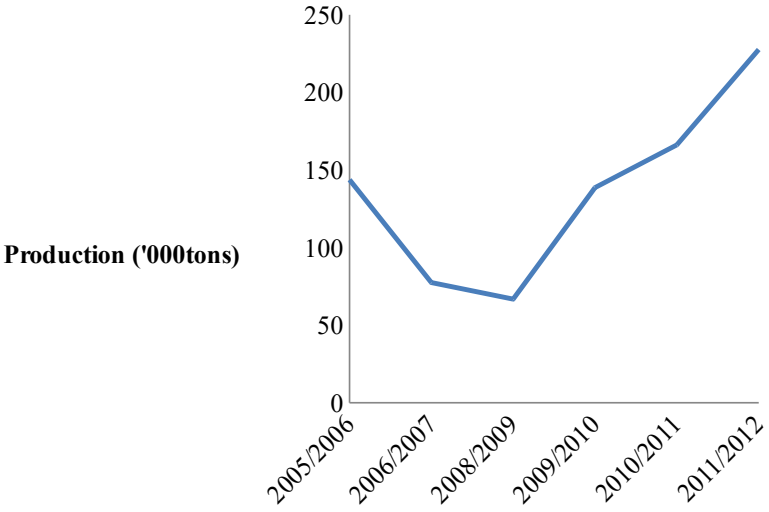

Fig.2: Pigeon pea production in Tanzania 2005/06 – 2011/12

In Northern Tanzania, varieties such as ICEAP 00040 and ICEAP 00053 which carry most of these traits have a reported adoption rate of above 60% (Mponda et al., 2013). Currently there are 16 released varieties in with production estimated at 300,000 MT per year (Mponda et al., 2013). Seeds are obtained mainly from National Agricultural Research Institutes (ARIs) through Community based organization (CBOs) and QDS schemes. Further, Catholic

Relief Service (CRC) works in collaboration with Technoserve, a non-profit organisation and TARI_Selian to help farmers to form cooperatives and providing training so as to meet European requirements for export. Reliable market opportunities and good partnership between government and private sector have been the driving force in the adoption.

III. CONCLUSION

In order to enhance adoption of climate smart varieties, the choice of a crop for promotion must take into consideration the traits that meet people's livelihood needs such as food or cash. At the same time the government need to put in place seed policies that will attract investment in different aspects of the seed value chain. A package of incentive that include lowering tariff on agricultural inputs and agro-processing machinery adds value and that farmers get premium prices on their produce, this in turn enhance adoption. Also, extension services help in making the right decision with regards to the choice of right variety and the best management practices for better results and is prerequisite for adoption.

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Design and Fabrication of A trapezoidal Form for Precasting of Concrete Canal-lets

Tahir Mohammed Ahmed

Department of Soil and Water Resources Management, Environment & Natural Resources & Desertification Research Institute, National Center for Research, Sudan
Tahir.abdu@yahoo.com

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Abstract— *Canalization system at Rawakeeb Research Station (RRS) experienced high water losses due to seepage. Based on maximum expected discharge at RRS of 200 m^3/s, a trapezoidal cross section form is designed then fabricated of local materials (angle bars, rectangular pipes, steel sheets, iron steel shaft, roller thrust bearings, steel wire and nuts) with the dimensions of 82 cm (width) x 2.5 m (height) x 82 cm (long) to precast concrete canal-lets of 1 m × 55 cm × 8 cm (length, width, thickness) as required for lining of RRS canal. Designed unit discharge and flow velocity were found to be 0.06 m^3/s, 0.5 m/s, precasted concrete canal-lets then cured for 14 days. The suggested trapezoidal form design can be adopted to produce trapezoidal precasted concrete canal-lets without distortions, precasted concrete canal-lets provided required water tightness. As a result the suggested precasting technique can be adopted.*

Keywords— ***Seepage, Canal Lining, Precasting Technique.***

I. INTRODUCTION

Life is tied to water as it is tied to air and food. Sudan occupies a region that is located in the middle part of the Nile Basin to the south of Egypt. The country is located within the Sudano- Sahelian region in north east Africa, with geographic coordinates of 4° and 22° N and 22° and 38° E. Sudan area was reduced from 2.500.000 km^2 to 1.882.000 km^2 following the independence of South Sudan in 2011. Most of Sudan area is located within arid and semi-arid regions. During the second half of the previous century, the arid and semi-arid regions of the country were subjected to different forms of land degradation. West of Omdurman particularly Rawakeeb Area, located within the arid region, experienced severe land degradation such as sand encroachment and deforestation in the past few decades, due to the influx of displaced people who entered the area fleeing from famine in Kordofan state and other parts of the country (Ahmed *etal.*, 2009[1]; Mahgoub, 2014[2]; El Gamri, 2004[3]). In many locations around the globe unlined irrigation canals are characterized by very high water losses. Out of these losses, seepage is the most significant one. Unlined canals lose a substantial part of the usable water through seepage so substantial amounts of water can be saved by improving water management at the farm (Ahmed *etal.*, 2008[4]; Uchdadiya *etal.*, 2014[5]; Ahmed, 2007[6]; Ahmed *etal.*, 2014[7]; Ahmed *etal.*, 2017[8]). Canalization system at Rawakeeb Research Station (RRS) has been suffering the problem of high water losses due to seepage (Ahmed, 2007[6]). Canal lining using precasting technique is anticipated to solve this problem for the following reasons: (a) Precasting has proved to be one of the best types of lining. (b) Availability of coarse aggregates and sand in the vicinity of RRS. (c) Availability of labor. The objective of this research is to design and fabricate a trapezoidal form to produce precasted concrete canal-lets that provided the required water tightness for lining of RRS canal. To achieve this goal, a trapezoidal section form was suggested considering many design aspects including; operation power, cross section and removing out of concrete canal-lets.

II. MATERIALS AND METHODS

2.1 DESIGN OF CANAL CROSS SECTION

The trapezoidal cross section was suggested considering many factors related to RRS conditions such as topography, soil type, operation power, and construction technique and form maintenance. A simple online flow calculator (Sturmfels, 2016[9]) based on Manning equation has used to calculate flow velocity and unit discharge out the following parameters:

a) With reference to Birch *et al* (1994[10]) and DWSRM/ENRDRI/NCR (2016[11]),canal top width was selected to be 0.41 m, canal bottom width was selected to be 0.25, canal depth was selected to be 0.47 m, and flow depth was selected to be 0.37 m.

b) Canal bed slope (S) was selected to be 0.001 m/m as suggested by Mashhadi, (1994[12]).

c) With reference to Zaidi, (1994[13]) the Manning's coefficient of roughness (n) was selected to be 0.016.

d) With reference to Michael, (1978[14]) the value of 0.1 m was selected for free board.

2.2 THE DESIGN OF CONCRETE CANAL-LET FORM

2.2.1 DESIGN AND FABRICATION OF INNER FORM

The original trapezoidal cross section was suggested by Birch *et al* (1994[10]), considering mentioned factors related to RRS, concrete canal-lets are to be precasted with the modified dimensions shown in Fig (1). The materials used to fabricate the inner form were:

1. Angle bars of 1¼″ (3.15 cm) side thickness.
2. Angle bars of 1½″(3.81 cm) side thickness.
4. Hot rolled (HR) of 3 × 6 cm rectangular pipes.
5. Cold rolled (CR) of 3 × 6 cm rectangular pipes.
6. Hot rolled (HR) of 5 × 2.5 cm rectangular pipes.

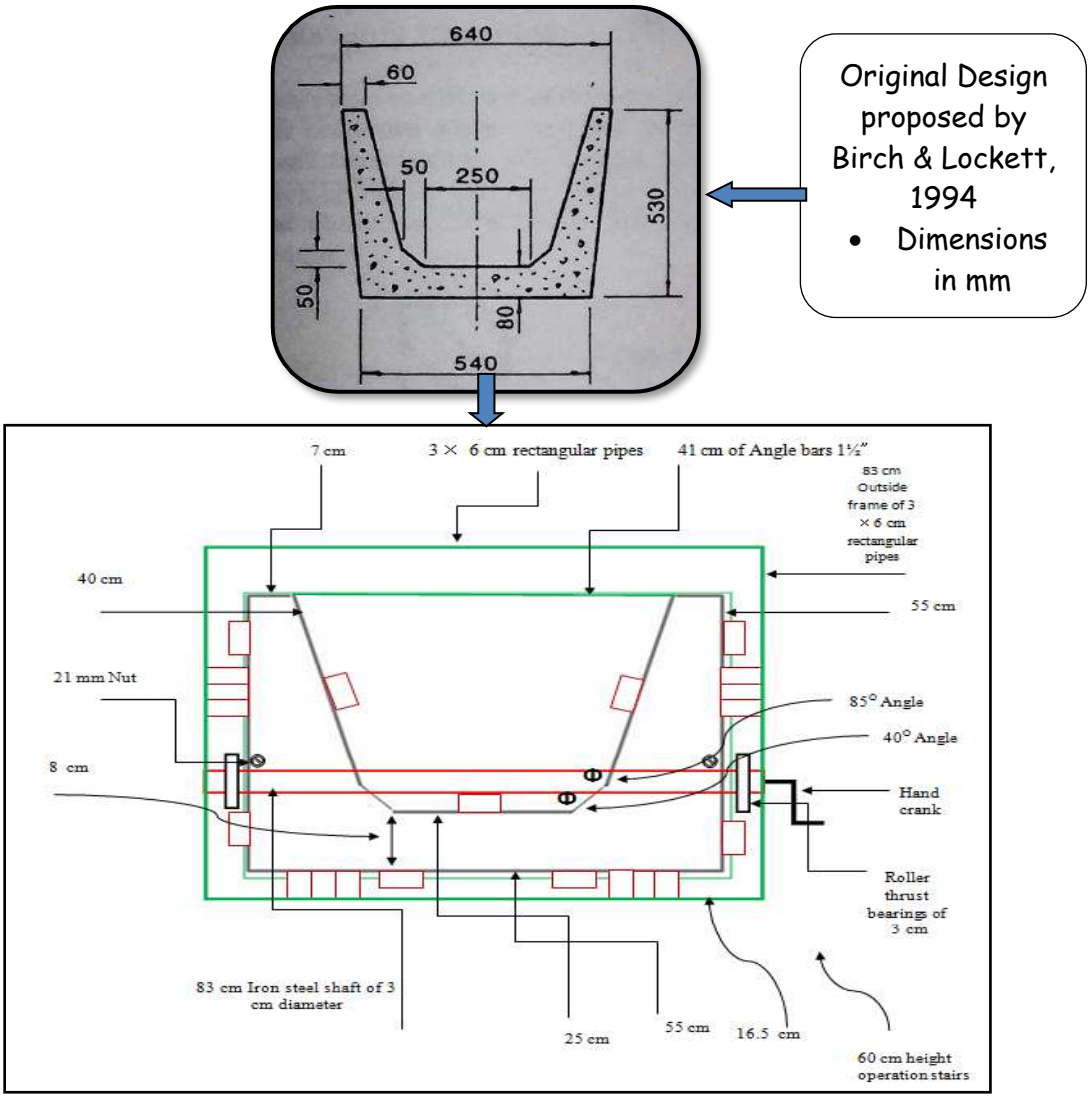

Fig.1: Proposed Design of Concrete Canal-Let Form

Plate (1) Fabricated inner steel form section

Plate (2) 21 mm Handling points

7. Cold rolled (CR) steel sheet of 1 mm thickness.

The trapezoidal section inner form was fabricated out of CR steel sheet of 1 mm thickness as shown in plate (1). Inner form was supported longitudinally from inside and outside with HR 3×6 cm rect. pipes welded internally and externally at each side. Four shaped angle bars of 3.15 cm were welded internally and externally to support the form transversally. Two 21 mm nuts were welded at the upper part of the form as handling points as shown in plate (2). Also, the inner form was supported with four HR 3×6 cm rect. pipes welded externally as sliding bars (two bars welded at back and one bar at each side) to facilitate up and down movements of it during operation. The bars were designed to be slided through four stand guides as shown in plate (3).

2.2.2 DESIGN AND FABRICATION OF MAIN FRAME

The main frame was fabricated of HR 3×6 cm rect. pipes with dimensions of 82 cm (width) x 2.5 m (height) x 82 cm (long). Three sides of the frame were provided with 3×6 cm rect. pipes welded externally to support the form longitudinally and to act as a guides for inner form sliding bars so as to ease handling of the inner form as shown in plate (4). The upper part of main frame was also provided with a hand cranking system as shown in plates (5) and (6). Hand cranking system (act at the same time as handling system for inner form) was fabricated of 3 cm Iron steel shaft, 3 cm Roller thrust bearings, 17 mm Screw pins and nuts, 21 mm Nuts, 5 mm Aluminum wires and 2 cm Steel hand crank.

2.2.3 PRECASTING OF CONCRETE CANAL-LETS

Precasting of concrete canal-lets had done following below steps:

1. Painting of inner form and sliding guides with burned car oil.
2. Preparing of fresh concrete mixture of 1:2:3 (cement: gravel: sand) to be added.
3. Compaction of concrete mixture inside inner form then after while, a gentle removing of inner form as shown in plate (7) and finally curing of concrete canal-lets for 14 days.

III. RESULTS AND DISCUSSIONS

Selected thickness of precasted canal-lets of 8 cm was found to be reasonable since Mashhadi, (1994[12]) reported that; in cases where foundation or subgrade conditions are unfavorable, or where high velocities are inevitable, thicknesses of 5.08 to 12.7 cm (2-5 in) have been used. No general rule can be stated for establishing the thickness of concrete lining which is not a structural number. For small canals such as RRS canal, un-reinforced concrete lining of 1½ inch thickness has been satisfactory.

Plate (3) Sliding bars of the inner form

Plate (4) Parts of main frame

Plate (5) Parts of hand cranking system

Plate (6) Cranking Mechanism

Plate (7) Removing out of inner form

In the Pakistan Command Water Management Project, concrete lining thickness of 3 inches with 1:2:4 volumetric mix (strength 3,000 ib/in^2) has been used for all canal section, discharge ranging from 6 to 600 cusecs. The obtained unit discharge of .06 m^3/s was found to be reasonable since the maximum discharge at RRS is expected to be about 200 m^3/s. The obtained flow velocity of 0.5 m/s was found to be as well as recommended by Kraatz, (1977[15]). 14 days of curing was found to be ideal as recommended by Mashhadi, (1994[12]) who stated that concrete cured for 14 days had a 28 day strength, as twice as that of concrete which was allowed to dry in open air. Many advantages were observed during precasting with the fabricated form:

1. The form can be operated manually easily.
2. Precasting (i.e. filling and smoothing of mixture) can be done easily and rapidly; no form accessories are needed.

3. The precasted concrete slabs can be removed out of the form easily (i.e. no need for hummer blows), no technical maintenance is needed and the form can be stored anywhere under any storage conditions .
4. Curing of 14 days provided the required water tightness.

IV. CONCLUSION

It can be concluded that, the suggested trapezoidal section design fulfilled all the required criteria to adopt precasting technique. Furthermore, the precasted concrete canal-lets shown in plate (8) can be produced with the dimensions of 1 m × 55 cm × 8 cm (length, width, thickness) for lining of RRS canal, with the specifications which provided required water tightness.

Plate (8) Precasted concrete canal-let

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Cost of Climate change Hazards on Livelihood Capitals of Farmers in Coastal Communities of Delta State of Nigeria

Adjekota Owhofasa Paul*, Rosemary Ngozi Okoh

Department of Agricultural Economics, Faculty of Agriculture, Delta State University, Abraka, Nigeria
*Corresponding Author: pauladjekota@gmail.com

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Abstract— *Climate change comes with hazards that impose cost on livelihood capitals that are very important to agriculture in particular and the economy in general. This study was aimed at eliciting evidence of Climate change and it's associated hazards and estimating monetary cost of the hazards on livelihood capitals with a view to making recommendations that will minimise the cost on livelihood capitals of farmers in coastal communities of Delta State of Nigeria. The study area which is found within the Niger Delta region of Nigeria that is ecologically characterised by rivers, tributries, wet lands, mangrove swamps and a rich collection of aquatic and terrestrial floral and fauna, is also the concentration of petroleum exploration and production in Nigeria. Random sampling procedure was used to select 240 respondents from 8 communities that were purposely selected for the study.Cost was estimated by Willingness to Pay (WTP) and it's determinants analysed with regression model. Findings revealed that the people perceive climate change in terms of unusual changes in frequency and intensity of climate variables and the hazards associated with these changes are coastal erosion, flood, extreme heat and "wind and rain storm". Climate change through the hazards was estimated to cost the average respondent 49,440 Nigerian naira or 123.60 US dollars (in livelihood capitals all of which are important to agriculture and the economy. Coastal erosion, flood, wind/rain storm and extreme heat were positively related to cost while literacy level, adaptation and number of income generating activities were negatively related to cost. Capacity building for improving existing adaptation strategies, literacy improvement, direct intervention projects and insurance were recommended as measures for minimising the cost of climate change on livelihood capitals of farmers in Coastal communities of Delta State of Nigeria.*

Keywords— ***Cost, Climate change, Livelihood capitals, Farmers, Coastal Communities.***

I. INTRODUCTION

The Intergovernmental Panel on Climate Change (ICPC) define Climate Change as any significant change in climate over time whether due to natural climate variability or as a result of human activity (Abazu and Abimbola, 2019). The main cause of climate change is global warming which results from accumulation of greenhouse gases like carbon dioxide, nitrous oxide, methane and chlorofluorocarbon. Carbon dioxide remain the most important influencer of climate change and it's concentration has been increasing since 1750 through 2019 (IPCC, 2021).

Climate Change is associated with hazards like extreme heat, flood, erosion, extreme rain and wind storm. Coastal communities are particularly more vulnerable to these hazards (Sinay and Bill, 2020). Many coastal communities especially in developing countries have limited or no human built protection against the hazards.

Kramer et al, (2017), established a strong relationship between coastal habitats and livelihoods of it's inhabitants. In this way, vulnerability of coastal communities to climate change, impose cost on the livelihoods of the people. This will be better understood by studying the cost imposed by climate change through associated hazards on

livelihood capitals of farmers in coastal communities of Delta State of Nigeria. The study will also contribute to the information needed by policy makers to protect natural and human capitals against climate change. The United State's Geological Survey (2008) emphasised that such information is needed by policy makers in coastal communities.

The cost of climate change is projected to be up to 3.6 percent of GDP by 2100 according to the Natural Resources Defense Council (NRDC) (2008). Uyigue and Agho (2007) describe the coastal communities of Delta State of Nigeria as predominantly farming and fishing communities. Therefore, this study which could contribute to policies that will reduce cost of climate change on livelihood capitals in the study area will also reduce the cost to farming households, increase income of farmers and improve welfare of farmers. The study is aimed at satisfy the following objectives.

1. Elicit evidence of Climate change and it's associated hazards from farmers in the coastal communities of Delta State of Nigeria.
2. Estimate the cost of the hazards on livelihood capitals of farmers in study area.
3. Analyse the determinants of cost of the hazards on livelihood capitals of farmers in the study area.
4. Generate recommendations that will help to minimise cost of climate change on livelihood capitals in the coastal communities of Delta State of Nigeria and similar ecosystems elsewhere.

