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Preface

We would like to present, with great pleasure, the inaugural volume-6, Issue-1, January 2020, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development*, and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

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

Environmental Research:

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

Agriculture Research:

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

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

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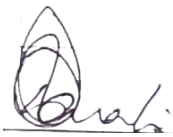
(Editor-in Chief)



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Agricultural Sciences	
Soil Science	Plant Science
Animal Science	Agricultural Economics
Agricultural Chemistry	Basic biology concepts
Sustainable Natural Resource Utilisation	Management of the Environment
Agricultural Management Practices	Agricultural Technology
Natural Resources	Basic Horticulture
Food System	Irrigation and water management
Crop Production	
Cereals or Basic Grains: Oats, Wheat, Barley, Rye, Triticale, Corn, Sorghum, Millet, Quinoa and Amaranth	Oilseeds: Canola, Rapeseed, Flax, Sunflowers, Corn and Hempseed
Pulse Crops: Peas (all types), field beans, faba beans, lentils, soybeans, peanuts and chickpeas.	Hay and Silage (Forage crop) Production
Vegetable crops or Olericulture: Crops utilized fresh or whole (wholefood crop, no or limited processing, i.e., fresh cut salad); (Lettuce, Cabbage, Carrots, Potatoes, Tomatoes, Herbs, etc.)	Tree Fruit crops: apples, oranges, stone fruit (i.e., peaches, plums, cherries)
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Dairy Sheep	Water Buffalo
Moose milk	Dairy product
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Silvopasture	Christmas tree cultivation
Maple syrup	Forestry Growth
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GIS-Based Soil Properties Analysis for Sustainable Agriculture in Bani Waleed (Libya)

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Abstract— *This paper presents an study Soil Properties analysis for sustainable agriculture by GIS through 15 soil samples chemical characterization conducts to soil numerical classification and crops soil suitability that has the advantage to guide the practices of soil management is as follows: Soil Salinity: The results of electrical conductivity indicated that the studied soils were generally positioned into the very saline class that had an area of (3847.96 ha) representing (79.50 %). The soils assembled into five classes; non-saline (198.5 ha) and it is suitable for most crops, moderately saline (385.75ha), where crops salt-tolerant crops give yield with marginal reduction. Finally, strong saline (112.00 ha) that it is suitable just for high salt-tolerant crops but also with yield reduction. Soil Sodic: the non-sodic soil class occupied the majority of the studied area with 96.8 % (4689.18 ha). The sodic soil had only (151.27 ha) 13.12 %. calcium carbonate to moderately calcareous soil (2317.93 ha) 47.89% and calcareous soil (2522.51 ha)52.11%. Crops soil suitability (Wheat): (S1), (S2) and (NS2) It is as follows (4000.78ha) 82.65 %, 114.37ha 2.36 %, and 725.30ha 14.98% of the studied area, respectively. (Tomato): is as follows: (4190.85 ha) 86.58 % of the study area is highly suitable (S1) and (NS2) (649.61ha) 13.42 % is unsuitable represent respectively. (Olive): The majority of the study area 4081.04 ha (84.31 %) was classified as highly suitable soils (S1), potentially suitable class (NS1) is about 236.61ha (4.89 %) and unsuitable class (NS2) is about (522.81ha) 10.80 % respectively. Soil Management and Crops tolerance for soil parameters The GIS-ESP soil map divided the studied area into three categories of ESP tolerance crops soil; Extremely sensitive ESP crop (4164.65 ha), sensitive ESP crop (594.13 ha) and moderately tolerant crop (81.67 ha). The GIS-CaCO3 soil map divided the studied area into two categories of CaCO3 tolerance crops soil; Crops that tolerate a certain (1924.92 ha) and Crops which support high (2915.54 ha). EC tolerance crops soil; Sensitive (3835.38 ha), moderately (224.28ha), highly (650.86 ha) and very highly (129.93ha).*

Keywords— Sustainable Agriculture, GIS, Soil Suitability and Tolerant Crops.

I. INTRODUCTION

The main soil problems of Libyan agriculture are erosion and salinity. New tasks that have become a priority in the past few years are the degradation of counter-land resources and the improvement of poor land management practices. About 1.75 million square kilometers in range. More than 95 percent of the country is desert. The arable areas cover an estimated 3.8 million hectares, just over 2 percent of the total area. The majority of cultivated land and pastures [1].Saline soils in Libya cover about 52%, which is as follows: 12% in the north, 16.5% in the west and 23.4% in central Libya. [2]. Water and wind erosion are also prevalent in western Libya (Jafara Plain and Jabal Nafusa) as a result of agricultural operations, and in the Wattiyah region and the southwestern Jafara Plain[3].Agricultural soils are of great importance for increasing crop production, protecting water and air, reducing greenhouse gas emissions, and maintaining natural biodiversity and food safety[4].The increase in the world's population is putting increasing pressure on natural resources [5,6]. This behavior of exploitation leads to multiple environmental problems of land and water [7], Appropriate land-use and management strategies must be needed to reduce the magnitude of negative human impacts [8,9]. Agricultural processes have an impact on the physical, chemical and biological properties of soils [10], resulting in environmental problems such as soil degradation [11. Sustainable land management requires reliable information on the spatial distribution of soil characteristics that affect both the landscape process and services [12,13].In the traditional soil study, soil properties are recorded in representative locations throughout the entire mapping unit, which are chosen using both physiological and geophysical methods. Although soil surveyors are well aware of the spatial variation of soil properties, traditionally prepared soil maps do not reflect them because the soil units are limited in boundaries [14]. Nature the soil properties are highly variable spatially [15].The traditional method of soil analysis and hence becoming expensive. Soil problems in Libya are: (1) improper agricultural operations, such as not using deep tillage, (II) overgrazing. (Third) the conversion of rangelands to croplands in marginal areas where rainfall is not sufficient to support crops in the long run; and (iv) urban and rural expansion at the expense of arable land in Libya, large areas of soil have deteriorated due to profound irrigation with saline groundwater. The main target aim of this study was to link the GIS- maps of soil to sustainable agriculture for soil.

II. MATERIALS AND METHODS

The study area is situated between coordinates (455726.38E) and (3495270.93N). Fig (1) show the study area is located in the northwest of Libya in the Bani Waleed region. The study area is extracted in WADY SEOFJEEN alongside to the Southwest of Tripoli. It is bounded to the north Mediterranean Sea. study area covers about 4840.45 Hectare Fig (2). The study was elaborated through four stages. The first stage was consecrated to build-up spatial database by processing of topographic maps; (a) collection, digitizing and mosaicking of the topographic maps (b) mosaicking clipping the topographic maps excerpt the studied area), by using the software of geographic information system (ArcGIS 10.3). The second stage was consecrated to the fieldwork to collect the sample's soil at depth (0-80 cm). Laboratory work represented the third which included that chemical characterization of soil samples. fig (1).