Hypothesis:

Climate change does not impose cost on livelihood capitals of farmers in coastal communities of Delta State of Nigeria.

II. METHODOLOGY

The Study Area

The study was conducted in Delta State of Nigeria with coordinates of Latitude 5.30^0N and Longitude 6.00^0East. The state has a land mass of 17698 kilometers square.

Delta State is ecologically divided into three agricultural zones: Delta North, Delta Central and Delta South. The topography of Delta North agricultural zone range from low lying planes to undulating hills of between 243 and 275 meters above sea level with only a few depression of river valleys and flood plains. The Delta Central and Delta South agricultural zones are predominantly coastal consisting of fresh water and mangrove swamps, alluvial plains and beach ridges. Therefore, the study was concentrated on the south and Central agricultural zones.

The study area share similar ecology with other coastal communities in the Niger Delta region of Nigeria which it also belongs in ecological and political grouping in Nigeria. The Niger Delta region is located in the Atlantic coast of southern Nigeria where the river Niger divide into many tributaries. Hence the name Delta.

Scope of the study

The study was limited to coastal communities in Delta State of Nigeria. The cost that was estimated include cost on all livelihood capitals in the study area. Only primary data generated in the field were used for the study.

Sampling procedure

Purposive sampling procedure was used to select 8 coastal communities in the study area after which 30 respondents were selected from each to give a sample size of 240. Communities selected for the study are Ekpan in Uvwie local Local Government Area (LGA), Egbo-Ideh in Ughelli South LGA, Abaro in Patani LGA, Aladja in Udu LGA, Oteghele in Warri south LGA, Ayakoromo in Burutu LGA and Bomadi in Bomadi LGA.

Data Collection

Questionnaire were used to collect data on the people's socio economic characteristics and perceived changes in climate and associated hazards in the study area. Cost on livelihood capitals were also collected. Data were collected from only persons of 40 years and above in order to obtain valid responses regarding climate change and associated hazards in the study area.

Data analysis

Data on observed changes in climate and associated hazards were analysed by the use of descriptive statistics like tables, frequency distribution and percentages. Cost of the hazards on livelihood capitals was obtained by the use of Willingness to pay methodology of social cost valuation. This was used to obtain the cost on each livelihood capital and aggregated to obtain the total cost on livelihood capitals. Nigerian naira and US dollar are the currencies adopted for presentation and interpretation of results.

Determinants of cost of climate change hazards were analysed by the use of multiple regression analysis. The model was explicitly specified as

$$Y = a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9+c$$; where

Y = estimated cost in dollars of climate change hazards on livelihood capitals

A= intercept

X_1= age of respondents measured in years

X_2= gender (dummy variable) 1 for male and 0 for female

X_3= level of education: number of years in formal education

X_4= livelihood options: number of income generation activities

IX_5= coastal erosion: 0 for not severe, 1 for extreme

X_6= flood: 0 for not severe, 1 for extreme

X_7= wind/rain storm: 0 for not severe, 1 for extreme

X_8= unusual extreme heat. 0 for not observed, 1for observed

X_9= adaptation to climate change hazards: money spent on adaptation in dollars

b_1, b_2…….b_9 = coefficients of the independent variables (X_1,X_2……..X_9) respectively.

E = error term which account for variables not included in the model.

The coefficients of the explanatory variables (b_1, b_2…….b_9) as specified in the model, indicates the net effect of a unit change in each of the explanatory variables (X_1, X_2……..X_9) on the cost of climate change on livelihood capitals. The coefficient of determination R square and F statistic of the regression analysis were used as measures of goodness of fit. R square indicates the degree of explanation for the cost of climate change on livelihood capitals in the coastal communities of Delta State of Nigeria that is collectively provided by the explanatory variables. F statistic measures the significance of the combined effect of all the variables. Therefore, the linear model of the regression analysis was adopted as lead equation for interpretation of result ahead of the semi log and double log functional forms that were also fitted because it's R square F statistic were superior.

Decision rule for Hypothesis

A positive value for any of the dependent variables representing climate change related hazards in the model will lead to a decision of "do not accept" for the hypothesis.

Apriori expectation

It is expected that hazards associated with climate change will be positively related to the cost of the hazards on livelihood capitals in the coastal communities of Delta State of Nigeria. This is based on explanation of the human ecology theory that ecosystem services provided by ecosystems functions may result to negative effects in the ecosystem if their utilisation alter natural cycles and balance in the ecosystem (Montayo and Raffaelli, 2010).

III. RESULTS AND DISCUSSION

Livelihoods and Other Socio Economic Characteristics

The age of respondents is between 41 and 78 years and the mean age is 56 years. The survey was evenly distributed along gender lines. Most of the respondents are married (95 percent) and majority of households have 4-7 persons. About half of the respondent had primary education. More than half of the remaining 50 percent do not have formal education while only a fewer number had post primary education. The mean annual income is about 600 dollars.

Many people in the coastal communities of Delta State of Nigeria are engaged in multiple income generating activities or livelihood options. It is only 35 percent of the people that rely on only one source of income while 42.5 percent and 22.5 percent engage in 2 and three income generating activities respectively. The mean number of income generating activities in the study area is 2.

Climate Change and Associated Hazards

Therewas a unanimous agreement by respondents that climate change is experienced in the coastal communities of Delta State of Nigeria. This is based on their observation of changes in pattern of rain fall and intensity of heat over the years. The change in pattern of rain fall was through intensity, frequency of events and duration of the season of rain (Table 1). This is in agreement with the findings of Li (2011) that climate change induced by pollution has resulted to increase in rain in coastal regions of the world.

The strongest evidence of climate change in the study area is in intensity of heat. All the respondents observed a drastic increase in intensity of heat in the coastal communities of Delta State of Nigeria. This is in line with data from Nigerian Metereological Agency (NIMET) as in Okoh et Al (2011).

It was also observed by all the respondents that there is a decrease in the intensity of harmattan. 92 percent observed delayed onset while 91 percent observed decrease in duration (Table 1). The findings agree with Abbey (2011) which linked delay in onset of harmattan in Ghana to climate change. The findings however, disagree with Abbey (2011) in the area of intensity. Abbey (2011) reported increase in intensity while this study found decrease intensity as shown in Table 1. The peculiarity of the coastal ecosystem and location could be responsible for this because according to Fernandez-Bilbao (2011), climate change could be affected to some extent by geographical distribution although it is a global phenomenon.

It is shown in Table 2 that erosion, flood and "rain and wind storm" are hazards associated with climate change in

the Coastal communities of Delta State of Nigeria. These hazards assumed extreme proportions in line with extreme changes in climate as observed by the respondents. This confirms the report of Li (2011) that climate change has increased the intensity of severe storms in coastal regions of the world. It is also in line with Kumar (2011) that flood and erosion are important climate change related hazards in coastal communities.

Cost of Climate Change Hazards on Livelihood Capitals

The cost imposed by climate change through associated hazards on livelihood capitals in coastal communities of Delta State of Nigeria is very high as it affects all livelihood capitals. The total cost to the average respondent is 49440 naira or 123.60 US dollars. The highest cost was recorded in natural capital where the mean cost to each responded was 21,752 naira or 61.88 dollars (Table 2). The cost on other livelihood capitals as presented in Table 2 are physical capital: 9,152 naira (22.88 dollars), financial capital: 8,460 naira (21.15 dollars), social capital: 2,976 naira (7.44 dollars) and human capital: 5,056 naira (12.64 dollars). The cost to agriculture is overwhelming as all components of the affected livelihood capitals as presented in Table 2 are relevant to sustainable agriculture and welfare of farmers and farming households.

Result of the regression model presented in Table 3 indicates a positive relationship between all the variables representing climate change hazards and cost on livelihood capitals in the study area. Flood, coastal erosion and wind/rain storm are significant. The implication is that as the hazards become more extreme, cost on livelihood capitals in the coastal communities of Delta State of Nigeria also increase. Therefore, we do not accept the null hypothesis. Adaptation, formal education and number of income generating activities are found to be negatively related to cost.

IV. CONCLUSION AND RECOMMENDATIONS

Cost of climate change through hazards like flood, coastal erosion, wind and rain storm and extreme heat on livelihood capitals of farmers in coastal communities of Delta State of Nigeria is very high as all livelihood capitals including agricultural resources and infrastructure are affected. Therefore, the following recommendations should be considered in order to minimise the cost.

1. Capacity building to improve on existing adaptation strategies.
2. Early warning of predictable extreme events related to climate change.
3. Investment in education to increase understanding of climate change information.
4. Direct intervention projects by government and development agencies.
5. Investing in additional income generating activities.
6. Insuring livelihood assetsof farmers in coastal communities against climate change related hazards.

Table 1: Evidence of Climate Change and Associated Hazards in the coastal communities of Delta State

Rain fall more intense	Agree: 212 or 88 percent	Disagree: 28 or 12 percent
Rain fall more frequent	Agree: 179 or 70 percent	Disagree: 38 or 16 percen
Rain onset delayed	Agree: 150 or 60 percent	Disagree: 90 or 40 percent
Heat intensity is increasing	Agree: 240 or 10 percent	Disagree: 0 or 0 percent
Harmattan is less intense	Agree: 240 or 100 percent	Disagree: 0 or 0 percent
Harmattan onset delayed	Agree: 231 or 96 percent	Disagree: 9 or 4 percent
Harmattan duration reduced:	Agree: 218 91 percent	Disagree: 22 or 9 percent

Source: researcher (field survey)

Table 2: Cost of Climate Change on Livelihood Capitals in Naira and US dollars in study area

Livelihood Capital	Cost to male		Cost to female		Mean cost	
	Naira	Dollar	Naira	Dollar	Naira	Dollar
Natural Capital: Loss of farm land	7252	18.13	14000	35.00	10600	26.96
Damage to cultivated crops	1552	3.88	1524	3.81	1536	3.84
Less productive fishing ground	12700	31.75	787	1.96	10288	25.72
Polluted water	824	2.06	1000	2.50	916	2.29
Damage to livestock	1600	4.00	1176	2.94	1388	3.47
Sub total	**22824**	**57.06**	**25576**	**63.94**	**24752**	**61.88**
Physical Capital: Damage to farming equipment	1600	4.00	3524	8.81	2564	6.41
Damage to fishing equipment	4024	10.06	2076	5.19	3052	7.63
Damage to roads and bridges	1224	2.81	952	2.38	1080	2.59
Damage to school infrastructure	724	1.81	800	2.00	776	1.92
Damage to health infrastructure	675	1.69	852	2.13	764	1.91
Damage to market infrastructure	776	1.94	1176	2.94	1386	3.47
Sub total	**8924**	**22.31**	**9380**	**23.45**	**9152**	**22.88**
Financial Capital: Reduced income from farming	2052	5.13	4532	11.33	3292	8.23
Reduced income from fishing	3176	7.94	1800	4.50	2488	6.22
Reduced sources of income	1028	2.59	736	1.84	888	2.22
Reduced savings	852	2.13	672	1.68	764	1.91
Reduced credit facilities	952	2.38	720	1.80	836	2.09
Sub total	**8076**	**20.19**	**8460**	**21.15**	**8268**	**20.67**
Social Capital: Separated relative	558	1.47	912	2.28	752	1.88
Weaker co-operative societies	1024	2.56	700	1.75	864	2.16
Less active social group	528	1.32	952	2.38	740	1.85
Increased communication gap	512	1.28	736	1.84	624	1.56
Sub total	**2632**	**6.63**	**3300**	**8.25**	**2976**	**7.44**
Human Capital: Increased health risk	900	2.25	1024	2.56	964	2.41
Increased migratio	476	1.19	952	2.38	716	1.79
Higher death rat	2252	5.63	2652	6.63	2452	6.13
Reduced skilled labou	852	2.13	1000	2.50	926	2.32
Sub total	**4480**	**11.20**	**5628**	**14.07**	**5056**	**12.64**
Total	**46952**	**117.38**	**52316**	**130.79**	**49440**	**123.60**

Source : researcher (field survey)

Table 3: determinants of cost of climate change on livelihood capitals in the study area

Variabl	Coefficient	Std Error	T	p-value
C	1008.34	951.80	1.059	0.2444
Age	197.85	82.10	2.410	0.0347*

Gender	38.18	33.36	1.140	0.2021
Education	-200.86	187.49	1.060	0.2444
Livelihood options	-797.13	265.71	3.000	0.0100**
Erosion	946.00	287.15	2.490	0.0291*
Flood	221.19	570.90	3.540	0.0070
Extreme heat	211.48	188.48	1.220	0.2239
Wind/rain storm	586.60	241.40	2.430	0.0302*
Adaptation	-14.77	5.86	2.520	0.0210*

Source: researcher (regression analysis)
**= significant at 1 percent
*= significant at 5 percent,
R-square = 78.22
F statistic = 101.11 (p-value = 0.00102)
Durbin Watson = 1.69

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Effect on Humans due to Deposition of Heavy Metals in Weras River and Remediation Techniques

IE Vidyananda[1], MB Samarakoon[2]

[1]Department of Civil Engineering, General Sir John Kotelawala Defence University, Sri Lanka.
Email: imasha.vid@gmail.com
[2]Senior Lecturer, Department of Civil Engineering, General Sir John Kotelawala Defence University, Sri Lanka.
Email:methsiri@kdu.ac.lk

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Abstract**—***This study was carried out to determine the deposition of heavy metals in Weras River and how in turn these metals would affect the lives of people. Heavy metals enter Weras River by natural and anthropogenic activities. Excess accumulation of heavy metals such as Pb, Hg, Cd, Cr, Zn and Cu can cause severe problems in living organisms. To ascertain the harmful effects on humans due to heavy metals deposited in Weras River, water samples were collected from the river, tested, and analysed. Lead concentration exceeded the safety standard specified for aquatic life and, zinc concentration increased over the past years. Through this study the level of contamination of water in Weras River was determined intending to emphasize the harmful effects of heavy metals on humans and to minimize diseases and complications caused by it as there is a serious effect on the long run if heavy metal contamination of water in Weras River is not remediated. Due to the severity of heavy metal contamination in Weras River treatment methods were suggested and a mathematical model to predict heavy metal concentrations in Weras River was developed.*

Keywords**—Heavy metals, Contamination, Bioaccumulation, Treatment, Weras River**

I. INTRODUCTION

With the growing urbanization and industrialization in the past several decades, the environment has been greatly polluted by the excess deposition of heavy metals. Increasing population in Sri Lanka has led to the pollution of waterbodies and these waterbodies undergo heavy metal contamination due to heavy metals released from industrial waste, automobiles, garbage dump sites and human waste. Heavy metals such as Pb, Hg, Cd, Cr, Cu and Zn are extremely toxic and consuming even very low levels of these metals can be harmful to humans.(Pandey & Madhuri, 2014)

Considering human health there are some metals deemed necessary, yet these metals react to cause harmful effects if the safety limits exceed. Heavy metals can enter a human body through ingestion, respiration, and skin. These metals mainly become toxic as they form toxic soluble compounds due to the presence of many minerals and chemicals in the human body. Some heavy metals such as iron and copper are naturally included in the human body and are needed for metabolism. However, soft tissues in the human body easily accumulate heavy metals and cause toxicity hindering the regular functioning of the body.(Jaishankar et al., 2014)

Considering heavy metal contamination, it can be detected by measuring the metal level in water, soil, and biota. Out of all the heavy metals Pb and Hg have a significant effect on humans as they are directly toxic, and the threshold level is low in humans. World Health Organization has studied about the effect of heavy metals to humans and they possess a rather serious threat causing reduction in foetal growth, chronic diseases and even cause cancer.(WHO, n.d.)

Heavy metals mainly enter the human body due to consumption of food fish and by drinking contaminated water. Heavy metals can easily accumulate in fish gills and

cause the fish to be poisonous. Some heavy metals can be essential nutrients in the human body. Yet heavy metals like lead, mercury and cadmium have no importance in the role of a living organism and only cause serious health risks. Overall heavy metals are considered to be nonessential elements for humans as most heavy metals are not necessary for the functioning of the human body.(Masindi & Muedi, 2018)

Due to the toxicity of heavy metals treatment methods are used to reduce the metal concentration in water. However, most of these remediation techniques are applied for drinking water and not specifically to surface water. With the development in technology and due to rapid urbanization proper prevention measures should be imposed for natural water bodies and models to predict contamination levels can be designed to obtain the level of contamination in aquatic systems.

II. MATERIALS AND METHOD

2.1 Weras Riverof Sri Lanka

Sri Lanka known as the Pearl of the Indian Ocean lies in the bay of Bengal between 5º55" and 9º51" latitudes north and between 79º41" and 81º53" south east longitude near the equator with an extent of the land area of 65610 km2. Out of many waterbodies that flow in the country, Bolgoda lake located in the Western Province of Sri Lanka is the largest natural freshwater body with a total basin area of 394 square kilometers. The lake is divided into the North Lake and South Lake connected by the BolgodaRiver. The northern end of the Bolgoda Lake is WerasRiver with a total drainage area of 55.5 square kilometers and is divided into seven subbasins.

Two subbasins namely, Thumbowila and Ratmalana-Moratuwa were chosen for the site of the research study. Considering these two subbasins WerasRiver flows passing the Karadiyana dump site and a part of it divides into a sub lake called MedhaLake and flows adjacent to the dumpsite towards Bokundara. This area has been exposed to higher sources of contamination, considering not only the dump site but hospitals, factories and industries and the cluster of houses built along the WerasRiver and therefore can be regarded as a crucial site for the testing of heavy metal contamination of WerasRiver.

2.2 Data Collection

Preliminary actions were taken by studying previously collected data, to obtain the best sample locations in order to collect data. The number of heavy metals to be tested and selected was decided upon learning the most toxic and abundantly available heavy metals in Sri Lanka. Thereby, six heavy metals such as Pb, Hg, Zn, Cu, Cd and Cr were selected as the heavy metals to be tested.The site was analyzed regularly to detect the areas where people were gathered frequently and where sources of contamination were located.

Fig.1- Contaminated Water in Medha Lake

Table 1- Sample Locations

Location	Co-ordinates (Northing, Easting)	Description
1	6.8170612, 79.8994751	Location selected from the small lake created by water flowing from Weras River and MedhaLake
2	6.818050, 79.898571	Point selected towards the North of WerasRiver close to the Borupana bridge
3	6.8102016, 79.9030317	Point towards the South of WerasRiver
4	6.8146683, 79.9006791	Towards the middle of WerasRiver in front of the Karadiyana dumpsite
5	6.8141183, 79.9026264	Point selected from the MedhaLake

After selecting the sample locations, five water samples of 300ml were collected to polyethylene (PE) bottles from the selected five locations each. Sample collection process was carried out from 7.30 a.m. to 9.00 a.m. and the locations selected were accessed by a boat and the water was collected from the bow of the boat. Prior to collecting, the water was muddled to obtain a maximum concentration considering the whole water column. The muddled water was collected at a depth of about 1m. As soon as the water was collected to the PE bottles it was then transferred to an ice box to avoid any changes to the original composition of

the samples. Thereafter, the collected samples were immediately transferred to the National Water Supply and Drainage Board in Thelawala. The transferred samples were stored in a refrigerator at 4℃ in the chemical laboratory of the Water Supply and Drainage Board until the samples were tested. Then the samples transferred were tested using the icap 7400 Inductively Coupled Plasma Optical- Emission Spectrometer (ICP- OES).

Then, the results obtained from testing were analysed with safety standards specified by the Central Environmental Authority and Sri Lanka Standards Institution. After analysing the results, treatment methods were suggested for Weras River, and a mathematical model was built to predict the heavy metal concentration in water in Weras River using MATLAB Software.

2.3 Treatment and Prediction of Heavy Metals

Due to the increase in contamination many methods have been implemented to remediate heavy metal pollution. However, some of these approaches cause the pollutant to be destroyed rather than averting the heavy metals entering the food chain. There are methods adopted to minimize the toxic substances entering the food chain. Phytoremediation, microbial culture, rhizofilteration and other remedial methods can be used without causing disturbances to the environment.(Mishra et al., 2019)

With the development in technology, empirical formulas can be used to predict the concentration of pollutants in a system. This can be applied to heavy metal contamination in water bodies. Data needs to be measured initially that can be used as variables in a predictive model that can relate to the concentration of a metal present in water. When a mathematical model is developed it should be developed such that it will have a minimum error maximizing the predictive variables accuracy.(Lindstrom, 2000)

III. RESULTS AND DISCUSSION

3.1 Heavy Metal Concentration in Weras River

Results of concentrations of Pb, Hg, Cd, Cr, Cu and Zn were obtained and graphically analysed to determine the heavy metals with the higher risk.

Table 2- Heavy Metal Concentration in Weras River- 2020

Heavy Metal	Concentrations of Sample Locations (µg/l)				
	1	2	3	4	5
Lead	17.00	6.00	11.00	8.00	7.00
Cadmium	-	0	2.00	0	0
Chromium	4.00	-	1.00	1.00	-
Copper	5.00	0	4.00	1.00	-
Zinc	48.00	17.00	39.00	28.00	29.00
Mercury	0.155	0.017	0.063	0.030	-

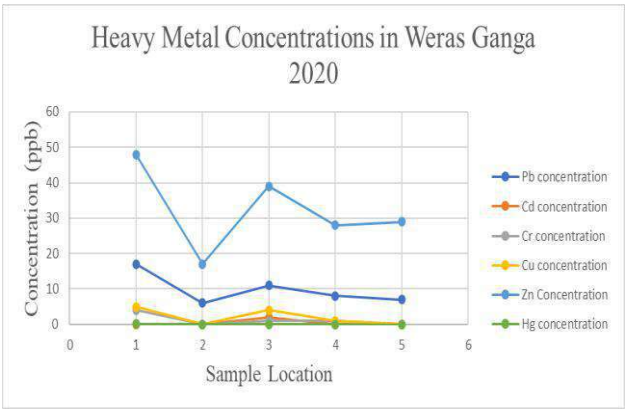

Fig.2- Analysis of Heavy Metals in Weras River

The above graph depicts the concentration of metals varying with the location tested. By analysing, it is evident that zinc has a higher concentration deposited in water of Weras River compared to the other metal levels. The metal levels in water deposited follow the order Zn> Pb> Cu> Cr> Cd> Hg.

The highest concentrations of metals were detected in sample location 1, where a small lake was formed by water flowing from Weras River and Medha Lake. Location 2 has relatively the lowest concentrations of metals deposited compared to all other locations. It is important to notify that the concentration at location 1 is high because this location was selected due to the fact that locals engage in fishing activities on a regular basis. Overall analysis showed that zinc and lead were detected from all five locations while chromium was detected in three locations, and cadmium has been detected from only one location but in low concentrations. However, mercury which is the most toxic metal considered in the study was detected from four locations in minute concentrations.

3.2 Analysis of Past Data and Safety Standards

Metal levels of lead, chromium, cadmium, zinc, and copper present in water in the year 2007 were tabulated and analysed with results obtained by testing water samples in the year 2020.

Table 3- Results of Heavy Metal Concentrations- 2007 vs 2020

Metal	Average Heavy Metal Concentrations in Weras River- 2020 (ppb)	Highest Heavy Metal Concentration detected in Weras River- 2020 (ppb)	Heavy Metal Concentrations in Weras River- 2007 (ppb)
Pb	10.0	17.00	29.5
Cd	2.0	2.00	8.3
Cr	2.0	4.00	6.3
Cu	3.0	5.00	21.9
Zn	32.0	48.00	29.3

The data obtained in the year 2007 was obtained during the dry season while the metal levels of the year 2020 was obtained during the rainy season. When the analysis was carried out by considering the average concentration obtained in Weras River in 2020, it was identified that zinc level has increased over the years. However, lead, cadmium, chromium, and copper has decreased in the deposited amounts. Yet copper is the element that has a significant reduction in its metal concentration.In contrast to the analysis of the average metal concentrations, it was identified that the highest concentrations obtained in 2020 does not have a significant or even noteworthy reduction in heavy metal concentrations over the 13 years that have passed by. In this case the zinc level has increased by a large concentration and the lead and chromium concentrations have no striking reductions in concentrations.

As there is a 13-year long gap between the two years of the comparative study it would have been expected that the reduction in metal concentrations were a remarkable reduction rather than only a notable difference due to the samples being collected during the rainy season and due to the reduction in contamination levels due to the COVID-19 pandemic in 2020.

Table 4- Safety Standards of Heavy Metals in Water

Heavy Metal	Highest Heavy Metal Concentrations in Weras River -2020 (µg/l)	Water Acceptable for Aquatic Life (µg/l)
Pb	17.0	2
Cd	2.0	5
Cr	4.0	20
Cu	5.0	100
Zn	48.0	1000
Hg	0.155	1

By obtaining the safety standards specified in Sri Lanka it was learned that there are no particular safety limits specified for bathing and contact recreational water except for mercury. Likewise, agriculture and irrigation has been specified standards for zinc and mercury, however standards have been specified for all metals when considering water suitability for aquatic life.

When considering standards specified for aquatic life, lead has exceeded the safety limit specified. With a notable difference of 15µg/l lead contamination has taken place in Wears River to a great extent. Cadmium concentration levels detected during the rainy season are comparatively high with only a 3µg/l difference in concentration specified for the safety of aquatic animals. This depicts probability for hazardous situations concerning health of aquatic species and humans during the dry season or when contamination rates increase. Also, analysis of these metals as bathing or recreational water signifies that the water is contaminated and is not suitable for the use of people as the WHO signifies that heavy metals can easily enter a human body and that the presence of heavy metals itself is toxic to a human.

3.3 Analysis of Effect on Humans

Heavy metal contamination is a known problem in the world due to the health risks heavy metal poisoning causes. Therefore, countries have taken measures by relative organizations to specify threshold levels for humans in order to prevent various diseases. However, as discussed in the review the World Health Organization emphasizes on the importance of preventing heavy metals entering a human body as these metals are toxic to the body in minute concentrations.(Rajeshkumar & Li, 2018)

When the present data was analyzed it was determined that lead was present in water exceeding the safety limit specified for aquatic life. Bioaccumulation of heavy metals take place in fish and since fish is a source of food for humans, lead contamination has been convinced to be a problem for human health. Starting from one producer, elements start accumulating in the food chain succeeding up to predators. Therefore, with the accumulation and the chemical decomposition that takes place in consecutive links of the chain, when a food source reaches a human it contains extremely high concentrations of elements and this phenomena will apply to humans in undergoing heavy metal poisoning.(Toxicity et al., n.d.)

As heavy metals enter the human body in various ways, such as through food, water, inhalation and by pores of skin, presence of heavy metals itself has been considered a threat to human health. It was established that although the heavy metals Hg, Cd, Cu, Cr, and Zn did not exceed the safety standards, some of their concentrations were marginal to the safety limits and zinc has increased in concentration over the past years while lead concentration has passed the specified safety standard.(Masindi & Muedi, 2018)

However, these metal concentrations are marginal to the safety standards and due to having high accumulation rates they cannot be adjudged to not cause harm to humans.

To emphasize on the wide ranging difference in concentrations obtained from the test results and the SLS standards specified for potable water it is evident that water in Weras River is extremely contaminated. Therefore, since the degree of contamination is high in relation to water that can be used by humans, heavy metal contamination level of Weras River is undeniably harmful to humans.

Moreover, Weras River flows from the south of Bolgoda Lake up to the North Lake thereby discharging into the Indian Ocean. The lake branches out and flows to other water bodies in the area including Kalu River. Ground water intrusion can take place polluting well water used by residents around the Weras River basin. With a total estimated number of households of 22,3000 in the Bolgoda Basin there is a high level of risk in heavy metal poisoning due to the contamination of water

3.4 Methods of Treatment

When considering Weras River, water flows over a large area and this water is not used as drinking water. Therefore, it is rather difficult to provide a treatment method for the water contamination due to heavy metals in Weras River. However, the contamination rate of water can be reduced by method of aeration. For this purpose, eutrophication of the lake needs to be prevented to maintain a maximum oxygen content in the water. Even though, the water body as a whole cannot be treated what can be done is to prevent heavy metals entering the water body from the sources of contamination. Soil contamination by heavy metal play a key role in water contamination. Therefore, soil can be treated to prevent the entry of heavy metals into the water body. Remediation method depends on the characteristics and level of contamination of pollutants of the site considered. (Lindstrom, 2000)

Generally, an aquatic system needs to be cleaned and the surrounding needs to be kept in an unpolluted state as water bodies are habitats for many living things. A long-term solution can be proposed for this problem either by moving the dumpsite to a more isolated area or constructing a method of proper disposal by transporting solid waste collected to a landfill with proper treatment. Also, as sediments are a main source of contamination in an aquatic system, dredging can help reduce the rate of contamination as it reduces the sediment content deposited in the river.

Generally, membrane filtration has been adopted as an effective method of treatment of heavy metals. In this technique, heavy metals get filtered through a membrane which can either undergo microfiltration, ultrafiltration or nanofiltration depending on the membrane that has been used. Most membranes used for this method are made of synthetic polymers. These membranes can be permeable, semi-permeable and impermeable depending on its polymer structure. Apart from these, geo textile membranes can be used to prevent the entry of suspended solids into a water body. Out of the filtration techniques ultrafiltration is the most effective due to the less usage of space, accelerated removal of toxic matter and ease of operation. (Mulligan et al., 2009)

Therefore, method of filtration can be used in treating water of Weras River by using these techniques. Membrane filtration method can be used in effluent discharge pipes so as to prevent the entry of suspended solids to the water body. Conventional method of sand filtration can be used by applying a technique of shoring using sandbags along the banks of the Weras River near the sources of contamination to maximize the filtration method by preventing any contaminant entering the water through ground water and even surface runoff. On the side of the Medha Ela, gabion walls have been constructed on either end. The water tested from this part of the River depicted lower concentrations. Prior to construction of gabion walls geotextile membranes can be laid in the area surrounding the Karadiyana dumpsite to prevent heavy metals getting added to the water body through ground water penetration.

Another method of treatment that can be used is by adsorption. Weras River which is located adjacent to the karadiyana dumpsite has gabion walls built along the riverbanks. These walls are cages filled with rocks, and rocks are a type of minerals that have adsorption properties to a certain extent. These walls help adsorb heavy metals but is not as effective. Therefore, buffer zones can be constructed by refilling the soil using clay minerals such as kaolinite, vermiculite, halloysite and, etc. with high adsorption properties. More rock minerals can be used such as slate or gneiss, but this technique will be expensive to be adopted for a large area. Therefore, most efficient method of using adsorption material is by creating buffer

zones filled with clay minerals and biomass depending on the depth of groundwater intrusion.

Another treatment technique can be treatment using plants and is generally termed as phytoremediation. This technology can be categorized further into phytoextraction, rhizofiltration, phytostabilization, phytodegradation and phytovolatilization depending the mechanism adopted for remediation.(Mishra et al., 2019)

The best option for remediation is by preventing the entry of heavy metals into the river by hindering the flow of contaminants to the river via ground water. Buffer zones with effect of phytoremediation can be used as an effective remediation technique. After these zones are filled with clay minerals that have adsorption properties, plants with phytoremediation abilities can be planted on the topsoil layer of the buffer zone. Out of the plants available for this technique most effective kind to be used in Sri Lanka are the well-known kinds of plants that are naturally grown in mangroves and across the coastal line as a natural remediation technique. Some such plants are phragmites karka, azolla (mosquito ferns), eichchornia, or types of grass such as couch grass and false oat grass, mugwort, ferns, cabbage and many more plants that can even be used as medicinal plants.(Mulligan et al., 2009)

Therefore, as an overall solution of the heavy metal contamination of Weras River techniques such as dredging of sediments, filtration, adsorption, and phytoremediation can be adopted to obtain more purified and unpolluted water that will in turn cause less harmful effects and health risks to humans.

3.5 Prediction of Heavy Metal Concentration

A mathematical model was designed using MATLAB, where an equation was obtained using the concentration of the heavy metal and the rate of flow of water in the sample location. This model was designed for lead, zinc and mercury as results obtained needed a minimum of three decimal places for accurate functioning of the software. These three metals selected were the critical heavy metals as lead exceeded the safety standard specified for aquatic life, zinc concentration had exceeded over the past years and mercury was the selected heavy metal with the highest toxicity as specified by health organizations.

The concentrations of heavy metals tested were used as the response or dependent variable while the flowrate was used as the predictor or independent variable. The flowrate was calculated by measuring the velocity of flow and obtaining other necessary data such as width and depth of the Weras River from past research carried out to determine stormwater drainage plan for the Metro Colombo Region.(Study et al., 2003)

Table 5- Data Required for Mathematical Modelling

Sample Location	Flowrate (m^3/s)	Heavy Metal Concentration		
		Pb (mg/l)	Zn (mg/l)	Hg (µg/l)
1	1.56	0.017	0.048	0.155
5	17.28	0.007	0.029	0.000
4	36.71	0.008	0.028	0.030
2	66.2	0.006	0.017	0.017
3	79.1	0.011	0.039	0.063

Lead

Table 6- Variables for Concentration vs Flowrate Graph for Lead

Flowrate (m3/s)	Independent Variable-x	1.56	17.28	36.71	66.2	79.1
Concentration (mg/l)	Dependent Variable-y	0.017	0.007	0.008	0.006	0.011

Fourth Order Polynomial

- $f(x) = 7.139e\text{-}09\times x^4 - 1.21e\text{-}06\times x^3 + 6.985e\text{-}05\times x^2 - 0.001596\times x + 0.01932$
- Sum of Squared Errors (SSE): 5.559e-33

Second Order Polynomial

- $f(x) = 5.311374e\text{-}06\times x^2 - 4.971676e\text{-}04\times x + 0.01671809$
- SSE: 1.541e-05

Using Matlab, two graphs were plotted, and the best fit was obtained for the fourth order polynomial graph. It also has a lesser sum of squared errors (SSE) compared to the second order polynomial graph obtained. The SSE obtained for the second order fit was 1.541e-05. But the error obtained for the fourth order polynomial fit valued at 5.559e-33 which is extremely low and has a comparatively large gap with the second order polynomial curve error.

Zinc

Table 7- Variables for Concentration vs Flowrate Graph for Zinc

Flowrate (m3/s)	Independent Variable - x	1.56	17.28	36.71	66.2	79.1
Concentration (mg/l)	Dependent Variable - y	0.048	0.029	0.028	0.017	0.039

Fourth Order Polynomial

- $f(x) = 1.948e\text{-}08 \times x^4 - 2.983e\text{-}06 \times x^3 + 0.0001525 \times x^2 - 0.003214 \times x + 0.05265$
- Sum of Squared Errors (SSE): 1.748e-31

Second Order Polynomial

- $f(x) = 1.364623e\text{-}05 \times x^2 - 0.001273914 \times x + 0.04983643$
- SSE: 0.0001409

As in the results obtained for lead, the fourth order polynomial obtained for zinc also has the least error compared to that obtained from the second order polynomial equation (Second order- 0.0001409 > Fourth order- 1.748e-31). Therefore, the most effective equation that can be used to predict the concentration of zinc using the flowrate of Weras River is the polynomial equation obtained from the fourth order fit graph.

Mercury

Table 8- Variables for Concentration vs Flowrate Graph for Mercury

Flowrate (m3/s)	Independent Variable- x	1.56	17.28	36.71	66.2	79.1
Concentration (µg/l)	Dependent Variable- y	0.155	0.000	0.030	0.017	0.063

Fourth Order Polynomial

- $f(x) = 1.01e\text{-}07 \times x^4 - 1.794e\text{-}05 \times x^3 + 0.001082 \times x^2 - 0.02494 \times x + 0.1913$
- Sum of Squared Errors (SSE): 1.998e-30

Second Order Polynomial

- $f(x) = 7.149604e\text{-}05 \times x^2 - 0.006620097 \times x + 0.143222$
- SSE: 0.004135

Like in the previous cases, the equation generated from the second order polynomial fit has a SSE of 0.004135 which is much greater than the error obtained for the fourth order polynomial fir valued at 1.998e-30 which is extremely less compared to that of the second order polynomial. Therefore, the equation obtained for mercury using the fourth order polynomial fit curve will be used to predict mercury metal levels deposited in Weras River Water.

Table 9- Past Data for Validation

Heavy Metal	Year	Flowrate (m^3/s)	Concentration (mg/l)
Zinc	2005	82.4	0.0358
Lead	2007	94.0	0.0293

The model was validated by substituting to the equation obtained for lead, for the above flowrate a concentration of 0.03mg/l was obtained. However, there is a minute error of 0.005mg/l. In considering the equation obtained for zinc, a calculated value of 0.042mg/l was obtained for a flowrate of $82.4 m^3/s$. However, as in the case of lead there is a small error of 0.006mg/l. The model for mercury was developed using concentration measured in micrograms per litre, the equation holds a high accuracy level with a minimum error of 1.998e-30.

However, the model developed has limitations due to the lack of availability of long-term data, the variation of flow rate due to climatic factors and the rate of contamination of the water in Weras River.

IV. CONCLUSION

Heavy metal concentrations of lead, mercury, cadmium, chromium, copper, and zinc were tested to determine the effect heavy metal contamination has on humans. Results obtained by testing water samples for metal levels were analysed with safety standards specified for bathing and contact recreational water, water suitable for agricultural and irrigational activities, water suitable for prevailing aquatic life and potable water. The tested heavy metal levels in Weras River varied in concentration in the order of Zn> Pb> Cu> Cr> Cd> Hg.

In consideration to the hypothesis and null hypothesis it was proved that heavy metal contamination of Weras River will affect humans in negative way resulting in serious health effects. Remediation methods were suggested to treat the water in Weras River either by using a method of membrane filtration, treatment by adsorption or by adopting a treatment method using plants. The mathematical model developed for lead, zinc and mercury can be used to obtain approximated metal concentration in

the Weras River by determining the flowrate of Weras River.