Building-up Spatial Database (topographic maps processing):

Building-up Spatial Database was built through the processes of maps collection, digitizing, mosaicking and Clipping. were digitized by Arc-GIS10.3 software. The coordinate was converted from the geographic coordinates (Lat.–Long.) system to Universal Transverse Mercator (UTM) coordinates system (Easting–Northing). The topographic map sheets, covering the surrounding region, were merged together in one map to compose mosaic map. The mosaic was clipped to extract the study area that has the coordinates (455726.38E and 3495270.93N) (the upper left corner), fig (1).

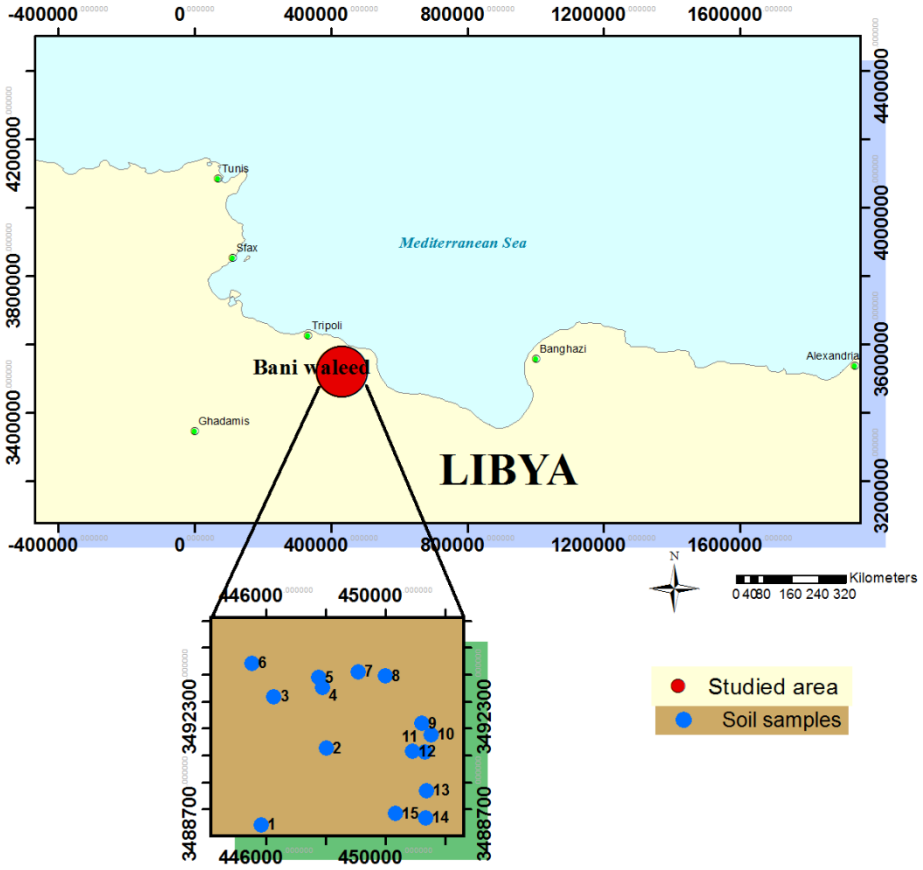


FIGURE 1. Location of studied area

2.1 Sampling and Analysis of Soil Samples

2.1.1 Soil Sampling

Fifteen soil samples depth (0-80cm) were collected to represent the root zone of the studied area. The samples were aired air dried and crushed pass through 2 mm sieve to elaborate the different analysis. Soil sampling was carried out using the random nested soil sampling design that covered an area Fig (2). Soil samples locations were determined by GPS.

2.1.2 Soils Physical and Chemical Characterization:

- **Soil Physical Analysis**

Texture was determined using sieves and Hydrometer method [16].

- **Soil Chemical Analysis**

Salinity was measured at in the soil paste extract and pH of 1:2.5 soil suspension by EC meter and P^H[17], Sodium Absorption Ration (SAR) was calculated from Ca, Mg, and Na soluble concentrations, soil organic matter content (OM%) was determined by Walkely & Black method [17] and CaCO3% was determined using the pressure calcimeter method [17].

2.2 Land suitability evaluation

Rated Land suitability classes (Table 1) [18,19,20].The majority of both limitation and parametric methods use the FAO (1976) framework for land suitability classification. In this framework, lands are classified into five classes ranging from highly suitable to permanently not suitable considering the existing limitations for a specific use (FAO 1976).Land suitability analysis is a very important technique for agricultural activities to deciding future cropping pattern, planning and activities. It is determining appropriate crops for a specific piece of land according to its characteristics [21,22] and allows identification of the limiting factors for the crop cultivation [23].

TABLE 1
LAND SUITABILITY CLASSES

Class	Description	Rating (%)
S1	Highly suitable	100 - 80
S2	Moderately suitable	80 - 60
S3	Marginally suitable	60 – 40
S4	Conditionally suitable	40 - 20
NS1	Potentially suitable	20 - 10
NS2	Actually unsuitable	< 10

TABLE 2
REACTION CLASS TERMS AND THEIR RANGES IN EC, ESP, CACO3, OM AND PH [24]

Rating	Class
EC(dS/m)	
Nonsaline	< 2
Very slightly saline	2 to < 4
Slightly saline	4 to < 8
Moderately saline	8 to < 16
Strongly saline	≥ 16
ESP%	
Non- Sodic	<15
Sodic	>15
CaCO3 %	CaCO3 %
Non Calcareous	<15
Moderately Calcareous	15-20
Calcareous	>20
OM%	
very low	<1
low	1–2.5
medium	2.5–5.0
high	5.0–10.0
very high	>10.0
PH	
strongly acidic	<5.5
moderately acidic	5.5–6.2
neutral	6.2–7.0
moderately alkaline	7.0–7.8
strongly alkaline	>7.8

Calcium carbonate - Calcium (Ca) is a common component in most soils. It is generally the most important cation (between 65 and 80 %) of the exchange complex, and most plants require it. It is only when too much (more than 5 %) free lime is present in the root zone that it affects some plants. Hence, this is not toxicity in itself but a suboptimal concentration of free calcium in the root zone due to either a natural weathering process of the underlying (carbonaceous) rock, or an accumulation of calcium compounds from wind or water deposits [25].