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Technical Efficiency Analysis of Potato Farming in Kerinci Regency-Indonesia (Approach Data Envelopment Analysis Method)

Yanuar Fitri[1], Saidin Nainggolan[2]

Department of Agribusiness Faculty of Agriculture, Jambi University, Indonesia
[1]yanuar_fitri@unja.ac.id; [2]saidinnainggolan@yahoo.com

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Abstract— *Kerinci regency is the highest production area compared to other potato centers. Kerinci regency has the most composition of 92.98 percent or as much as 76477.4 tons with, productivity of 17.06 tons / ha. The scope of this research is focused on knowing the use of production factors and the level of technical efficiency of respondent farmers. The research was conducted within the scope of West Kayu Aro District, Kerinci District, Jambi Province. The analysis tool used is Data Envelopment Analysis, with input-oriented Return To Scale (VRS) Variable models. The use of inputs in seed potato farming activities as much as 2315,403 kg / ha, SP 36 fertilizer as much as 191,129 kg / ha, KCl fertilizer as much as 137,258 kg / ha, phonska fertilizer 157,419 kg / ha fungicide as much as 452.9 gr / ha, insecticides of 597.4 gr / ha, and labor 73.2 HOK / ha / MT. The average value of technical efficiency obtained by farmers respondents to the research area was 0.936 with the highest value of 1 and the lowest value of 0.763. Farmers respondents who are classified on the IRS scale as many as 21 people or by 33.9 percent, DRS as many as 10 people by or 16.1 percent, and CRS as many as 31 people or by 50 percent.*

Keywords— ***Technical Efficiency, Potato Farming, DEA.***

I. INTRODUCTION

Potato production is generally grown in highland areas. Jambi Province has 3 areas that are in the highlands and produce potatoes, namely Kerinci Regency, Merangin Regency, and Sungai Penuh City. Kerinci Regency is one of the regencies in Jambi Province. Kerinci Regency is mostly located in the highlands, with an altitude of 1,400-1,600 meters above sea level, so the land in some areas of Kerinci is suitable for growing crops, especially potatoes. The majority of the people of Kerinci Regency make a living as farmers.

Kerinci Regency during the period 2005 - 2022 is the main production center area compared to other potato center areas. Kerinci Regency has the most composition of 92.98 percent or as much as 76477.4 tons with a productivity of 17.06 tons/ha and has the widest harvest area among other central areas in Jambi Province, which is 4,482 ha with a composition of 92.72 percent. Meanwhile, Merangin Regency has a land area composition of 6.37 percent and production of 6.21 percent of the total land area and production of Jambi Province. Sungai Penuh City is the area with the least land area and potato production, the composition of potato area planted in Sungai Penuh City is only 0.91 percent and production is 0.81 percent of the total. This proves that Kerinci Regency is the largest center of potato commodities in Jambi Province.

Increasing production requires optimal use of inputs. The optimal use of inputs is the use of inputs appropriately and does not damage the surrounding environment. Farmers do farming with the aim of increasing their productivity and making a profit. Decreased productivity can occur due to several things, such as inefficiency in the use of inputs, damaged land conditions due to inappropriate use of pesticides and drugs, and low quality of seeds used. The

use of inputs that are not optimal will affect productivity. If the use of input is not optimal then the productivity will be low. The use of inappropriate inputs such as excessive fertilizers and pesticides can also affect productivity. For this reason, technical efficiency analysis needs to be carried out to determine the combination of factors that are effective in using inputs to increase farmers' profits. The measurement of technical efficiency in this study uses the Data Envelopment Analysis (DEA) method. The DEA method is a non-parametric approach. The DEA method can handle many inputs and outputs and does not require the assumption of a functional relationship between input or output variables.

II. RESEARCH METHODS

The scope of this research is focused on knowing the use of production factors and the level of technical efficiency of respondent farmers. The research was conducted in the area of West Kayu Aro District, Kerinci Regency, Jambi Province. This location was chosen deliberately because Kerinci Regency is a potato commodity center. The object of the sample in this study is a farmer who grows potatoes.

The sampling technique in this study uses Simple Random Sampling, which is a sampling method where each population has an equal opportunity to be selected as a sample. Sampling is done by lottery. The size of the sample drawn is as many as 62 farmers.

There are two types of data sources in this study, namely primary data, which is data obtained directly from respondents' interviews using questionnaires. Secondary data is data obtained from offices or institutions related to potato farming, as well as literature studies in the form of books, journals, and scientific writings.

The data analysis method used is to analyze the technical efficiency and scale of farmers and to find out the distribution of technical efficiency based on the characteristics of farmers. The analytical tool used is Data Envelopment Analysis, with an input-oriented Variable Return To Scale (VRS) model using DEAP 2.1 software. measuring the technical efficiency of farmers using the following equation:

$$Maximize\ \theta, \lambda\ \theta$$

$$-\theta yi + Y\lambda \geq 0,$$

$$Xi - X\lambda\ \geq 0,$$

$$\mathrm{N1}'\lambda = 1$$

$$\lambda\ \geq 0$$

Where θ is the technical efficiency score (TE), Yi is the amount of potato production from farmer to i, xi is vector Nx1 of the number of production inputs for the farmer to i, Y is a vector is 1xM for production, N is the NxM matrix of the number of production inputs used. is used, is the Mx1 vector of weighting, and is the switch.

Technical efficiency by using the VRS model will produce scale efficiency by decomposing the total technical efficiency of Constant Return To Scale (CRS) into technical efficiency of Variable Return To Scale (VRS) and scale efficiency. While the scale efficiency (SE) is calculated:

$$SEi = \frac{\theta i\ CRS}{\theta i\ VRS}$$

III. RESULTS AND DISCUSSIONS

Characteristics of Respondent Farmers

The characteristics of respondent farmers in West Kayu Aro Subdistrict, Kerinci Regency, which were examined in this study included land area, farmer's age, farming experience, and farmer's level of education. The area of land owned by respondent farmers varies from 0.1 ha to 2 ha. The distribution of farmer characteristics by age is in the age range of 20 to 61 years. In terms of farming experience, respondent farmers in the area have a relatively high average of 13.13 years. Most of the farmers graduated from high school by 41.9 percent, did not finish elementary school by 6.5 percent, elementary school by 19.4 percent, junior high school by 29 percent, and undergraduate by 3.2 percent. This can be seen in table 1.

Table 1. Characteristics of farmers in the Research Area, 2020

Description	Minimum	Maximum	Average
Land Area (ha)	0.1	2	0.75
Age (Years)	20	61	39,9
Farming Experience (Years)	4	35	13.13
Education (Years)	3	16	9.52

Production Input Usage

The use of inputs in potato farming in West Kayu Aro District, Kerinci Regency, is in the form of land area, seeds, fertilizers, pesticides, and labor. It can be seen in table 2.

Table 2. Allocation of Potato Farming Production Input Range in the research area in 2020

Decription	Range	Average	Recommendation
Land Area (ha)	0.1-1.80	0.75	
Seeds (kg/ha)	220-3,000	1,880	1,250-1400
SP 36 Fertilizers (kg/ha)	50-400	1805	200-250
Phonska Fertilizers (kg/ha)	50-300	256.6	300-450
KCl Fertilizers (kg/ha)	50-250	120.3	150-200
Herbicide (gr/ha)	100-1,000	450.5	
Fungicide (gr/ha)	80-800	672.8	
Insecticide (gr/ha)	750-4,000	893.4	
Labor (HOK/ha)	40-165	132.2	

Source: processed primary data.

The types of potato seeds planted were granola varieties with grades G0 to G7. The number of seeds used varies from 220 kg to 5.7 tons. In this study, there were 3 types of fertilizers used by all respondents, namely KCl fertilizer, Phonska fertilizer, and SP 36 fertilizer. The average dose of SP 36 fertilizer was 191.129 kg/ha, KCl fertilizer 137,258 kg/ha, and Phonska fertilizer 157.419 kg /Ha. The dose of fungicide usage was 452.9 g/ha and the insecticide was 597.4 g/ha. The average use of labor in potato farming is 73.2 HOK, whereas the amount of labor used in HPT control activities.

The use of seeds in the research area is more than the use of potato seeds in the Bumiaji sub-district of Batu Malang City as much as 2115.27 kg/ha (Rizkiyah et al., 2014). The use of potato seeds in Pagar Alam City is relatively low at 968.12 kg/ha, while the use of fertilizers is also relatively low, with the use of SP 36 fertilizers at 78.38 kg/ha and Phonska at 97.01 kg/ha (Maryanto et al., 2018).

Technical Efficiency Analysis

Based on the calculation results, the results that show the average value of the technical efficiency of respondent farmers can be seen in table 3. Table 3 shows as many as 16 respondents or 25.8 percent are technically efficient, while 46 respondents, or 74.2 percent have not reached efficient value. Overall, the average value of the VRS technical efficiency obtained by the respondent farmers in the research area is 0.936 with the highest value of 1 and the lowest value of 0.763. Analysis of the technical efficiency of the CRS model is known as many as 14 respondents or 22.6 percent have been technically efficient, while 48 respondents, or 77.4 percent have not reached their efficient value. Overall, the average value of CRS technical efficiency obtained by the respondent farmers in the research area is 0.924 with the highest value of 1 and the lowest value of 0.706.

Table 3. The average value of the calculation of constant return to scale (CRS), returns to scale (VRS) variable, and scale efficiency (SE)

Description	CRSTE	VRSTE	SE
Mean	0.924	0,936	0,987
Max	1,000	1,000	1,000
Min	0.706	0,763	0,898
Number of Farmers Value E = 1	14 people	16 people	31 people
Number of Farmers Value E < 1	48 people	46 people	31 people

Source: processed primary data.

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The technical efficiency of potatoes in the Gowa district, South Sulawesi, shows an average technical efficiency of 0.842 with a minimum value of 0.421 and a maximum value of 1,000, with a total of 23 farmers who have an efficient value equal to one (Arifin *et al*., 2021). Pahlavan *et al.* (2011) also found that as many as 27 respondent farmers studied, 15 farmers who had an efficiency value equal to one, or about 55.5 percent could be declared technically efficient. Meanwhile, according to Utami (2016), the technical efficiency of farmers in Wajak District, Malang Regency, around 41.94 percent of the efficiency value is equal to one.

Consistent with Afifah (2017) with the research title "Analysis of the Efficiency of the Use of Production Factors in Potato Farming in Batur District, Banjarnegara Regency" the results of this study state that the production factor of the land area is negative and insignificant to potato production with an elasticity coefficient of -0.0,01. It is suspected that the land used in the research area is too large. Seed production factors, pesticides, fertilizers, and labor, have a positive and significant effect on production results. The value of technical efficiency is 0.83 or 83 percent. This number shows that the use of production factors is not efficient. Because the average productivity that can be achieved is 83 percent based on the frontier calculation (maximal production that can be achieved). Muarip *et al.* (2019), in their research on Technical Efficiency Analysis of the Use of Potato Farming Production Factors (Solanum tuberosum L) in Wonokitri Village, Tosari District, Pasuruan Regency, in their research concluded that seven variables had a significant effect on potato production results in Wonokitri Village, namely area land, urea fertilizer, SP36 fertilizer, ZA fertilizer, organic fertilizer, medicine, labor. These production factors affect the yield of potato production.

Technical Efficiency Distribution Based on Farmer Characteristics

The area of land, farmers who have an efficiency value of > 0.950 are obtained in a land group of 0.1 to 0.5 ha. It can also be seen that farmers who have achieved their efficient value are mostly found in the group of the land areas of 0.1 – 0.5 ha and 0.6 to 1 ha.

Distribution of Farmers' Technical Efficiency by Age

The age of the farmer is considered one of the causes of technical inefficiency in farming activities. By classifying the age of farmers, it can be seen that the efficient value > 0.950 is widely distributed in the age range of 34 to 40 years. This shows that the older the farmers, the more difficult it is for them to receive new information and their physical strength begins to decrease. Sahara stated that the higher the age of the farmer, the lower the efficiency value. This is also supported by Mandei's (2015) statement that farmers who have a productive age range have the motivation to increase production and are more prepared to take risks, but the older the farmers, the lower their efficiency value (Manurung et al., 2018).

Distribution of Farmers' Technical Efficiency Based on Farming Experience

Farming experience of farmers whose efficiency value > 0.950 is found in the range of farming duration between 4 to 11 years. This indicates that the longer farmers carry out farming activities can lead to saturation and trust in the habits carried out. In Sahara *et al.*'s research (2019) the efficient value of >80 is in the range of 11 to 20 years of farming experience, about 16 farmers, or 53.33 percent of farmers who has a high-efficiency value. This is in line with the research of Hoar and Fallo (2017), suggesting that the more experienced a farmer is, the more difficult it is for a farmer to accept innovations and suggestions because farmers have high confidence in carrying out their farming activities.

Distribution of Farmers' Technical Efficiency Based on Education Level

The formal education of farmers whose efficiency value is > 0.950 was obtained by farmers at the high school level as many as 15 farmers. This indicates that the higher the education of farmers, the higher the value of technical efficiency. Consistent with Fahriyah *et al.* (2018) stated that the higher the level of education of farmers, the higher the value of efficiency. This is because the knowledge and insight of farmers affect farmers in carrying out their farming activities. However, this research is inversely proportional to the Sahara *et al.*'s research (2019) in the Sahara study, the distribution of farmer efficiency based on the level of education is widely distributed among farmers with less than 10 years of education (junior high school equivalent), in his research he stated that the higher the level of education of farmers, the lower the value of technical efficiency.

Analysis of the Efficiency of the Use of Production Inputs for Potato Farming

Data Envelopment Analysis (DEA) can show trends in farmers in the research area. The DEA CRS (constant return to scale) model and the DEA VRS (return to scale variable) model were used to see the trend of the respondent farmers. The trend in the research area belongs to the Increasing Return To Scale (IRS), namely the increase in output is greater than the increase in input, Decreasing Return To Scale (DRS), namely the increase in output is smaller than the increase in input, and Constant Return To Scale (CRS).), i.e. increased output and balanced input.

The scale efficiency of respondent farmers in the research area can be seen in Figure 1 Respondent farmers belonging to the Increasing Return To Scale (IRS) of 33.9 percent or as many as 21 people, this shows that the addition of the input proportion will produce an output that is greater than the number of inputs. used, even though the respondent farmers have achieved an efficient value, but with the addition of inputs proportionally will increase the optimal output. Respondent farmers belonging to the Decreasing Return To Scale (DRS) of 16.1 percent or as many as 10 people, shows that the addition of the input proportion will produce a smaller output than the input used, so respondent farmers need to reduce the number of inputs used to a more suitable proportion. Respondent farmers who are classified as Constant Return To Scale (CRS), by 50 percent or as many as 31 people, show that the use of inputs used is optimal and the output produced is optimal.

The measurement of the technical efficiency of the respondent farmers in the research area who has achieved an efficient value equal to one and operates on a Constant Return To Scale (CRS) scale, is 14 people, or 22.66 percent of the total respondent farmers.

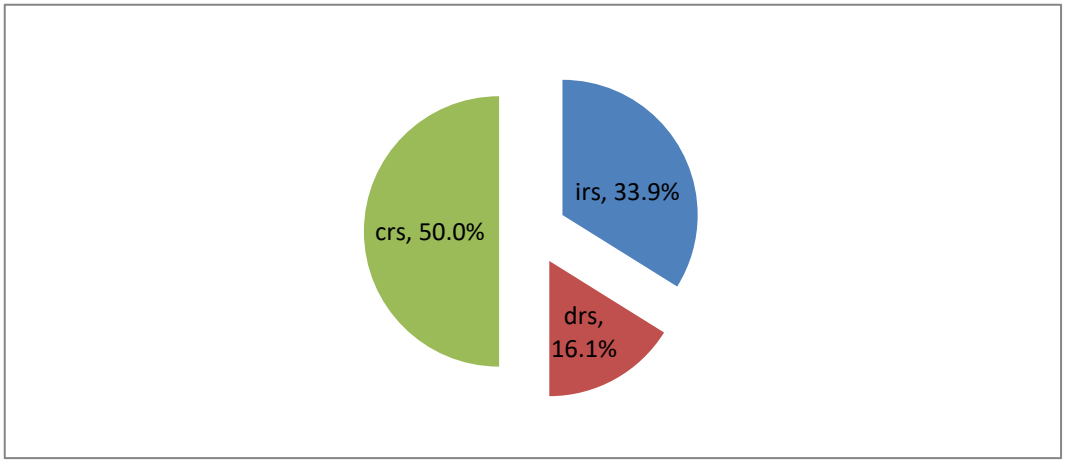

Fig.1. Efficient scale of potato farming

The results of Amandasari *et al.*'s research (2014), "Technical Efficiency of Sweet Corn Farming in Gunung Malang Village, Tenjolaya District, Bogor Regency" explained the number of farmers who were used as respondents as many as 31 people, as many as 18 people or 58.06 percent belonging to the increasing return to scale (IRS), as many as 3 people or 9.68 percent belong to the decreasing return to scale (DRS), and as many as 10 people or 32.26 percent belong to the constant return to scale (CRS). This explains that the research area is in a position where the increase in output is greater than the increase in input. Meanwhile, the results of Fahriyah *et al.*'s research (2018) "Analysis of Technical Efficiency of Farming in Rice Fields and Dry Land", explained that the number of farmers who became respondents was as many as 87 respondents in sugar cane in paddy fields, and 114 respondents in dry sugar cane fields. A total of 78 respondents or 90 percent belong to the increasing return to scale (IRS), 2 respondents or 2 percent belong to the decreasing return to scale (DRS), and as many as 7 respondents or 8 percent belong to the constant return to scale (CRS). While in dry land sugarcane the number of respondents was 114 farmers. As many as 101 respondents or 88 percent belong to the increasing return to scale (IRS), 2 farmers or 2 percent belong to the decreasing return to scale (DRS), and 11 farmers or 10 percent belong to the constant return to scale (CRS).

IV. CONCLUSION

The use of inputs in potato farming is relatively not as recommended. The average land area is only 0.56 ha, the seeds used for granola types G0 to G7 on average are 2315,403 kg/ha, SP 36 fertilizer is 191.129 kg/ha, KCL fertilizer is 137,258 kg/ha, Phonska fertilizer 157.419 kg/ha fungicide 452.9 g/ha, insecticide 597.4 g/ha, and labor 73.2 HOK/ha/MT. Potato farming is relatively technically efficient

Efficiency distribution is based on characteristics with an efficient value >950. Based on the land area, the ET value > 0.950 is in the range of 0.25 to 0.5 ha. The distribution of efficiency based on age is widely spread in the age range of 34 to 40 years, the distribution of efficiency based on farming experience ranges from farmers who already have 4 to 11 years of experience, while the distribution of efficiency of farmers based on education level whose ET value > 0.950 is at the high school education level. The potato farming scale is relatively in the Constant Return to Scale. Respondent farmers belonging to the IRS scale as many as 21 people or 33.9 percent, DRS as many as 10 people or 16.1 percent, and CRS as many as 31 people or 50 percent.

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How Rational and Practicable is the Land use Charge in Anambra State of Nigeria?

Chinaza Henry Obineme, Charles Chukwunwike Egolum and Christian Uchenna Ezeudu

Department of Estate Management, Nnamdi Azikiwe University, Awka
Department of Estate Management, Federal Polytechnic Oko, Anambra State Nigeria

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Abstract— *This work was undertaken to identify how rational and practicable Land Use Charge is in Anambra State. The Land Use Charge is one of the Land-based taxes that tries to integrate other land-based taxes into a single tax. The Land Use Charge as practiced in some States of Nigeria is subjected to criticism because of overwhelming evidence that the institutional control measures in place are at variance with the tested and accepted standards in some other countries, particularly in the United Kingdom. The work adopted a survey design to generate data from the landlord, Anambra State Property, Land Use Charge (APLUC) staff, and Estate Surveyors and Valuers. The responses to the questions were taken to measure their views using relative important index. They suggested that for a Land Use Charge to be rational, practicable, and acceptable, the charge should be fair, the control of the APLUC department must be steady and the basis of the assessment clearly stated. They were also of the view that information on skills and training of members of the tax assessment appeal panel should be mentioned and so on. The issues raised and the remedies proffered in this work would be of immense benefit to policymakers and management of Land Use Charge.*

Keywords— ***Rational, Practicable, Land Use, Charge, Anambra State.***

I. INTRODUCTION

Anambra State Government has made significant effort in improving the Land taxation system. Over the last several years, government-provided considerable assistance to the land taxation system as regard to Assessment, Appeal, and Administration, aiming at improving the overall Property and Land Use Charge compliance. This resulted in the enactment of the Anambra State of Nigeria (A.S.N) Law No. 1 of 2011, the Property and Land Use Charge (APLUC) Law, which repealed the Anambra State of Nigeria (A.S.N) Law No. 5 of 2000.

The APLUC law, which harmonized existing land charges, according to the State Government, is to develop the state that has been facing a growing population without corresponding increase and improvements in physical and social infrastructure (Odimegwu, Anyakora & Odumodu, 2018).

This law empowers the government to tax on incomes and asset holdings of the citizens to raise revenue for carrying on the business of governance in the state (Egolum, n.d). The tax legal and regulatory framework must be significantly stated and in clear terms, and as such (assumed) to decrease compliance burden for taxpayers (as regards understanding) and administration alike and increase voluntary compliance. Nevertheless, Smith (as cited in Odimegwu et al., 2018) found that a good land tax system should conform to the Cannons of Taxation which are equity, certainty, efficiency, and convenience.

Perhaps, varying criteria for evaluating a land tax have emerged overtime, therefore a good land tax must be fair, equitable, set in clear terms, be acceptable to the payers, consistent with the goals of promoting a stable economy, have revenue adequacy, consider the ability to pay based on income, and should be proportional to the benefits received from government services (Ogbuefi, 2004), while

an inequitable discriminatory tax policy administered haphazardly would breed opposition, hostility and non compliance.

1.1 Forms of Land Taxation in Nigeria

Nigerian law taxation is enforced by the three (3) tiers of Government. These are Federal, State, and Local Government Taxes and Levies Act, Cap. T2 Laws of the Federation of Nigeria, 2004, and on May 26, 2015, this Act was amended. The Act is an existing law under the 1999 Constitution of the Federal Republic of Nigeria, section 315 of which provides in subsections (1)(a) that subject to the provisions of this Constitution, an existing law shall have effect with such modifications as may be necessary to bring it into conformity with the provisions of this Constitution and shall be deemed to be: (a) an Act of the National Assembly to the extent that it is a law with respect to any matter on which the National Assembly is empowered by this Constitution to make laws.

Section 315 subsection 2, states that the appropriate authority may at any time by order make such modifications in the text of any existing law as the appropriate authority considers necessary or expedient to bring that law into conformity with the provisions of this Constitution. The 1999 Constitution, Part II of the Second Schedule, Paragraphs 7, 8, 9, and 10 and Fourth Schedule, Paragraphs 1 and 2, show that the Federal, State and Local Governments have the responsibility to collect taxes and levies.

The one that is of importance in this work is the State form as it concerned Anambra State land taxation and reform and the tax regulation pertaining to this, is APLUC Law No. 1 of 2011. The APLUC Law tries to integrate all real property with all land-based rates and charges which were formerly charged under the Assessment Law, the Land Rates Law, the Neighbourhood Improvement Charge Law, and the Tenement Rates Law, into one single Property Land Use Charge. The property rating practice in Anambra State before the advent of APLUC was characterized by corruption, personnel problems, ignorance, lack of adequate materials, apathy, poor street naming, and house numbering among others, and of course, poor revenue generation (Ezeudu, 2009). All these, are geared towards the decision of the State Government to undertake the tax reform.

1.2 The Advent of APLUC Law

The Lagos State Land Use Charge Law integrated all real property with all land-based rates and charges which were formerly charged under the Assessment Law, the Land Rates Law, the Neighbourhood Improvement Charge Law, and the Tenement Rates Law, into one single Property Land Use Charge ("LUC"). Egolum (as cited in Odimegwu et al., 2018) found that the Lagos State LUC led to the advent of the APLUC Law of 2011, followed by Federal Capital Territory, (Abuja) (though the bill has not been passed into law), Oyo and Edo States in 2012, Ondo and Abia States in 2014, Osun and Enugu States in 2016.

II. METHOD

This work adopted the descriptive survey research design. The properties owners (landlords), APLUC staff, and Estate Surveyors and Valuers are the target population. The Estate Surveyors and Valuers as mentioned are the real property consultants and professionals recognized in Nigeria.

The APLUC office in Awka indicates that a total number of 25 staff work in Awka. Landlord's (Udoka housing estate phase 2) population was drawn from Anambra State Housing Development Corporation. And Anambra State Housing Development Corporation indicates that a total number of 213 landlords own properties in Udoka housing estate Awka. The other group of the population chosen for this study is the Estate Surveyors and Valuers. The Anambra State branch of the Nigerian Institution of Estate Surveyors and Valuers secretariat Awka (2020) indicates that a total number of 21 Estate surveyors and valuers are in the membership level of fellows and associates practicing in Awka. This is to show that all of the respondents came from this area mentioned above.

The APLUC and Estate Surveyors and Valuers were selected for questionnaires administration by use of the total population (census) technique due to manageable size (25) and (21) respectively. And a random sample selection of the landlords was done. This method was adopted because it prevents bias in the sample selection of the sample population and for the work to be faster the research adopted the survey monkey approach. The survey monkey application is a useful online tool for creating and administering surveys as well as managing and analyzing data. This tool walks the researchers through the basics of using Survey monkey from creating a survey in survey monkey to downloading the data. The researchers ensure careful review and consider the question types.

However, an aggregate sample size of 157 landlords was adopted as the sample size, using Kothari (2004) proportional allocation method, while APLUC and Estate Surveyors and Valuers were selected using the total population (census) technique due to the manageable size of 25 and 21 respectively. This research featured questionnaires/oral interviews.

III. RESULTS

Data Presentation and Analysis

Table 3.1. Distribution of Questionnaires to Landlords, APLUC staff and Estate Surveyors and Valuers.

S/N	Location	No of population	Distributed	Retrieved	% of success
1	Awka	Landlords (213)	157	144	92
2	Awka	Estate Surveyors and Valuers (21)	21	15	71
3	Awka	APLUC staff (25)	25	16	64
Total					77

A response rate of 76% was achieved on Questionnaires to all the 144 Landlords, 16 APLUC staff and 15 Estate Surveyors and Valuers. Oral interview guides were also applied in the study.

3.1. How Rational is the APLUC Law No. 1 of 2011?

The revenue generated as shown in Fig. 3.1 below, is from the Anambra State Ministry of Finance, which provided that the following amounts have been realized from the property tax between 2011, the inception of the APLUC law and 2015.

Fig. 3.1.Revenue Generated from 2011 to 2015 and there was no revenue recorded from 2016 to 2020. This shows the flow of the revenue generated from 2011 to 2020.

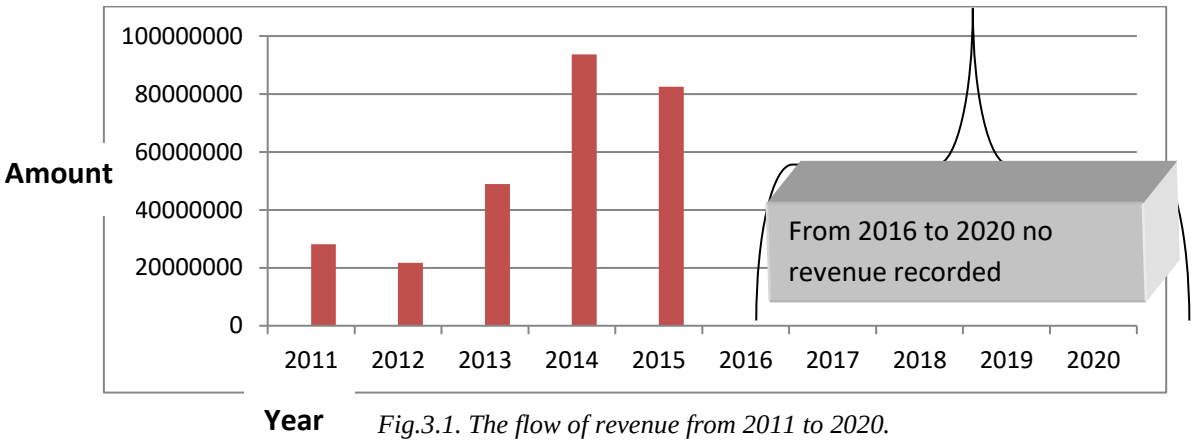

Fig.3.1. The flow of revenue from 2011 to 2020.

The fig 3.1 also shows fluctuating amount which provided an irregular rising and falling in amount generated and non revenue generated from 2016 to 2020. Government believed that land taxes increase would enhance the internal generating revenue (IGR), whereas without acceptability by the people to pay then the overall purpose of the increase would be defeated.

A survey of what could cause amount fluctuation, was carried out through the use of oral interviews and questionnaires. One hundred and forty four (144) landlords, sixteen (16) APLUC staff and fifteen (15) Estate Surveyors and Valuers were surveyed in Awka and analysed with relative important index. Respondents' responses were in terms of Strongly Agreed (SA), Agreed (A), Strongly Disagreed (SD), Disagreed (D), and Undecided (U) for the analysis in assigned 5, 4, 3, 2 and 1 respectively.

Table 3.2. Landlord responses

Landlords	SA W=5	A W=4	SD W=3	D W=2	U W=1	Total	RII	Ranking
No Awareness	0 WF=0	100 WF=400	0 WF=0	0 WF=0	44 WF=44	144 (444)	3.1	3rd
Charge too High	46 WF=230	35 WF=140	0 WF=0	43 WF=86	20 WF=20	144 (476)	3.3	1st
Because Estate	24	22	23	47	28	144	2.8	4th

Surveyors and Valuers are left out during law making	WF=120	WF=88	WF=69	WF=94	WF=28	(399)		
Lack of Basis of Assessment	45 WF=225	35 WF=140	0 WF=0	26 WF=52	38 WF=38	144 (455)	3.2	2nd
Skill and Training of Members of Appeal Panel not Provided	0 WF=0	0 WF=0	36 WF=108	43 WF=86	65 WF=65	144 (259)	1.8	5th

Key: WF = Weighted frequency.

Table 3.2 reveals that 'Charge too High' ranked first (RII = 3.3). This was followed by 'Lack of Basis of Assessment', which ranked second (RII = 3.2). And followed by 'No Awareness' (RII = 3.1). Then, followed by 'Estate Surveyors and Valuers' who are left out during the law making process (RII = 2.8) and the last is 'Skill and Training of Members of Appeal Panel not Provided', which ranked fifth (RII = 1.8).These explained that the five analysed indicators affect compliances. From this analysis, it reveals that the amount fluctuation is as a result of lack and drop of compliance on the part of the landlords.

Responses from the Landlords on what causes lack and drop in compliance with APLUC as regards to revenue generated.

The landlords are of the opinion that APLUC can be said to be accepted and the compliance level increases if the under listed are taken care of:

a. The calculation of the charge should be clear on the method they use to arrive at the assessment and taxes.
b. The tax should be reduced.
c. The revenue collected must be used for the reason(s) of the charge and not diverted to other things.

Responses from the Staff with regard to compliance

The staff revealed that the APLUC collection had been stopped and that the last revenue collection was done in the year 2015.

Then, the reasons given for the stoppage of collection of the revenue are as follows:

a. The stop was as a result of misunderstanding between the Governor and the contractor.
b. The staff salaries are not paid.
c. The unsteady control of the APLUC department as it was initially under the Ministry of Finance in 2011, moved to the Ministry of Lands in 2014 and moved to the Board of Internal Revenue in 2019.

Table 3.3. Estate Surveyors and Valuers Responses

Estate Surveyors and Valuers	SA W=5	A W=4	SD W=3	D W=2	U W=1	Total	RII	Ranking
No Awareness	0 WF=0	4 WF=16	3 WF=9	5 WF=10	3 WF=3	15 (38)	2.5	3rd
Charge too High	0 WF=0	9 WF=36	0 WF=0	4 WF=8	2 WF=2	15 (46)	3.1	2nd
Because Estate Surveyors and Valuers are left out during law making	0 WF=0	3 WF=12	1 WF=3	11 WF=22	0 WF=0	15 (37)	2.5	3rd
Lack of Basis of Assessment	15 WF=75	0 WF=0	0 WF=0	0 WF=0	0 WF=0	15 (75)	5	1st
Skill and Training of Members of Appeal Panel not Provided	0 WF=0	1 WF=4	2 WF=6	6 WF=12	6 WF=6	15 (28)	1.9	4th

Key: WF = Weighted frequency.

Table 3.3 reveals that 'Lack of Basis of Assessment' ranked first (RII = 5). This was followed by 'Charge too High' which ranked second (RII = 3.1). And followed by 'No Awareness' and 'Estate Surveyors and Valuers are left out' during law making was ranked third (RII = 2.5) and the last is 'Skill and Training of Members of Appeal Panel not provided', ranked fourth (RII = 1.9). These explained that the five analysed indicators affect compliances. From this analysis, it reveals that the amount fluctuation is as a result of lack and drop of compliance as shown in the analysis.

Then, the reasons given for expectation of APLUC not realizable by Estate Surveyors and Valuers are as follows:

a. Basis of assessment is not stated.

Basis of Property Rating Assessment

Anambra State of Nigeria (A.S.N) Law No. 1 of 2011 Property and Land Use Charge Law did not state the basis of assessment while there are two generic basis used in assessing property for rating purpose and these are Annual and Capital value (Ogbuefi, 2004). Thus, this fact is very important for the assessment and as such this was not stated therefore makes the Property and Land Use Charge vague.

For instance, in using capital value, it required the capital sum and the rate(s) of interest to be applied. The rate (percentage) to be used should take into consideration all factors in order to ensure equity to both the ratepayer and the rating authority. And as such, the rate used should not be too high, and it should also not be too low. Perhaps, the entire rate must be that which is in line with the basic cannons of taxation but where the basis is not stated is not clear.

Nevertheless, when compared to country like the United Kingdom; annual value of hereditament was the prescribed basis of assessment (Ogbuefi, 2004).

Ogbuefi (2004) found that in the former Anambra State, comprising Enugu, present day Anambra and parts of Ebonyi states, the state local Government Edict, 1976 states the basis of assessment of properties as state below.

This is stated in the tenement rating (method of assessment) order, 1977 section 3.

The assessed value of a tenement liable to tenement rate under the Edict shall be the rental value at which the tenement might reasonably be expected to let annually, as at the date of valuation, less a reasonable allowance for the cost of outgoings necessary to maintain the tenement in the state to command the rent, provided that in all cases the total deduction from such rental value for such expenses shall not exceed two-fifths (2/5) of the rental value.

b. Information on skills and training of members of the tax assessment appeal panel are not mentioned.

c. Estate Surveyors and Valuers should be among the members appeal panel.

d. Information on the skills and training of tax assessors are not stated.

e. The cycles for updating taxable values are not stated.

f. The charge failed when checked with the cannons of tax (equity, certainty, efficiency and convenience). The tax is not equitable in the sense that tax payers are all into tax bracket irrespective of the individual tax liability under the previous laws. Furthermore, the assessment method is uncertain and as such prone to abuse then, efficiency and convenience can not be in place when equity and certainty are lacking. Ordinarily, tax payers should be able to know in advance how much tax expected to pay.

g. Constant rate schedule employed in the exercise (per unit square) and lump taxes are inadequate for property valuation since real properties are heterogeneous and as such no two properties can ever be identical.

The above stated reasons are said to be the causes for the drop and lack of compliance towards APLUC Law.

Lagos State LUC, commercial and residential owner-occupied properties attract an annual property Land Use Charge Rate of 0.394% of the assessed value of the property; new owner-occupier/individual properties are assessed at an annual land use charge rate of 0.132% of the assessed value of the property (Oserogho & Associates, 2012) stated as a guide but in APLUC is missing.

IV. DISCUSSION/CONCLUSION

The APLUC Law No. 1 of 2011, section 16, subsection 1 (b) stated that, a person may appeal to the Tribunal if he is aggrieved by any calculation of an amount which he is liable to pay as Property and Land Use Charge and the Tribunal shall make such decision as it deems fit. And as such there is need to state the basis of assessment for acceptability, to increase voluntary compliance, decrease compliance burden for Property and Land Use Charge payers and administration alike. Meanwhile, the need to include the information on skills and training of members of the tax assessment appeal panel is of great importance as such will disqualify unqualified from being a member. And for transparency' sake, the Estate Surveyor and Valuer should be among the members since he is the only professional authorized by law to place values on landed assets. More so, the information on the skills and training of tax assessors needs to be stated and the cycle for updating taxable values are of necessity when viewed at APLUC Law No. 1 of 2011 section 5 subsection (2) and APLUC Law No. 1 of 2011 section 7 as stated above. Moreover, Estate Surveyors and Valuers should have been

involved in the making of APLUC Law, to eliminate most of these shortcomings and as such there is need for a review of the APLUC Law.

The unsteady control of the APLUC department as stated by the staffs should be stopped for the good of APLUC.

Looking at the foregoing is not rational and practicable. It is the reason for the fluctuation in the revenue generated from 2011 to 2015 as observed and as such gradually leads to the stoppage. And for the expectations of the Law to be achieved then the reasons of Landlords, APLUC staffs and Estate Surveyors and Valuers should be taken care of.