TABLE 3
CROPS TOLERANCE AND CaCO3 SOIL PARAMETERS

Crops which support high amounts of free CaCO3(>25%)	Crops that tolerate a certain amounts of free CaCO3(5-25%)	Crops that are sensitive to CaCO3(<25%)
Dates	Barley	Citrus tress
Olives	Cotton	Bananas
figs	Maize	Potato
Alfalfa	Millets	Cassava
wheat	Rice	Tea
----------	Grapes	Lupins

III. RESULTS AND DISCUSSION

3.1 Physical and chemical of the soil samples:

Fifteen soils samples (0-80 cm) were taken from the clipped agricultural area. Soils locations were determined by their UTM coordinates table (4), fig (2). The results of particle size distribution classified the collected soil samples into four textural classes table (5): Silty loam (samples 1 and 14) Sandy clay loam (samples 2and 3) Sandy loam (samples 4,5,6,7,8,10,11 and 13), loam (samples 9,12 and 15).

TABLE 4
UTM COORDINATES OF SOIL SAMPLES

No (Sam)	Soil Samples coordinates (UTM)	
	Easting	Northing
1	445854.144	3488195.231
2	448034.696	3490781.467
3	446209.118	3492404.203
4	447907.92	3492759.177
5	447755.788	3493114.15
6	445524.526	3493570.545
7	449074.262	3493291.637
8	449987.051	3493139.506
9	451204.103	3491592.835
10	451508.366	3491212.506
11	451330.879	3490578.625
12	450925.195	3490654.69
13	451381.59	3489285.507
14	451356.235	3488423.428
15	450342.024	3488550.204

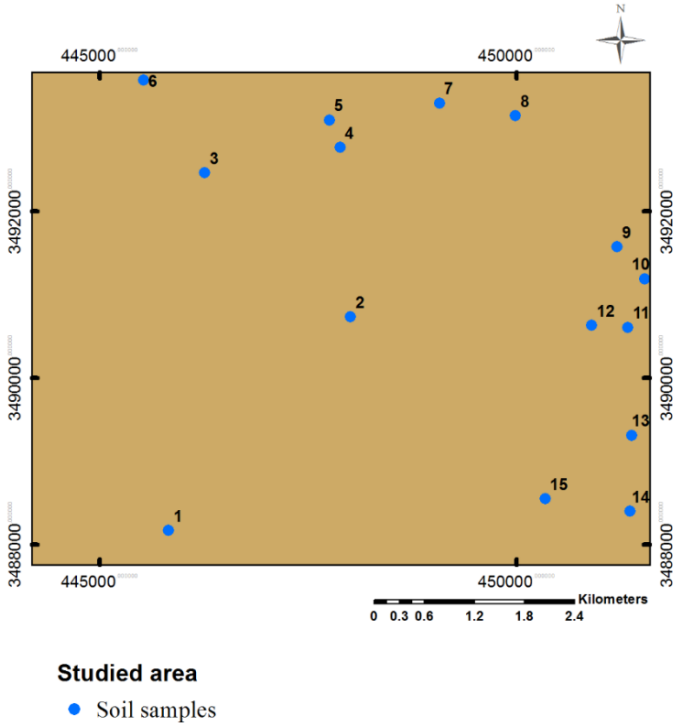


FIGURE 2: Studied area and soil samples locations

3.2 Soil Chemical Characteristic

This tables (2 and 5) showed that the samples were distributed into five pH, salinity and OM classes and into two ESP classes, and into three CaCO3 classes with summarizes some soil chemical characteristics of soil samples. It is as follows: (pH) as criterion, classified the soil samples: The high pH values obviously indicated that the soils are strongly alkaline ones. The maximal pH value was 8to represent strongly alkaline soil that had pH values > 7.8 (sample 9 and 15). (saline) as criterion, classified the soil samples: Nonsaline soils: (samples 1,2,3 and 14),Very slightly saline (samples 4,10,11 and 13), Slightly saline soils : (samples 9,12 and 15), Strongly saline soils : (samples 5,6,7 and 8 (OM) as criterion, classified the soil samples: very low:(samples 2,3,4,5,6,7,8,9,10,11,12,13,14 and 15), low sample 1). (ESP) as criterion, classified the soil samples: Non- Sodic:(samples 1,2,3,4,5,6,8,10,11,13 and 14), Sodic: (samples 7,9,12 and 15). (CaCO3) as criterion, classified the soil samples: Moderately Calcareous: (samples 4,8,10,11,13 and 15), Calcareous: (samples 1,2,3,5,6,7,9,12 and 14).

TABLE 5
PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOIL SAMPLES

Samples No	pH	EC dS/m	Soluble Ions (meq / L)						ESP %	$CaCO_3$(%)	OM (%)	Textural Class
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-2}				
1	7.5	1.4	12	13	8	5.1	18	16.6	8	41	1.16	Silty loam
2	7.8	1	2	2.2	6	0.6	5	3	3.6	20	0.5	Sandy clay loam
3	7.8	1	2.6	2.1	5.9	0.6	5	5.3	3.7	20	0.5	Sandy clay loam
4	7.5	2	10	4.8	3	1.5	10	5.2	6	16.3	0.5	Sandy loam
5	7.6	17	55	32	77	1.8	168	11	14	30	0.5	Sandy loam
6	7.6	17	55.8	33	76	1.7	169	10.4	13.8	30	0.9	Sandy loam
7	7.7	46	140	71	209	2	394	19.6	25	28	0.9	Sandy loam
8	7.6	17	56	33	78	1.8	398	12	14	16	0.6	Sandy loam
9	8	7	35	27	37	0.9	40	24.4	19	25	0.7	loam
10	7.5	2	10	5	4	1.5	5.3	5.6	7	16.2	1.5	Sandy loam
11	7.5	2	10.5	4.9	3.5	1.7	5	5	6	16	0.5	Sandy loam
12	8	7	35.8	26.8	38	1.9	39.8	24	19	25	0.6	loam
13	7.5	2	11	4.5	3	0.9	10	5	6.5	15.5	0.8	Sandy loam
14	7.5	1.4	12	13.5	8	5	17	15	8.5	42	0.4	Silty loam
15	8	7	35	27.5	37	0.8	41	24	19	17	0.7	loam

3.3 Soil Univariate Chemical Classification for sustainable agriculture

The studied soils were chemically classified basing separately on the thresholds of pH, EC, ESP and CaCO3 that are the most effective factors on soil production: Soil Salinity: The results of electrical conductivity indicated that the studied soils were generally positioned into the very saline class that had an area of (3847.96 ha) representing (79.50 %). The soils assembled into five classes; nonsaline (198.5 ha) and it is suitable for most crops, moderately saline (385.75ha), where crops salt-tolerant crops give yield with marginal reduction. Finally, strong saline (112.00 ha) that it is suitable just for high salt-tolerant crops but also with yield reduction (Table 6 and Figure 3).