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Unlocking Opportunities in Edible Oil Crop Production and Market Dynamics to Accelerate Agricultural Investment in Kagera Region, Tanzania

F. M. Reuben* and J. L Meliyo

Tanzania Agricultural Research Institute (TARI)
*Corresponding author e-mail address: mfrankreuben@yahoo.com

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Abstract— *Edible oil crops such as sunflower, oil palm, sesame, groundnuts, avocado and canola are one of the fastest-growing agricultural sectors for investment at global scale. Demand for edible oil currently at local and neighbouring countries indicate huge gap that is an opportunity for production. The oil crops are grown under varied agro climatic conditions and they are vital commodities in the trade and commerce of many economies globally. Edible oil imports account for 34 % of the growth in food imports in Africa of which palm oil contributes 65% of all imports in the continent. In East Africa countries; Tanzania, Kenya, Uganda, Rwanda, Burundi, Southern Sudan and DR-Congo and SADC countries the edible oil imports exceed US$ 1 billion. Tanzania produces 290,000 MT of edible oil a year, which is not enough to meet its current annual demand of 650,000 MT, therefore, it is compelled to spend over US$ 200 million annually for import to cover the shortage. Thus, there is great business opportunity for Kagera region which is endowed with a favourable equatorial climate for agriculture, extensive arable land of more than 24,953 sq, km. (water bodies of 11,885 sq. km. that is covered by Lake Victoria, Ikimba and Burigi Lakes, Kagera and Ngono rivers), forests and biodiversity. It is envisioning that if 10 percent of the land is put under oil seed, (about 249,600 hectares) under intensified production, more 249,600 MT of grains per season will be processed, employing many people along the value chain, hence addressing the income earnings instability, mask the climate and market instabilities. The oil seed crops are alternative processing crops with price stability, high demand elasticity and low substitutability to moderate prevailing instability in earnings from coffee and banana crops. It is concluded therefore that, the proposed crop diversification will shape a strategy to deal with climate variability by increasing a range of food and cash crops, that enhances productivity, encourages youth self-employment and incomes generation along the value chain in Kagera region.*

Keywords— ***crop diversification, edible oil, climate variability, business.***

I. BACKGROUND

Oil seeds are the principal group of crops which are source of edible oil and protein thus provide a nutritionally balanced diet (Sharma et al. 2011; Narayan, 2017; Negash et al. 2019). Oil crops account for approximately 23% of the world's croplands, but only 6% of these crops are directly used for food. It is one of the fastest-growing agricultural sectors in the global, including oil palm, coconut, cotton, soybean, groundnut, sesame, canola, safflower and sunflower. The demand for oil crops is growing mainly being influenced by edible oil and livestock feed industries. The oil crops are boosting edible oil processing industries (Narayan, 2017) involving about 40 different plant species whose oil can be consumed but only a few are of significant for global trade (Sharma et al. 2011). Major plant oil sources of commercial importance out of the 40 documented for edible oil include soybean, sunflower, groundnuts, canola (rapeseed), coconut, and oil

palm (Nde and Foncha, 2020, NBS, 2021). These oil crops are grown worldwide under varied agroclimatic conditions and are of vital trade commodities for many nations including Indonesia, Malaysia, and Ukraine (FAO,2021) to mention a few. The global production of vegetable oil has steadily increased from about 90.5 million metric tons in 2000/2001 to 207.5 million metric tons in 2019/2020 and these trends are expected to continue in the future proportional to the global population growth. This indicates the future areas of investment and markets. In Tanzania, edible oil seed crops are grown under diverse agro-ecological zone from the along the coastal to highlands, almost in more than 19 regions, although there are more favoured than others for examples the agriculture is highly productive in areas with reliable rainfall than areas characterized with semi-aridity and arid. Some areas also are characterized by poor rainfall distribution and high land pressure which obstruct large scale investment.

However, Kagera region is characterized with equatorial climate with bimodal rainfall patterns per year and therefore allows more than three crops growing per year and it has the land area that covers 40,838 sq. km of which 28,953 sq, km. is landmass and 11,885 sq. km., for waterbodies; whereas 86% of the landmass is estimated arable land that can grow diverse edible oil crops include sunflower, canola, sesame and oil palm, which offers plenty of future agriculture investment.

II. JUSTIFICATION

Kagera region unlike most of other regions has two - three advantages for agricultural investment, the opportunity that is not fully utilized. The region has a good equatorial climate characterized by having reliable rainfall throughout the year and farming can be done two to three folds a year. Second, it has abundant arable land (AGRA, 2021) of more than 24,000 sq. km which is suitable for growing all tropical crops including: cereals, oil crops, fruits and legumes to mention but few. Third, comparably to other regions of Tanzania, Kagera region has literate population who can take an opportune of edible oil market share if are well sensitized. Then, there is a ready-made edible oil market that is just waiting to be filled by whoever comes first to filling the shortage. The shortage in Tanzania is worthy US$ 200 million, while the EAC market and SADC is more than US$ 1 billion.

To achieve productivity growth and market connections, while enhancing resilience to climate change is to unlock agricultural potentials by making the region participate fully in the “trillion-dollar opportunity” of agricultural markets in the country, regional (ECA, SADC) and in the world. Kagera has a potential to become a country and regional player in the industry of oil crops, there is a need to focus on positioning the domestic edible oil sub-sector. The edible oilseeds can increasingly become important commodities in the development of the region in terms of food security, import substitution, foreign currency earning, employment creation and domestic technology development.

In addition, edible oilseeds have strong linkages with the domestic animal sub-sector as they provide vital input in animal feed production. The livestock sector is estimated to grow by 3 to 4% (GAFSP, 2016) with a corresponding sunflower seed cake increase for poultry feed (Kilimo Trust, 2017), supported by broiler and hybrid poultry market. Notwithstanding the significance of the crops, there has been limited production. It is for this reason that authors have sought to come up with this catalytic paper that present rarely seen vision and so kickstart the discussion with strategic edible oil stakeholders along the commodity value chain and facilitate making choices for investment. The edible oil market is there and it is booming up.

The overall objective: is to unlock opportunities by enhancing edible oil seeds production, industrial competitiveness and economic development for improving income earning opportunities in Kagera region and beyond.

Global Business of Edible Oil

Edible oil from oil seed crops is one of the highest trade shares (42%) of production of all agricultural commodities (OECD-FAO, 2019) in the World. The global edible oil market is estimated to grow at 3.6% from a market value of US$ 96.878 billion in 2019 to attain a market value of US$ 119.571 billion by the end of 2025. Developing regions of the world are predicted to contribute to increasing the market growth for vegetable oil during the forecast period. In the coming years, vegetable oils with low cholesterol, fat, and calories are likely to gain high response due to growing health awareness among people across the world. This share is expected to remain stable throughout the outlook period, with global vegetable oil exports reaching 91 MT by 2026

Demand of Edible Oil in Africa

Edible oil imports account for 34% of the growth in food imports in Africa, the highest share of any food category (Olabisi et al. 2018). Palm oil accounts for about 65% of all edible oil imports to the continent. The EAC imports edible oils reaching nearly $1 billion (UIA,2021). The demand for seed cake increases at an average annual growth rate of 117% in EAC. The business potential for edible oil is thus clear because there is an opportunity for import substitution (Kilimo Tust, 2017)

Demand for Edible Oil in Tanzania

Tanzania looks much like the rest of Africa in terms of the rapid growth in edible oil consumption and imports. Currently, Tanzania produces about 290,000 MT of edible oil a year, which is not enough to meet its annual demand of 650,000 MT. The country is thus compelled to spend over US$ 200 million annually for import to fill the shortage gap. However, the Government of Tanzania (GoT) is keen to reduce the dependence of imports of edible oil by setting interventions that stimulate, boosts and promote the domestic oil seed production and downstream oil processing capacity (Balchin,2018; Mgeni et al. 2019). The country stands out for its dramatic rise in local production and processing of sunflower oil. The production of sunflower is growing due to demand, available land for expansion and Government will to support sunflower production and processing (BOT, 2017). For instance, sunflower production has increased as much as 10 times, placing the country second in Africa after South Africa (FAO, 2018). In addition, to ensure the sustainability of the edible oil sub-sector, the use of improved seeds, inputs, and appropriate agronomic practices should be coupled with assured markets for the edible oil products (Mgeni et al. 2019).

Edible Oil is a Contemporary Opportunity in Kagera Region

Agriculture contributes over 80 percent of the Kagera region economy and more than 90 percent of the of working population is involved on crop production, livestock keeping and fishing for subsistence and income. The Kagera region is famous for coffee, tea and tobacco as key cash crops whilst bananas, beans, maize, paddy and cassava serve as main food crops. In most cases the food crops grown serve as cash crops too. However, Kagera farmers except for coffee and sugar cane, produce and sell their crops independently hence have little bargaining power over buyers due to lack of strong formal organization. For successful edible oil crop production, farmers need to form cooperatives and linked them to formal markets or practice contractual farming. Following the coffee style of production and marketing, it is envisioned that edible oil crops are coming as a game changer. The oil crops: sunflower, oil palm and canola or rapeseed are climate smart crops and also have limited diseases. It is envisioned that when farmers are well organized and linked to financial institutions, investment to tap the huge market of edible oil can be realized. The consideration is that there is entire full chain of the commodity production to marketing and processing.

Kagera stand out to have comparative advantage because of the big land available and a very good reliable equatorial climate where for short times crops like sunflower, two crops can be grown per year. This is crucial for sustainable and continuous supply of industrial raw materials. Kagera has been known as an agricultural region with exports of coffee, but of recent there are investment of large plantations for avocado production leading to investing the facilities for processing of edible oil (TIC,2021). Also, the area is potential for production of sunflower (NBS, 2021) which has a growing demand particularly for edible oil and seed cake and this expands opportunities of farmers to increase production (Tibamanya et al. 2021). Important to note that the oil seed crops are getting credit in Kagera region because of their increasing monetary value associated with relatively low cost of production.

Oil Seeds for Crop Diversification in Kagera region

Oil seed crops are perfectly okay for diversification as they form an effective strategy for profit maximization through reaping the gains of complementary and supplementary relationships or in equating substitution and price ratios for competitive products (Barman et al. 2022). Oil seed crops act as a powerful tool in smallholder farming that can contribute significantly to livelihoods, improved health and nutrition, household food security, and ecological sustainability income growth, poverty alleviation and employment generation (Waha, 2018, Mango et al. 2018) especially if the farmers are linked to the oil processing industries, hence assured markets. Many crops can be used in crop rotation but also can be used in crop intercropping, maximizing use of agricultural land but also help to control some pests and diseases apart from improvement soil fertility. Crop diversification is also associated with increased agricultural income (FAO, 2018) and can also provide a buffer against price fluctuations because cultivating several crop species helps to manage both price and production risks (Mango et al. 2018; Heumesser and Kray, 2019). Increasing crop diversification is vital for improving food security, nutrition and diets and also has important socio-economic and climate-resilience benefits (Mango et al. 2018). Therefore, crop diversification using oil seed crops is the best resilience of an agricultural system to climate change and can give range of crop of economic value in agricultural production, biodiversity and livelihoods.

Current Oil Seed Production and Market Dynamics

It is estimated in Tanzania that close to 4 million farmers are involved in oilseeds farming (GAFSP,2016). The area cultivated and increase use of modern farming practices have driven oilseeds production to increase over four-year period in the country from 674,327 MT in 2016/2017 to 1,583669.28 MT in 2019/2020 (URT,2021). This shows

that, production of oilseeds in Tanzania increases rapidly at the compound annual growth rate (CAGR) of over 14% per annum. Tanzania is ranked as one of the top ten sunflower producers in the world (GAFSP, 2016) and the recent sources position the country as the top producer of sunflower in the continent. Globally, the overall market of edible oil crop products has dynamics of prices in the international market which are conditioned by the relationship between demand and supply. The increase in consumption of comestible oils in domestic and international markets and intensification of livestock production have led to increased demand for oil crops. The oil palm supplies about 40% of all traded vegetable oil (Kilimo Trust, 2017, Murphy et al. 2021). Currently, the domestic market and global market conditions of edible oil following the COVID-19 pandemic, Ukraine–Russia conflict with negative impact on countries which form world sunflower triangle (Ukraine, Russia and Argentina) and additional problem attributed to climate change have left beyond spillover effects on edible oil supply. This has resulted into shortage of edible oil and price increase of palm, soy and rapeseed oils (OECD/FAO, 2021; FAO, 2022). This is an interesting area for investment with assured market.

The Edible Oil Market Opportunities

Kagera region has an attractive diverse environment supporting a number of oil seed crops. The region shares land borders with Uganda, Rwanda, and Burundi and a marine border with Kenya on Lake Victoria (KEPRO, 2015, URT, 2019), which expands the market of whatever is produced in the region. It is also within easy reach of South Sudan and DRC. Considering that the region borders four East African Community (EAC) member states hence the region is strategically located for potential cross-border trade (URT, 2019). The increasing number of countries in EAC, increasing population, economic growth and industrial development result into increase of the demand of edible oil in these countries. Thus, the sector is experiencing strong growth, drivers of this growth from the demand side include national economic growth as well as population growth. This makes the oil seed crops be among the competitive crops in the region. The increase in prices of palm oil in the world market is providing the space in the domestic market to produce the edible oil. The economic and population growth in Kagera region of about 3.5 % per annum calls for increasing demand for edible oil today and in the near future. There is growing recognition of the strategic role of edible oilseeds by the Government by supporting scalability of technologies which make production attractive and profitable.

III. CONCLUSION

This review shows that there is edible oil deficit that is being filled through imports using forex. More than US$ 200 million is used for the edible oil imports. This money could be investing in Kagera region which has an ample land and retain the money in the country and create huge badly needed employment to different categories along the edible oil value chain. Additionally, from the edible oil supply side, show that the Government and other stakeholders including NGOs, financial institutions and private investors have contributed significantly to the growth of the sector. Global demand for edible oils has increased competitiveness of domestic oil sources. Concerted efforts by national and international development organizations is needed and necessary to promote the crops under value chain approach. National campaign on sunflower and oil palm has added impulses into the sunflower and oil palm production particularly through access to seeds and mechanization. The edible oil sector supports livelihoods of many households from production, transport, processing and marketing of edible oil. It also has potential to contribute to foreign exchange generation on the regional markets for oil and international markets for seedcake. Therefore, efforts gear towards contributing to investing in special regions such as Kagera region should be recognized and supported for it aims to local self-sufficient of edible oil and the excess for export market.

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Identification of Potential Runoff Harvesting Sites in Wadi Elrawakeeb-Alsayal Watershed

Tahir Mohammed Ahmed

Department of Soil and Water Resources Management, Environment & Natural Resources & Desertification Research Institute, National Center for Research, Sudan
Tahir.abdu@yahoo.com

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Abstract— *To identify the suitable areas for potential runoff harvesting in Wadi Elrawakeeb and Wadi Alsayal desertified watershed, spatial suitability analysis was applied considering three major factors; potential surface runoff, inhabited sites, sites planted with field crops, and two additional factors; sub-basins average runoff and outlet locations of sub-basins. Obtained results showed that; most, middle and least suitable areas for water harvesting in the studied watershed are located at the sub-basins outlets, which are formed by the longest flow paths of both Wadis.*

Keywords— ***water harvesting, runoff potential, spatial suitability analysis.***

I. INTRODUCTION

The United Nations Environment Program (UNEP) defines water harvesting as the collection of rainwater from the surface and storing it to meet the needs of humans, animals and plants for water when needed (Ahmed, 2018[1]). With limited resources and rapidly increasing demands, sustainable development of Wadi systems is becoming increasingly important, which is a difficult goal to be achieved. Watershed management of Wadi systems leads to the improvement of these resources. Although Wadis in Sudan have high runoff potential, they have been suffering from lack of data that can be used to manage and evaluate them, which calls for an urgent initiative to evaluate this precious water resource. There is a need in Sudan for technologies such as RS, GIS, GPS, and Hydrological Modeling Systems (HMS) to help provide reliable, useful and timely data for water resource management (Alhassan, 2011[2]; Salih and Ghanim, 2002[3]; Wheater and Alweshah, 2002[4]). Weighted Overlay Analysis is one of the overlay analysis tools included in the Spatial Analyst Extension of ArcGIS; it is often used to solve complex problems. Spatial Suitability Analysis aims to test a suitable spatial location to perform a specific function by applying the specific conditions for how to choose, and it is one of the most important functions of GIS technology (Dawood, 2012[5]). Wadi Elrawakeeb and Wadi Alsayal watershed is located at Elrawakeeb Area at western Omdurman which is located in semi-arid region as shown in Figure (1) and which suffer from severe land degradation such as sand encroachments. Wadi Elrawakeeb and Wadi Alsayal share one watershed with a total area of 257 km^2 and one outlet. The average annual rainfall in the region is about 121.4 mm, mostly falling in July and August; the actual annual rate of evaporation is about 850 mm; the average daily potential evaporation is about 7.7 mm, and the average relative humidity values are 38% and 23%, respectively. The average annual temperature is about 29º C; the average daily maximum and minimum temperatures are 37º C and 21.6º C, respectively (Ahmed, 2020[6]). Wadi Elrawakeeb and Wadi Alsayal have been suffering from a lack of rain-runoff data that can be used to manage and assess them. The sudden and fluctuating nature of precipitation at their watershed makes the process of rain and runoff gauging rather difficult due to the topographical variation in the region. On the other hand, achieving an adequate scientific understanding of Wadi system in arid and semi-arid regions is a challenging task, for this reason the study had directed attention for the hydrological parameters estimation and rainfall-runoff modeling of this

vital resource which is expected to assist in management and evaluation of these systems and leads to better use of Wadi systems to meet current and future demands. The study mainly aimed to identify suitable areas for runoff harvesting at Wadi Elrawakeeb and Wadi Alsayal desertified watersheds, using a GIS-based approach that incorporates hydrological and socioeconomic criteria's for selecting sites.

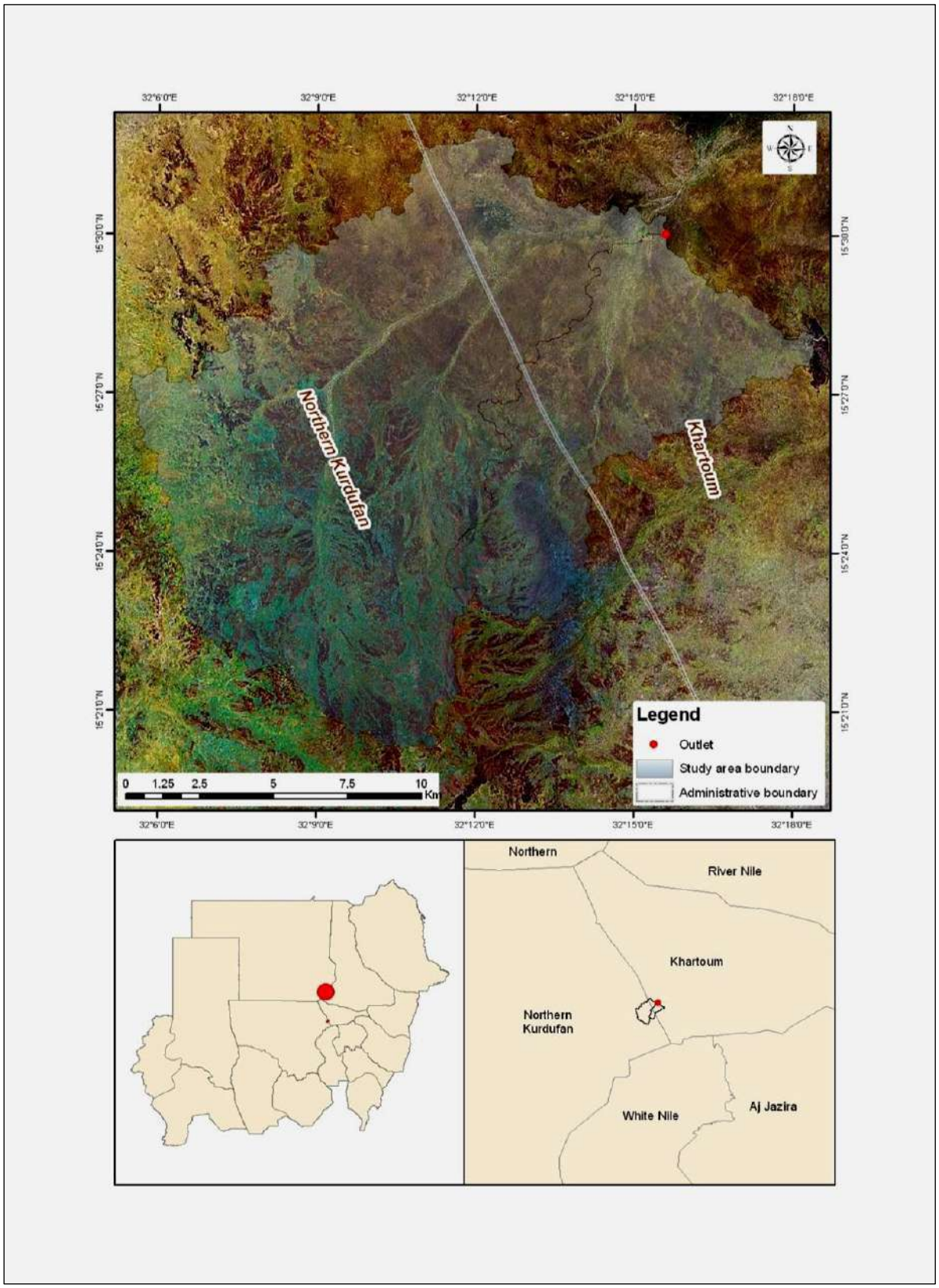

Fig.1: Location of study area decertified watershed

II. MATERIAL AND METHODS

2.1 Development of a semi-distributed model for study area watershed

In order to develop a hydrological model, ArcGIS [9.3], Archydro [1.3], HEC-GeoHMS [5], DNR Garmin [2.02] and HEC-HMS [3.1.0] were used integrally to develop hydrologic inputs for Hydrological Engineering Center-Hydrological Modeling System (HEC-HMS) semi-distributed model for the study area. The constructed model divided the studied watershed into 35 subbasins, and then two simulation runs were carried out to cover the first period from 22nd July to 4th August 2011, which contains 3 rainstorms, and the second period from 20th August to 2nd September 2011, which contains two rainstorms. The constructed model was calibrated for both simulation runs (1) & (2) Ahmed (2020[6]).

2.2 Development of raster datasets for spatial suitability analysis

Figure (2) shows the major steps taken to process the collected datasets to generate useful output in the form of runoff potential and suitable runoff harvesting sites using GIS tools. Three major factors were selected to perform spatial suitability modeling as suggested by Sharma and Singh (2012[7]) which were potential runoff, populated sites and cropped sites. With reference to Ramakrishnan *et al* (2009[8]), Ahmed (2020[6]) suggested two additional factors as shown in Fig (2); the first factor is sub-basins average runoff which was obtained from calibrated semi-distributed model, and the second factor is the sub-basins outlet locations. The raster datasets needed for analysis were produced as follows:

(1) **Potential runoff layer:** Both the SCS-CN and Slope raster layers were combined to produce it; with reference to Hassan *et al* (2020[9]), the produced layer was then reclassified into 5 classes so that

all the produced layers will be on one scale, which in this case is from 1 to 5, considering that number 5 is the highest suitable location for water harvesting.

(2) **Inhabited sites, sites planted with field crops layers**: These sites were tracked using a GPS, and then by using the straight line distance function, the produced layer was buffered by 100 meter distance as a distance suitable for water harvesting from inhabited and cropped sites as suggested by Sharma and Singh (2012[7]). With reference to Hassan *et al* (2020[9]), the two produced layers were also reclassified into 5 classes.

(3) **Sub-basins runoff layer**: Values of mean runoff volumes for the sub-basins were extracted from the calibrated semi-distributed model (simulation runs 1&2) then attached to each subbasin. The layer was converted to a raster layer, and then the produced layer was buffered by 1 Km distance as a distance appropriate to construct barriers for water harvesting cross Wadi section as suggested by Ahmed (2020[6]); With reference to Hassan *et al* (2020[9]), the produced layer was also reclassified into 5 classes.

(4) **Sub-basin outlet locations layer**: Outlet locations for each sub-basin were also extracted from the calibrated semi-distributed model (simulation runs 1&2) and then attached to each sub-basin, the produced layer was also buffered by 1 Km distance as a distance appropriate to construct barriers for water harvesting far from each subbasin-outlet as suggested by Ahmed (2020[6]). With reference to Hassan *et al* (2020[9]), the produced layer was also reclassified into 5 classes.

2.3 Factors evaluation using a raster calculator

With reference to DWSRM/ENRDRI (2020[10]) of NCR, produced raster datasets of runoff potential, settlements, croplands, sub-basin runoff, and subbasin outlets were given appropriate weights, then by using raster calculator, all layers were evaluated. The number of coding categories of the produced raster layer was changed to 3 new categories which are high, medium and low suitability to facilitate display of results.

III. RESULTS AND DISSCUSIONS

Obtained results showed that the most, medium and least suitable areas for runoff harvesting at the studied watershed are located around the sub-basins outlets at end of the longest flowpaths of each two Wadis as shown in Figure (3).

Obtained results were found to be compatible with findings of Sharma and Singh (2012[7]) who stated that providing an accurate spatial representation of potential runoff estimation in any water basin is an important factor for establishing any water harvesting strategy in the relevant basin. Measurement of runoff volume at the end of the longest flowpaths within the study area watershed is rather difficult due to the nature of watershed surface which contains a number of sandy hills and stone heights so Ahmed (2020[6]) suggested using sub-basins average volume generated by the SCS_CN method and using the sub-basins outlet locations as additional factors for analysis as suitable sites to construct earthen or rocky barriers for water harvesting. The buffered distance suggested by Ahmed (2020[6]), which is 1 km was found to be plausible since it considered diversity of the spatial variance and generated runoff of studied watershed. Although Ramakrishnan *et al* (2009[8]) carried out field investigations for their derived suitability maps and

obtained an accuracy of 80-100%, field investigations of the derived sites were obstructed by the hard surface nature of the examined watershed. Finally, obtained results showed that, the suggested GIS approach which considers additional factors, is well realizes hydrological modeling inputs by identifying specific areas (sub-basins) in the studied watershed, which are the potential sites for water harvesting.

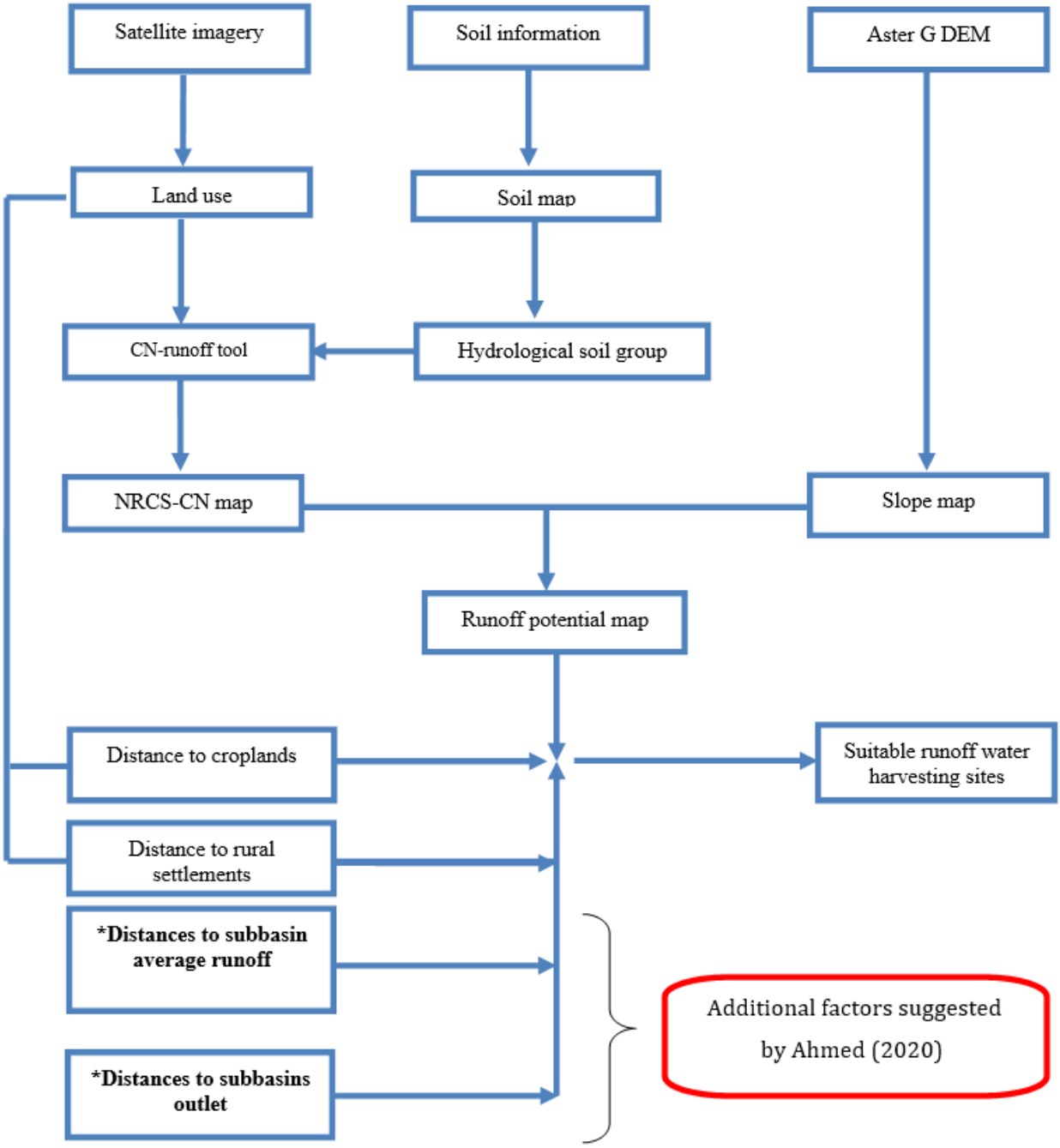

Fig.2: Flow chart for deriving suitable runoff harvesting sites

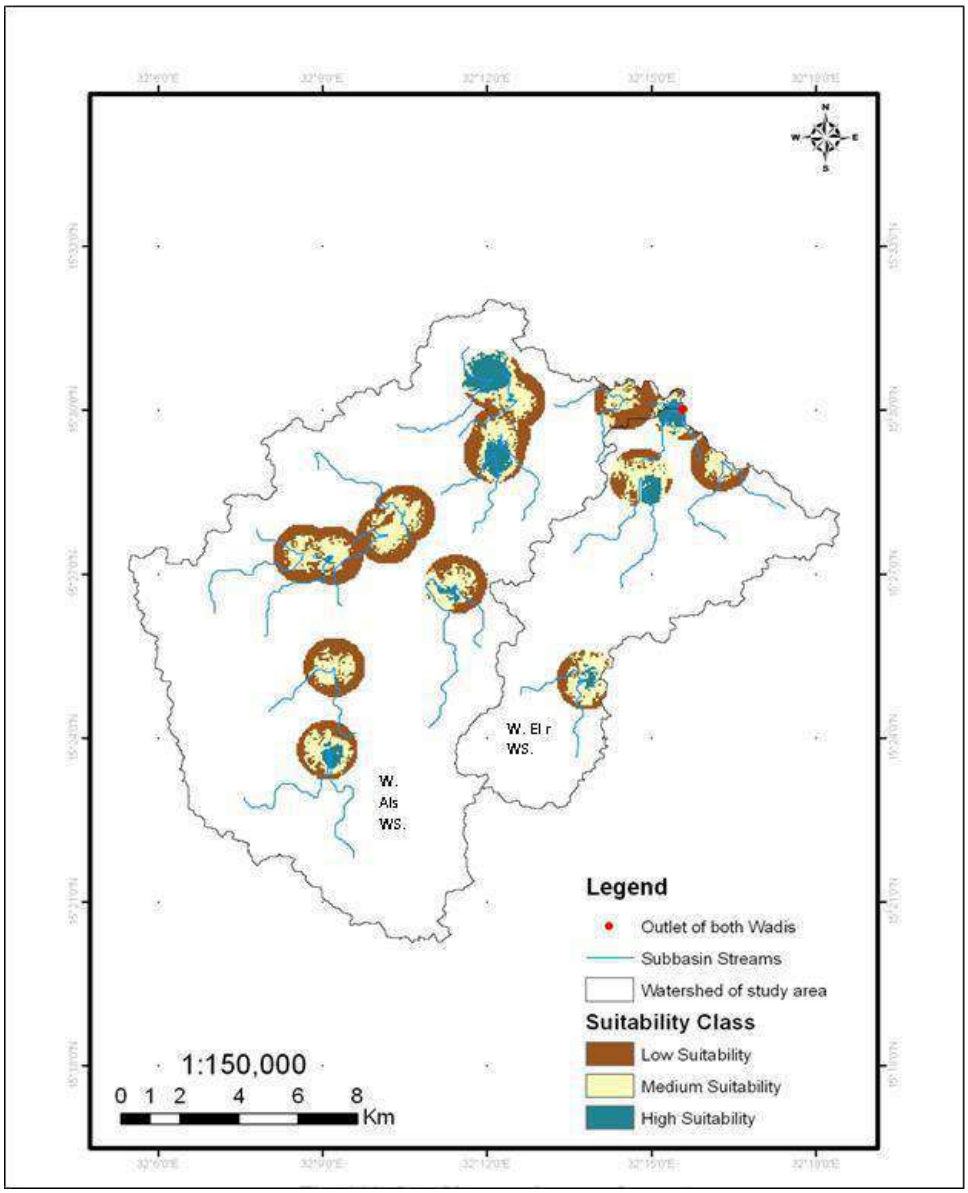

Fig.3: Suitable areas for runoff harvesting at Wadi Elrawakeeb & Wadi Alsayal watershed

W. Als WS= Wadi Alsayal Watershed.

W. El r Ws= Wadi Elrawakeeb Watershed.

IV. CONCLUSION AND RECOMMONDATIONS

In conclusion, the conventional hydrological data are inadequate for the purpose of modeling rainfall-runoff relationship of ungaged Wadi systems. Remote sensing data such as ASTER GDEM 30 m resolution is of great use for the estimation of relevant hydrological data and can serve as model inputs to construct semi-distributed model linking rainfall-runoff. GIS offers the potential to increase the degree of definition of spatial sub-units, in number and in descriptive details. In this study a GIS approach has been utilized for the identification of suitable sites for potential runoff harvesting at Wadi Elrawakeeb and Wadi Alsayal desertified watershed, the adopted GIS approach can be utilized considering additional factors that take the spatial variation in the examined watershed into account to obtain more adequate results. The study recommends using of high resolution ASTER G-DEM, as well as adding more factors to the analysis, especially those related to generated runoff volume, the study also recommends conducting of field investigations into the selected locations of runoff harvesting that had been identified to obtain fairer and accurate results.

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Case study on Risk and Benefit of Genetically Modified Nitrogen-use Efficient Water-use Efficient and Salt-tolerant Rice Breed in Nigeria.

Seyi Ebun Adeboye[1], Shakirat O.A Ajenifujah-Solebo[1], Hannah Oluwakemi Oladipo[2], Dolapo Adetokunbo Adeshina[1]

[1]Department of Agriculture, National Biotechnology Development Agency Abuja, Nigeria
[2]Bioresources Development Centre, National Biotechnology Development Agency, Ilorin, Nigeria
Email of the corresponding author: oluseyiadeboye@yahoo.com

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Abstract— *This study aimed to examine the perceived risks and benefits of Genetically Modified Organisms (GMO) in Nigeria with a focus on the agricultural technology of nitrogen use efficient, water use efficient, and salt-tolerant (NEWEST) Rice. A descriptive survey method was adopted for this study. Using a convenient sampling technique, 100 residents were drawn from the general population as respondents for this study. The questionnaire which was the instrument for data collection was administered to the respondents by the researcher personally. The results show that 58% of respondents will buy or eat NEWEST Rice. About 20% of the respondents would buy or eat NEWEST Rice because of its cheaper price, 15% for its nutritional benefits, and 13% for its better look and taste. Findings from this research also revealed that the perceived risks of NEWEST Rice are cross-pollination, adverse effects to human health, not looking and tasting good like organic rice, and antibiotic resistance in humans. The benefits identified include an abundance of rice supply to reduce poverty and starvation in Nigeria, improve the efficiency, profitability, and productivity of farmers, NEWEST Rice can minimize the use of water and fertilizer, better nutritional qualities, and reduction in pesticide use. This study, therefore, shows that NEWEST Rice will be averagely accepted (58%) in Nigeria. However, due to the intense debate on GM crops, there is a need for an improvement in the efficacy of scientific communication. There is also a need to create an informed, balanced public perception on the important issue of genetic engineering used in agriculture, even from the confined field trials, multi-location trials and use of GM crops in Nigeria.*

***Keyword*—agricultural technology, benefits, genetically modified organisms, NEWEST rice, risks**

I. INTRODUCTION

Agricultural biotechnology is the application of technology to agricultural systems. It has been recognized as a technology that can help farmers produce more from improved crop cultivars that are pest resistant, drought tolerant, water use efficient and efficient in nitrogen fixation [1]. The edible plant parts

can also be genetically modified to provide consumers with more micronutrients to correct for malnutrition and diseases, especially in children and vulnerable groups. Agricultural biotechnology has been around for thousands of years. Farmers have engaged in what plant breeders now call selective breeding, by selecting and saving seed from those plants with the most desirable features. Over time, plant breeding has become more sophisticated, and now involves the deliberate crossing of different varieties or even species, including close wild relatives [2].

The discovery of DNA in 1954 led to breakthroughs in agricultural biotechnology. Techniques were developed that would enable individual genes that make up a DNA code to be modified to express or suppress important traits such as fruit yield, wood quality, fat content or disease resistance – a process known as genetic modification (GM). Although early applications of this technique involved the manipulation of a host's genome [3], later applications involved the transfer of genes between organisms that are not normally able to crossbreed, resulting in novel combinations. It is this ability to move genes across species barriers that give GMO important potential, but also renders it highly controversial.

However, not all forms of modern agricultural technology involve genetic modification; other, non-GM applications of agricultural biotechnology can assist in breeding plants as well as in the development and propagation of new crop varieties. These include tissue culture, molecular markers, diagnostic techniques and microbial products. Local farmers in Africa have benefited from tissue-culture technologies for banana, sugar cane, pyrethrum, cassava, and other crops [3].

GMOs have been developed that modify the quality of produce by increasing the nutritional value or providing more industrially useful qualities or quantities. The Amflora potato produces a more industrially useful blend of starches. Soybeans and canola have been genetically modified to produce more healthy oils. The first commercialized GM food was a tomato that had delayed ripening, increasing its shelf life [4].

Plants and animals have been engineered to produce materials they do not normally make. Pharming uses crops and animals as bioreactors to produce vaccines, drug intermediates, or the drugs themselves; the useful product is purified from the harvest and then used in the standard pharmaceutical production process [3].

There have been concerns about the risks and benefits of GMO technology across the world including Nigeria. Public concern over GMOs is centered in three areas: human health, environmental safety, and trade impacts [5].

GMO biosafety is also forcing both agriculture and food companies to appreciate GMO safety in their marketing decisions [6]. The adoption of GMOs in a given jurisdiction is a function of public GMO acceptance as well as the level of public trust of regulatory authorities based on the perceived risks and benefits [7].

Opponents of GMO technology have questioned their necessity in terms of agricultural productivity to feed the world [8]. They point to studies that have shown that current agricultural output far exceeds global calorie needs and that distribution, access, and waste are the key limitations to feeding those who are hungry and not gross production per se [9]. The world population has exceeded 7 billion people and is forecasted to reach beyond 11 billion by 2100 [10]. The provision of adequate food supply for this booming population is an ongoing and tremendous challenge. The companies that develop GM seeds point to this challenge as the key rationale for their need, and they explain that GM seeds will help to meet the "feeding the world" challenge in several ways.