TABLE 6
UNIVARIATE SOIL CHEMICAL CLASSIFICATION

Soil chemical Criteria	Thresholds	Soil Chemical Classes	Soil chemical Criteria	Thresholds	Soil Chemical Classes	Area(ha)
Exchangeable Sodium Percentage (ESP) %	< 15	Non-Sodic	Electrical Conductivity (EC) ds/m	< 2	Nonsaline	198.5
				2 to < 4	Very slightly saline	3847.96
	>15	Non-Sodic		4 to < 8	Slightly saline	296.96
				8 to < 16	Moderately saline	385.75
				≥ 16	Strongly saline	112.00
CaCO3	15-20	Moderately Calcareous	Area(ha) 2317.93	CaCO3>20	Calcareous	2522.51

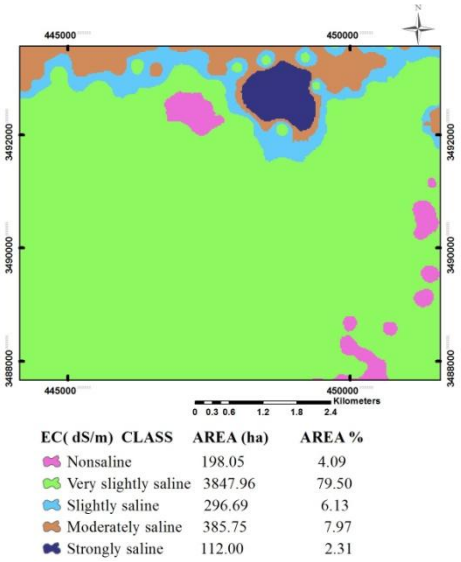


FIGURE 3. EC ds/m

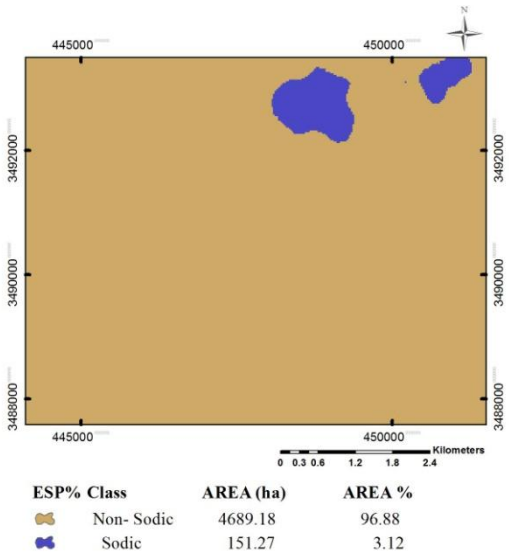


FIGURE 4. Soil ESP %

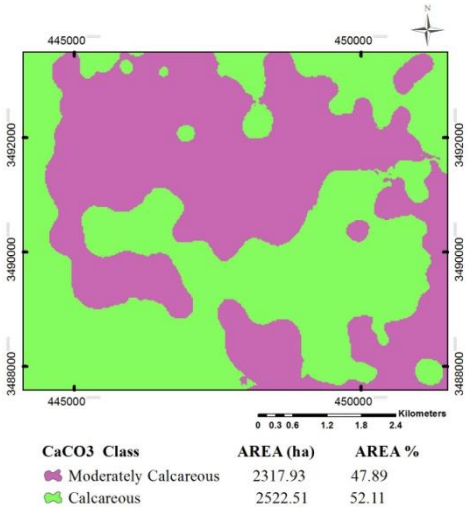


FIGURE 5. CaCO3 %

Soil Sodic: Results showed for (Table 7 and Figure 4). The non-sodic soil class occupied the majority of the studied area with 96.8 % (4689.18 ha). The sodic soil had only (151.27 ha) 13.12 %.

Calcium Carbonate Content: Calcium carbonate of the study area had different forms such as powder, nodules, concretions, and hard layers. Calcium carbonate in calcareous soil gives it one of the important morphological phenomena, which is the surface crust. Results showed for (Table 7 and Figure 5) The study area was to classified into two classes according to the percentage of calcium carbonate to moderately calcareous soil (2317.93 ha) 47.89% and calcareous soil (2522.51 ha) 52.11% .

Land evaluation for Suitable crops:

(Cereals crop Wheat): The data indicated that the studied soil conditionally suitable for wheat crop. The class of conditionally suitable (S1) Highly suitable soils, (S2) low degree of soil suitability and (NS2) unsuitable represent It is as follows 4000.78 ha 82.65 %, 114.37 ha 2.36 %, and 725.30 ha 14.98% of the studied area, respectively (Table 1 and Figure 6).

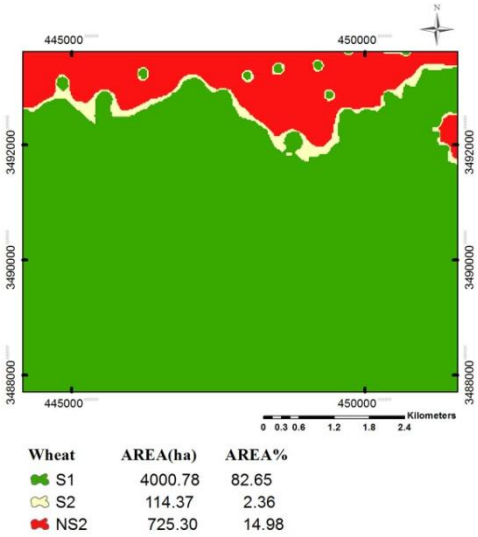


FIGURE 6. Soil suitability classes for wheat crop

Vegetables (Tomato): The results of this study are suitable for tomato plantation is as follows: 4190.85 ha 86.58 % of the study area is highly suitable (S1) and (NS2) 649.61 ha 13.42 % is unsuitable represent respectively (Table 1 and Figure 7).