The risks and benefits of GMO are many and diverse. However, there is little argument over the ambiguous consequences of this comparatively new technology, and numerous critics noted the potential risks and benefits of GMOs as soon as they were launched [11][12][13]. Hence, the current researcher is examining the perceived risks and benefits of GMOs in Nigeria with a focus on the agricultural technology of the newest Rice.

Rice (*Oryza sativa*) is an important food crop in Africa. It is an ancient crop consumed as a healthy and staple food by more than half of the world's population. Rice production in Nigeria increases gradually over the years, with area expansion surpassing major Rice producing countries like Côte d'Ivoire and Sierra Leone [14]. However, demand in recent times has not been accompanied by a corresponding rise in production. This is attributed to wide- spread poverty, the dominance of the nation's agriculture by smallholders the use of relatively primitive tools for farm operations, lack of exposure to improved agricultural technology (improved seeds, fertilizers, and pesticides) and inadequate farm mechanization aids by the government [14].

Efforts to develop rice cultivars with stress-tolerant traits have resulted in the release of several varieties, but no known developed variety has combined the three traits of nitrogen-use efficiency, water-use efficiency and salt-tolerance, which are the major abiotic stresses to rice production in all the agro-ecologies in Africa. The new variety includes a trait for increased nitrogen use efficiency, which helps the plant take better advantage of the scant nitrogen found in Africa's often nutrient-poor soils. Soil nitrogen deficiencies limit yields on roughly 90 percent of the lands African farmers use for growing rice [14]. The engineered variety could also promote responsible fertilizer use by improving the crop's responsiveness to smaller doses of fertilizer. Rice varieties that are nitrogen use efficient, water use efficient and salt-tolerant (NEWEST) could therefore, boost yields by up to 30 percent in many regions, increasing farmers' climate resilience while also minimizing their use of fertilizer and water, reducing deforestation, and slowing the expansion of cultivated lands. As a complement to traditional

breeding programs, biotechnology has developed powerful tools that could help meet these ambitious agricultural and environmental goals. The objectives of this study are therefore to examine, the perceived risks of agricultural technology (GMO) in Nigeria, the benefits of agricultural technology (GMO) in Nigeria, and the level of acceptance of GMO rice in Nigeria.

II. MATERIAL AND METHOD

The study employed a descriptive design to assess the perceived risks and benefits of GMOs (a Case study of NEWEST Rice) among residents in various States, Nigeria [15]. Using a convenient sampling technique, 100 residents were drawn from the general population as respondents for this study. This is a statistical method of drawing representative data by selecting people because of the ease of their volunteering or selecting units because of their availability or easy access. The questionnaire which was the instrument for data collection was administered to the respondents by the researcher personally. It was divided into two (2) sections covering the research objectives of the study. Section A of the questionnaire covers the Bio-data of the respondents while section B covers the perceived risks and benefits of GMOs (Case study of newest Rice). The questionnaires were collected back from the respondents immediately after completion in order to avoid mutilation and to record a high response rate from the respondents. The data generated from this research was presented in a tabular form and analyzed using the descriptive statistics of frequency counts and percentage, the mean and standard deviation to enhance quick and easy understanding of the respondents' responses or opinions on the topic being researched on. The Statistical Package for the Social Scientists (SPSS) and MS Excel 2016 was employed to analyze the obtained information statistically from the questionnaires.

III. RESULTS AND DISCUSSION

A total of 100 questionnaires were administered but the researcher was able to retrieve 93 questionnaires back and all were considered valid for this study. This represents a 93% response rate in this study.

3.1. Socio-demographic characteristics of the respondents

The results of the socio-demographic characteristics of the respondents as presented in Table 1 show that out of 93 respondents to the questionnaires, 49 (52.7%) were females. In contrast, 44 males which constitute 47.3% of the respondents were males. The majority of the respondents 31(33.3%) were within the age group 46 years and above, followed by age group 36-45 years 29(31.2%). The least number of respondents 9(9.7%) were within the age group 15-25 years. The result in table 4.1 shows that 35 respondents representing 37.6% are single, while 53 respondents representing 57% are married and only five respondents representing 5.4% are divorced or separated. The results further revealed that only two respondents representing 2.2% had attained a primary level of education, two respondents representing 29% have achieved secondary level of education, and 64 respondents representing 68.8% of the total respondents have attained BSc/MSc. Hence, the respondents that have BSc/MSc level qualifications have the highest frequency while the respondents that have attained primary level of education have the lowest frequency.

3.2 Level of acceptance of GMO rice in Nigeria

The respondents were asked if they have heard about NEWEST Rice and only 35% said they have heard about it. The 65% that have not heard about NEWEST Rice were briefly educated about it. They were told what NEWEST Rice means and its status in Nigeria. The result in Table 2 shows that 58% of respondents would accept, buy or eat NEWEST Rice, while 43% would not. This is similar to the findings of Eneh *et al.* [16] who reported that 58% of respondents in Enugu metropolis Nigeria are willing to accept GM foods. Al-Khayri and Hassan [17] also reported that 48% of consumers will buy or eat GM foods in Saudi. The difference between the acceptance and non-acceptance of NEWEST Rice as observed in this study is not much. Therefore, it can be presumed that NEWEST Rice will be averagely accepted by the Nigerian populace.

Despite the acceptance of NEWEST Rice in Nigeria, some people are still not in agreement with the acceptance of GM crops in Nigeria. Some argue against the principles of genetic modification because of ethical or religious beliefs. However, the main arguments relating to how GM is actually applied. Proponents for GMO claim that through GM crops, trees, livestock and fisheries, biomass (including food and fiber) production can be enhanced while indirectly reducing environmental impacts, for example, through less use of pesticides or fertilizers. They also oppose that GMO can improve the nutritional value of many crops, or reduce the possible food safety risks posed by crops such as cassava [14].

According to Eneh *et al*. [16], certain people's view GM foods production and processes as not 100% safe which is a reason for it's none acceptance. However, others claim that the scientific knowledge on potential risks and benefits of GMO is elementary, the net gains in agricultural productivity and the potential profits are both unclear, and the health and environmental risks are little

understood. Antagonists claim that the potential direct effects of GMO crops on biodiversity and human health are unknown and are potentially so damaging that a moratorium must be placed on all GMO products until more information is available. Others emphasize the indirect impacts that GMO crops can have on traditional farming patterns, conservation efforts, livelihoods and trade [14].

More so, most people disapproval to genetically modified (GM) food and crops are caused by the public's misunderstanding of the risks, what comes to their mind is the risk associated with it without really putting much thought that the benefit is vast and no unique risk have been identified.

As presented in Table 2, 20% of the respondents would buy or eat NEWEST Rice because of its cheaper price, 15% for its nutritional benefits, 13% for its better look and better. This is in accordance to the findings of Eneh *et al.* [16] who found that 38.3% would eat or buy GM foods for nutritional benefits. Ebuehi & Ailohi [18] however found that a higher number of students (75.6%) were willing to buy or eat GM foods for better nutritional characteristics.

The respondents were also asked their opinion if Nigeria Government should legalize the production and importation of GM foods in Nigeria, 56% said Nigeria should, while 34% thought Nigeria should not. According to the report of Global Biotech [19], developing countries are fast accepting agricultural technology hoping to lessen hunger and poverty. These countries account for forty percent of the global farmlands used for GM crop cultivation including Nigeria.

Although, there are reasons, controversies, disagreement, and hesitation about the acceptance of genetically modified foods in Nigeria, the introduction of GM crops to Nigeria as one of the strategies to address food security crisis has gained increasing momentum because it has the potential to improve crops appearance, taste, nutritional quality, drought tolerance, insect and disease resistance [20]. The embracement and adoption of GM foods by the Nigerian Government would provide sustainable food security and, increased productivity in the agricultural sector that would lead to the improved socioeconomic status of Nigerian farmers and enhanced national economic prosperity.[4].

Table 1: Socio-Demographic Characteristics of Respondents

Gender	**Frequency**	**Percentage (%)**
Male	44	47.3
Female	49	52.7
Total	93	100
Age Range		
15 – 25	9	9.7
26 – 35	24	25.8
36 – 45	29	31.2
46 and above	31	33.3
Total	93	100
Marital Status		
Single	35	37.6
Married	53	57.0
Divorced/Separated	5	5.4
Widow	-	-
Total	93	100
Level of Education		
Primary School Certificate	2	2.2
SSCE	27	29.0
BSc/MSc	64	68.8
Total	93	100

Table 2: The level of acceptance of GMO Rice in Nigeria

SN	Questions	Yes %	No %	Not Sure %
1	Have you heard about NEWEST Rice?	35	65	0
2	Are you willing to accept, eat or buy the NEWEST Rice	58	43	0
3	Reason for accepting NEWEST Rice			
	*Nutritional benefits	15		
	*Look or taste better	13		
	*Cheaper price	20		
	*Lower risks of pesticide poison	10		
4	Should the FG legalize the production and importation of GM foods in Nigeria	56	34	10

3.3 Perceived Risks of Agricultural Technology (GMO) in Nigeria

The results of this study reveal the perceived risks of agricultural technology (GMO) of the NEWEST Rice in Nigeria. The risks were identified as cross pollination, adverse effect to human health, not looking and tasting good like organic rice and antibiotic resistance in humans (Table 3). As revealed in Table 3, majority of respondents (69%) are of the opinion that NEWEST Rice is artificial and may not taste good like organic Rice. This is consistent with the report of Eneh *et al*. [16] who reported that 65% of respondents believed that GM foods were artificial. Some people believe that GM foods were artificial and may not taste and look good probably because of their ignorance about the composition and benefits of new GM foods compared with non-GM foods.

This study shows that 65% of respondents believed that NEWEST Rice can affect human health negatively. Ebuehi & Ailohi [18] similarly reported that 58.9% of respondents are concern that GM foods could cause adverse effects to human health.

This shows that there are still many people who hold anxieties about the potential risks of GM foods to human health. For some this is related to whether transgenesis itself causes unintended consequences, while for others it is concerns around the traits that are possible using GM [5]. Some criticize the use of antibiotic resistance as markers in the transgenesis procedure and that this can facilitate antibiotic resistance development in pathogens that are a threat to human health. Many critics of GM crops express concerns about allergenicity [7].

GM crops have also been criticized for promoting the development of pesticide resistant pests [21]. The development of resistant pests is most due to the overuse of a limited range of pesticides and overreliance on one pesticide. Although the deregulation of GM crops includes extensive assessments of possible human health impacts by competent authorities, there are still many who hold concerns about the potential risks to human health of GM crops. For some this is related to whether transgenesis itself causes unintended consequences [22], while for others it is concerns around the traits that are possible using GM [23]. Other concerns that have been raised regarding GM crops as reported by some researchers include the effects of transgenic on the natural landscape, significance of gene flow, impact on non-target organisms, progression of pest resistance, and impacts on biodiversity [20]. Again, many of these concerns may be more a function of the impacts of simple and broad-scale farming practices facilitated by GM crops rather than GM crops as such.

Table 3: The perceived risks of GMO Rice in Nigeria

SN	Questions	Yes %	No %	Not Sure %
1	NEWEST Rice can affect human health negatively	65	25	10
2	It can cause harm to the environment	39	43	18
3	The outcome of cross-pollination is one of the risks of agricultural technology (GMO Rice)	61	35	4

4	NEWEST Rice is artificial and may not taste good like organic rice	69	28	3
5	It can lead to antibiotic resistance in humans	54	41	5
6	One of the negative outcomes of GM Rice is pest resistance	45	40	15
7	It can cause genetic mutation in humans	40	36	24

3.4 Benefits of Agricultural Technology (GMO) in Nigeria

The results also reveal the benefits of agricultural technology (GMO) Rice in Nigeria as presented in table 4. Some of the identified benefits include abundance of rice supply to reduce poverty and starvation in Nigeria, improve the efficiency, profitability and productivity of farmers, NEWEST Rice can minimize the use of water and fertilizer, better nutritional qualities and reduction in pesticide use. The majority of the respondents (75%) believed that NEWEST Rice will lead to adequate rice supply for the Nigerian populace. This result is in affirmation to the report of [24] that GM foods provides abundant food supply, as global food insecurity will not fade away without this new technology. This is in accordance to the proposition of some scientists that a second Green Revolution including the use of modified crops is needed to provide sufficient food [25]. Commercial GM crops are known to have traits that reduce yield loss from insect pressure or weed interference thereby making food widely available to consumers [26].

According to United Nations Department of Economics and Social Affairs [27], the world population has exceeded 7 billion people and is forecasted to reach beyond 11 billion by 2100. The provision of an adequate food supply for this booming population is an ongoing and tremendous challenge. Therefore, agricultural technology is essential to feed growing world population.

According to Table 4, 64% of the respondents were of the opinion that NEWEST Rice would fundamentally improve the efficiency, profitability and productivity of rice farmers in Nigeria. This is true as agriculture always provides opportunities to turn rural poverty and stagnation into development [28]. But acceptance and broad usage of genetically engineered foods is needed to achieve this. [29]. The economic value of GM food's to farmers is one of its major benefits in developing nations [30]. The Economics comprehensive study in 2012 established that GM crops increased farm incomes all over the world by $14 billion in 2010 and with over half this amount going to farmers in developing countries [31].

In addition GM seed companies argue that the adoption of GM crops helps to reduce the application of pesticides, which has a direct impact on the sustainability of the cropping systems as well as profitability for farmers [32]. Some respondents (52%) also believed that NEWEST Rice can minimize the use of water and fertilizer. This is one of the advantages of NEWEST Rice, it is expected to solve the problem of water and fertilizer for rice farmers.

Table 4 also shows that 58% of respondents believed that GM Rice will contain better nutritional qualities. This result was close to the findings of Eneh *et al.* [16] where 75% of people resident in Enugu metropolis Nigeria thought that GM foods enhance nutritional value. However, this result is contrary to the report of Ebuehi & Ailohil [18] who found that 43.3% of University of Lagos students believed that GM foods have more quality nutrients and better health benefits compared with non-GM foods. The difference could be attributed to some people disbelieve in GM foods or ignorance about the relatively new GM foods compared with non-GM foods.

Table 4: Benefits of Agricultural Technology GMO Rice in Nigeria

SN	Questions	Yes %	No %	Not Sure %
1	NEWEST Rice will lead to adequate rice supply	75	15	10
2	NEWEST Rice would fundamentally improve the efficiency, profitability and productivity of farmers	64	24	12
3	NEWEST Rice can minimize the use of water and fertilizer	52	33	15
4	It can increase climate resilience and therefore boost productivity	44	32	24
5	NEWEST Rice may look or taste better than organic Rice	40	32	28
6	It has better nutritional qualities	58	36	6
7	NEWEST Rice would reduce pesticide use	51	35	14

IV. CONCLUSION

As revealed by this study, the perceived risks of NEWEST Rice are cross pollination, adverse effect to human health, not looking and tasting good like organic rice and antibiotic resistance in humans. The benefits identified include an abundance of rice supply to reduce poverty and starvation in Nigeria, improve the efficiency, profitability, and productivity of farmers, NEWEST Rice can minimize the use of water and fertilizer, better nutritional qualities and reduction in pesticide use. This study, therefore, shows that NEWEST Rice will be averagely accepted in Nigeria. However, due to the intense debate on GM crops, there is a need for an improvement in the efficacy of scientific communication, which could have a significant impact on the future of agricultural genetic engineering. There is a need to create an informed, balanced public perception on the important issue of genetic engineering used in agriculture, even from the confined field trials, multi-location trials, and use of GM crops in Nigeria.

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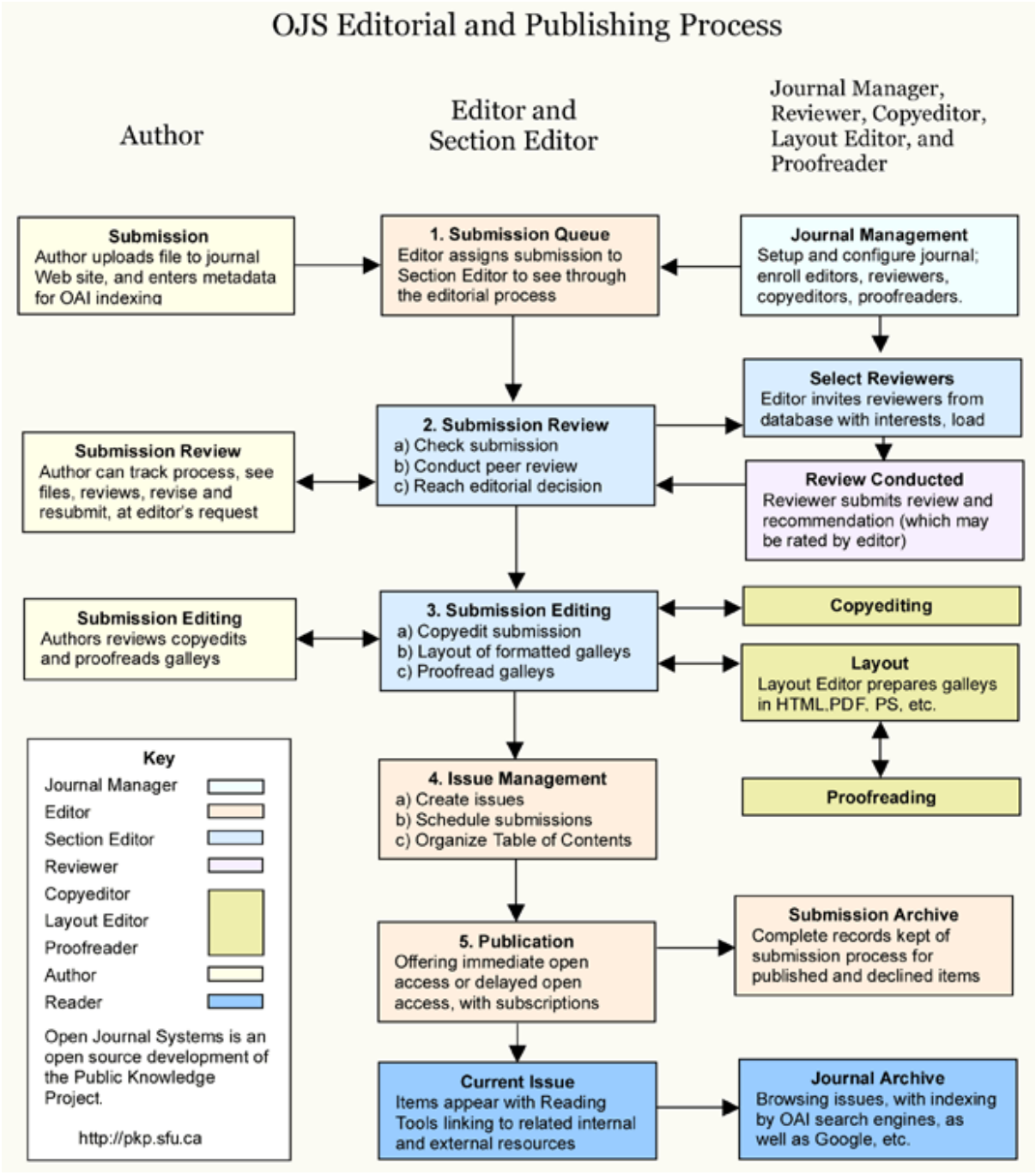

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