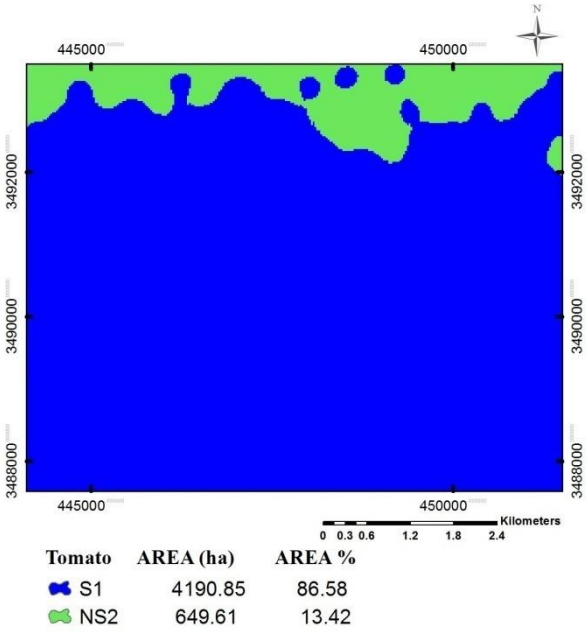
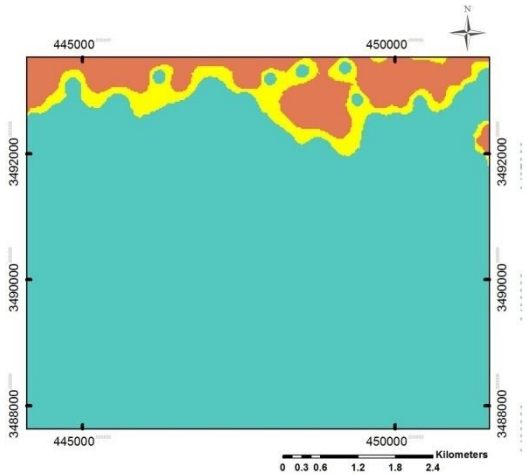


FIGURE 7. Soil suitability classes for tomato crop

Perennial crop (Olive): The results of this study showed that the region is meanly suitable for olive plantation (Table 1and Figure 8). The majority of the study area 4081.04 ha (84.31 %) was classified as highly suitable soils (S1), potentially suitable class (NS1) is about 236.61ha (4.89 %) and actually unsuitable class (NS2) is about 522.81ha (10.80 %) respectively.



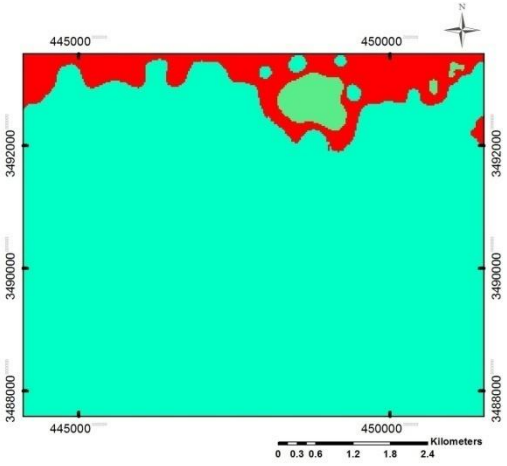
Olive	AREA (ha)	AREA %
S1	4081.04	84.31
NS1	236.61	4.89
NS2	522.81	10.80

FIGURE 8. Soil suitability classes for olive crop

Soil Management and Crops tolerance for soil parameters (Basing on soil chemical univariate classification): Soil ESP Problem: Selected to reduce the problem of soil ESP (Table 8) .GIS-ESP soil classification was elaborated by assignment ESP thresholds of tolerant crop range (Table 8) to GIS-ESP soil map (Figure 9). The GIS-ESP soil map divided the studied area into three categories of ESP tolerance crops soil; extremely sensitive ESP crop (4164.65ha), sensitive ESP crop (594.13 ha) and moderately tolerant crop (81.67 ha)

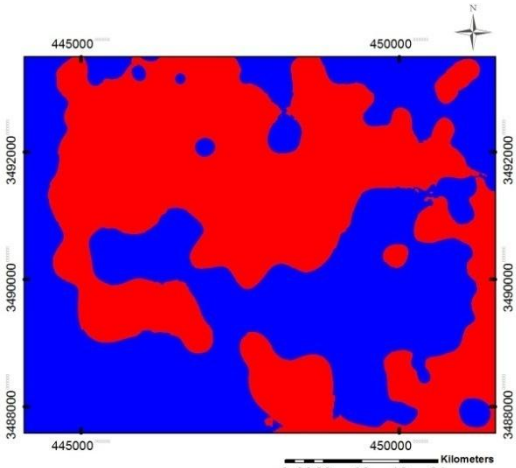
Soil CaCO3 Problem: GIS-CaCO3 soil classification was elaborated by assignment CaCO3 thresholds of tolerant crop range (Table3) to the GIS-CaCO3 soil map (Figure 10). The GIS-CaCO3 soil map divided the studied area into two categories of CaCO3 tolerance crops soil; Crops that tolerate a certain (1924.92 ha) and Crops which support high (2915.54 ha).

Soil EC Problem: EC as shown in figure 11. This map involved four classes of EC tolerance crops soil range (Table7): Sensitive (3835.38 ha), moderately (224.28ha), highly (650.86 ha) and very highly (129.93ha).



ESP Crops Colerant	AREA (ha)	AREA %
Extremely sensitive	4164.65	86.03
Sensitive	594.13	12.28
Moderately tolerant	81.67	1.69

FIGURE 9. ESP Crops Tolerant



CaCO3 Crops Colerant	AREA (ha)	AREA %
Tolerate acertain	1924.92	39.77
Support high	2915.54	60.23

FIGURE 10. CaCO3 Crops Tolerant

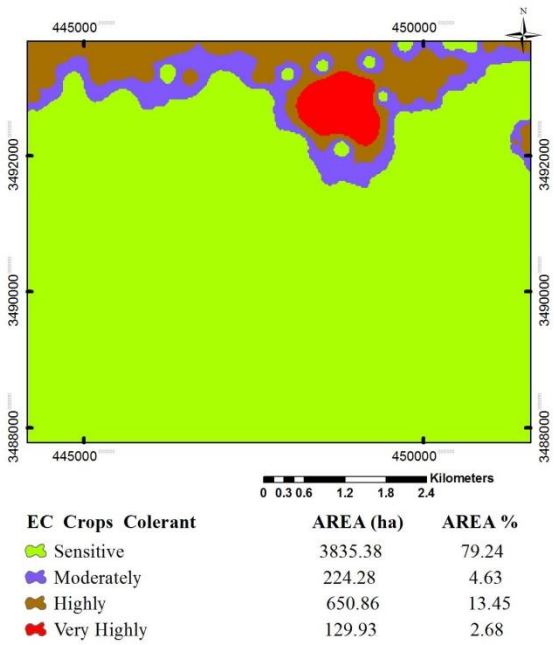


FIGURE 11. EC Crops Tolerant

TABLE 7
CROPS TOLERANCE AND EC SOIL PARAMETERS

Mapping Unit	EC Crop Tolerance	EC (dS/m) tolerant crop range
1	Sensitive EC crops: (Field crops) Sunflower, Soybean, Faba bean, Lins, (Vegetable crops) Sweet corn, Lettuce, Onion, Eggplant, Carrot, (Fruit crops) Date, Olive, Peach , Orange, Grapes	1 - 4
2	Moderately EC tolerant crops: only field crops Barley, Cotton, Sugar beet, Grain sorghum, Wheat	4-8
3	EC tolerant crops: No crops have 0 % yield reduction	8-16
4	Highly EC tolerant crops: No crops have 0 % yield reduction	16-32

TABLE 8
SELECTION ESP CROPS TOLERANT

Soil Chemical Classes	ESP Crop Tolerance	ESP (dS/m) tolerant crop range
Non-Sodic	Extremely sensitive ESP Crops (ESP = 2-10) ; Nuts , Citrus, Avocado Sensitive ESP crops (ESP = 10-20); Beans Moderately tolerant (ESP = 20-40); Clover	<15
Sodic	Tolerant crops (ESP = (40-60) ; Wheat, Cotton , Alfalfa , Barely , Tomato, Beets Most tolerant crops (ESP > 60); Tall wheat grass , Rhodes grass	>15

IV. CONCLUSION

Soil Properties analysis for sustainable agriculture led to soil classification that guide accurately and quantitatively the practices of soil management. Comprehensive analytical approach of soil by GIS evaluation of the processes of soil classification, soil suitability for crop Hence land suitability analysis outputs reliable information related to crop opportunity and reduction; it provides a significant contribution to land use reliably and economically. Farmers can use soil suitability information to choose crops suitable for their soil, as well as an accurate database and guide maps for decision-makers. The suitability of the soil for crops It mainly determines the characteristics of the soil and crop yield, EC, ESP, and CaCO3 crop tolerance. After the limit Or eliminate the factors that limit the soil in the area studied Maybe grown wheat, Olives and tomatoes. Some Selected crops such as olives and Tomatoes It is recommended to grow it in the study area. Most Marginally

suitable land with severe restraint factors Such as EC, ESP, and CaCO3 It is located in the northern upper part of the study area. Through digital maps, the study area where salinity is mostly low, as well as Sodic, calcium carbonate is high, and this indicates that the soil has some obstacles that hinder the agricultural process, While as it is suitable for wheat crop by 82.62%, tomato crop by 86.58% and olive crop by 84.31%. Assignment ESP thresholds of tolerant crop range Extremely sensitive 86.03%, CaCO3 of tolerant crop range 60.23%, EC tolerance crops soil Sensitive 79.24%.

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Effect of Storage and Poultry Manure Dosage on Soil Nitrate (NO_3^-) and Ammonium (NH_4^+) Availability, N-Uptake, and Yield of Head Lettuce (*Lactuca Sativa*, L.) Grown on Typic Calciaquolls

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***Abstract*—** *The objective of this experiment was to investigate the effect of storage and poultry manure dosage on soil nitrate (NO_3^-) and ammonium (NH_4^+) availability, N-uptake, and yield of Head lettuce (Lactuca sativa, L.) grown on Typic Calciaquoll. Data obtained from the experiment of seven treatments with four replications were subjected to Randomized Block Design. The observation conducted in three times i.e. 4 Week After Plant (WAP), 6 WAP, and 8 WAP. The treatments were: (1) without poultry manure (control), (2) dry poultry manure (DPM) with 12,5 g dosage, (3) DPM with 25 g dosage, (4) DPM with 37,5 g dosage, (5) fresh poultry manure (FPM) with 12,5 g dosage, (6) FPM with 25 g dosage, (7) FPM with 37,5 g dosage. The results of experiment showed that there were significantly effects of storage and poultry manure dosage on soil nitrate and ammonium, N-uptake, and yield of head lettuce. The treatment combination of DPM 37,5 g showed the highest value on soil nitrate and ammonium in 4 WAP, N-uptake in 6 and 8 WAP, and the yield of head lettuce in 6 and 8 WAP. The treatment combination of FPM 37,5 g showed the highest value on soil nitrate and ammonium in 6 and 8 WAP, N-uptake in 4 WAP, and the yield of Head lettuce in 4 WAP. Generally, it concluded that the dry poultry manure (DPM) had the better effects than the fresh poultry manure (FPM) on yield of head lettuce.*

***Keywords*— Ammonium, Head lettuce, Nitrate, Poultry manure, Yield.**

I. INTRODUCTION

Fertilization is one of the most significant agricultural practices used to improve the yield and quality of traditional crops. The need to use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic fertilizers worldwide (Seifritz 1982).Manure improves the chemical, physical and biological characteristics of soils (Yolcu et al., 2010) and increases the yield and quality of crops. For example, use of organic manures alongside inorganic fertilizers often lead to increased soil organic matter (SOM), soil structure, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient status, caution exchange capacity (CEC) and soil's biological activity (Saha et al., 2008). Although chemical fertilizers are important input to get higher crop productivity, but over reliance on chemical fertilizers is associated with decline in some soil properties and crop yields over time (Hepperly et al., 2009).

Poultry manure is known to give increased yields of many different crops. Increases in the demand for poultry products have led to rapid and concentrated growth of the industry, which has caused excessive manure supplies in certain areas. For sustainable management of poultry manure, it is important to understand the chemical composition of manure and reactions of manure with soil nutrients (Amanullah, 2019). Furthermore, organic manure activates many species of living organisms which release phytohormones and may stimulate the plant growth and absorption of nutrient (Naguib and Aziz, 2004).

Recent studies show that poultry manure applied to cropping systems affected in improvement of soil properties, whereby able to support the growth and production of the plant. More than it, the using of poultry manure will ensure the sustainability of soil productivity. Poultry manure has the highest nitrogen contents than the others animal manure (Rismunandar, 1981) whereas Slykes (1932 in Foth 1998) stated that in poultry category, it is the second position after sheep manure in nitrogen nutrient level. The high value of its nitrogen contents is proper to be applied as one of input materials for both organic and anorganic farming systems. Nitrogen is one of essential nutrients for the plant growth, it is one of the primary elements in protein and nucleic acid formation (Tisdale, et al. 1993).Nitrogen has fastest effect on cereals production (Brady, 1999).

The objectives of this experiment were to investigate the effect of storage and poultry manure dosage on soil nitrate (NO_3^-) and ammonium (NH_4^+), N-uptake, and yield of Head lettuce (*Lactuca sativa*, L.) grown on Typic Calciaquolls.

II. MATERIAL AND METHOD

This experiment was conducted in the Greenhouse of Horticulture Faculty of Fachhochschule Erfurt, Germany. The experimental design was Randomized Block Design, consist of seven treatments with four replications. The treatments were: (1) without poultry manure (control), (2) dry poultry manure (DPM) with 12,5 g dosage, (3) dry poultry manure (DPM)with 25 g dosage, (4) dry poultry manure (DPM) with 37,5 g dosage, (5) fresh poultry manure (FPM) with 12,5 g dosage, (6) fresh poultry manure (FPM) with 25 g dosage, (7) fresh poultry manure (FPM) with 37,5 g dosage. The examinations were observed in three times i.e. 4 Week After Plant (WAP), 6 WAP, and 8 WAP. The soil was Typic Calciaquolls.

The dry poultry manure was incubated under 20 ºC for six day before using in the seventh day, while the fresh poultry manure was taken in the morning and used as fertilizer in the afternoon. Soil samples were taken using soil sampler to examine soil nitrate (NO_3^-) and ammonium (NH_4^+) from each pot in every observation time and were analyzed using Flow Colorimetry Method. The plant samples were collected from each pot to examine N-uptake and fresh weight of the plant. N-uptake measurements were obtained using The Kjehdahl Method and fresh weight was measured by the analytical scales. Completed data was statistically analyzed, followed by mean separation with Duncan's New Multiple Range Test.

III. RESULT AND DISCUSSION

3.1 Effect of Treatment on Soil Nitrate (NO_3^-) and Ammonium (NH_4^+)

Based on statistical analysis, showed that there were any effect of treatment on soil nitrate (Table 1) and Ammonium (Table 2). In 4 WAP observation, almost all of the treatments showed the significant effect compared with control. Generally, the dry poultry manure treatments showed the higher value on soil nitrate and ammonium compared with fresh poultry manure treatments (at the same dosage) due to decomposition process in the terms of incubation on dry poultry manure increased its nutrients content. The dry poultry manure that has been decomposed contain approximately 2 % N and 1,7 % K_2O, P_2O_5 (Cooke, 1972). Generally It is higher than nutrients content of animal manure, that only contain about 0,5 % N, K_2O, and 0,25 % P_2O_5. Sarief (1993) concluded that application of manure will be better when it has been incubated for 1 until 2 week before planting, due to its higher nutrients content.

TABLE 1
THE EFFECT OF STORAGE AND POULTRY MANURE DOSAGE ON AVAILABILITY OF NITRATE (NO_3^-) IN SOIL (PPM)

No.	Treatments	Time of Observation		
		4 WAP	6 WAP	8 WAP
1.	Control	0.2600 a	0.1000 a	0.1000 a
2.	DPM 12.5 g	0.5125 b	0.1375 c	0.1300 b
3.	DPM 25 g	0.8200 d	0.1625 d	0.1525 c
4.	DPM 37.5 g	1.4025 e	0.1775 e	0.1700 cd
5.	FPM12.5 g	0.2250 a	0.1200 b	0.1175 ab
6.	FPM 25 g	0.4175 b	0.1575 d	0.1625 c
7.	FPM37.5 g	0.7075 c	0.1975 f	0.1900 d

Note: : same letters represent insignificant values at 5 % level by Duncan's Multiple Range Test.

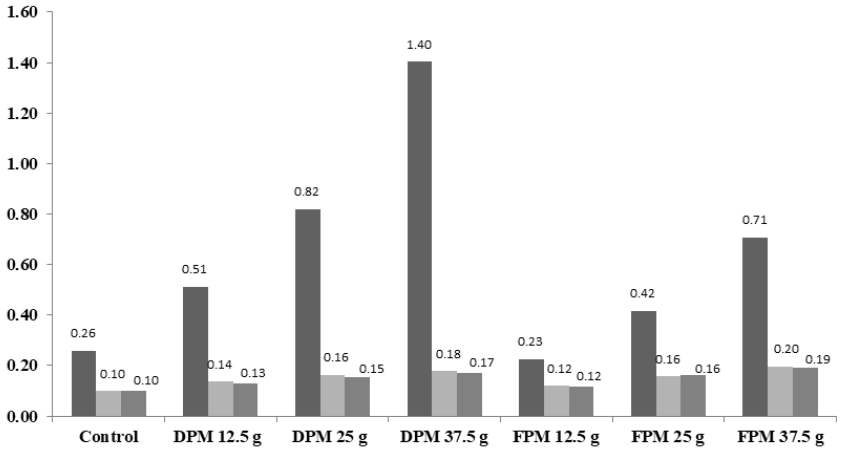

FIGURE 1: The Effect of Storage and Poultry Manure Dosage on Availability of Nitrate (NO_3^-) in Soil (ppm)

The contribution of inorganic nitrogen in the soil due to the manure being applied which was consistent with that reported by Walker and Bernal (2008) who noted that soil improved with manure increased significantly nitrogen due to the fact that in the process of decomposition of manure generated nitrites and nitrates that are incorporated into the soil. In all cases the nitrogen availability increased and the highest availability of N found from poultry manure. The result might be due to improvement of other physical and chemical properties for organic manure application.

TABLE 2
THE EFFECT OF STORAGE AND POULTRY MANURE DOSAGE ON AVAILABILITY OF AMMONIUM (NH_4^+) IN SOIL (PPM)

No.	Treatments	Time of Observation		
		4 WAP	6 WAP	8 WAP
1.	Control	0.1000 a	0.1000 a	0.1000 a
2.	DPM 12.5 g	0.1125 ab	0.1150 a	0.1050 ab
3.	DPM 25 g	0.1325 c	0.1325 b	0.1175 b
4.	DPM 37.5 g	0.1650 d	0.1500 c	0.1325 c
5.	FPM12.5 g	0.1000 a	0.1075 a	0.1150 ab
6.	FPM 25 g	0.1175 b	0.1350 b	0.1425 c
7.	FPM37.5 g	0.1450 c	0.1775 d	0.1600 d

Note: same letters represent insignificant values at 5 % level by Duncan's Multiple Range Test.

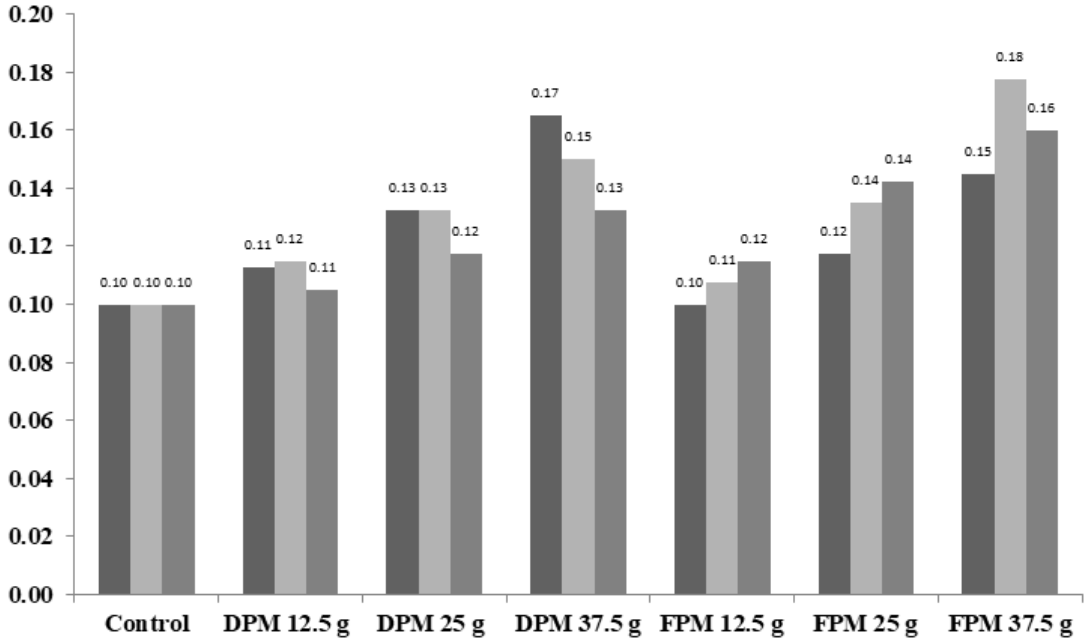

FIGURE 2: The Effect of Storage and Poultry Manure Dosage on Availability of Ammonium (NH_4^+) in Soil (ppm)

3.2 Effect of Treatment on N-Uptake

Based on statistical analysis, showed that there were any effects of treatment on N-uptake (Table 3). In all of observation time showed that all treatments were significantly different compared with control, it proved that nutrient uptake by the plant are different depend on the type of plant, soil nutrients content, and environment factors (Donahue, 1958). N-uptake increase continuously along of the plant growth phase. Russel (1973) concluded that N, P, K, and Ca fastly absorbed by plant in initial growth, and it will be higher in the dry materials forming. The highest value of N-uptake can be reached in 6 and 8 WAP.

TABLE 3
THE EFFECT OF STORAGE AND POULTRY MANURE DOSAGE ON N-UPTAKE

No.	Treatments	Time of Observation		
		4 WAP	6 WAP	8 WAP
1.	Control	0.6650 a	1.6875 a	2.1925 a
2.	DPM 12.5 g	1.3675 b	5.1050 c	5.5775 b
3.	DPM 25 g	2.3025 c	8.2725 d	8.7125 c
4.	DPM 37.5 g	2.7650 cd	9.0600 d	10.8150 d
5.	FPM12.5 g	1.3775 b	3.6075 b	6.2150 b
6.	FPM 25 g	1.9475 bc	5.8450 c	8.7750 c
7.	FPM37.5 g	3.3775 d	8.5200 d	10.7925 d

Note: Same letters represent insignificant values at 5 % level by Duncan's Multiple Range Test.

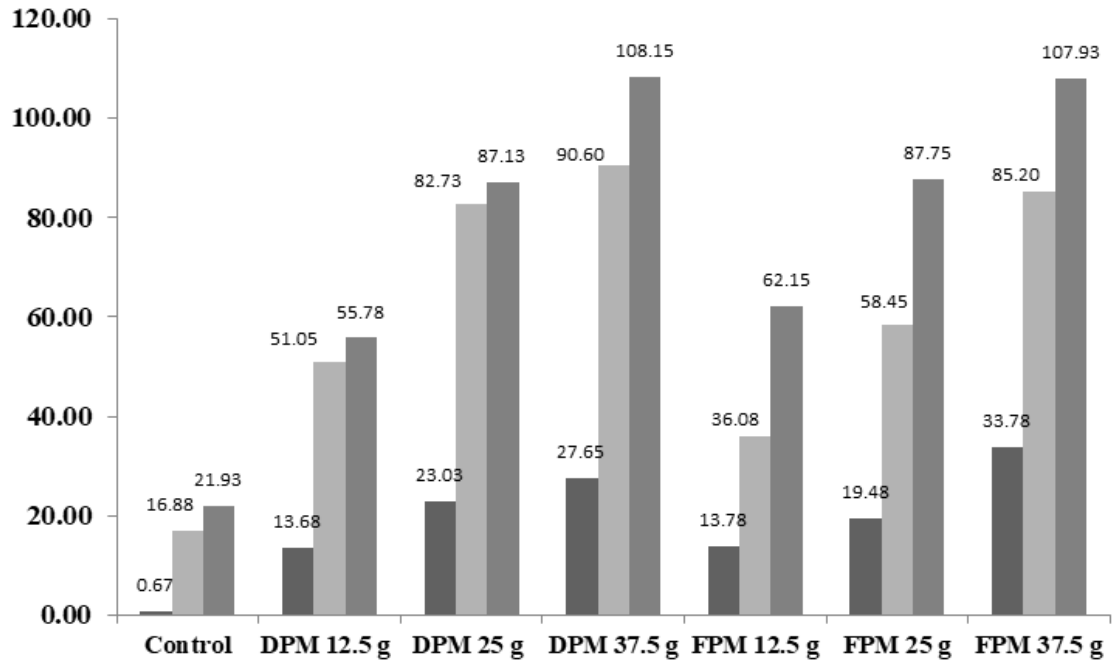

FIGURE 3: The Effect of Storage and Poultry Manure Dosage on N-Uptake (mg/kg)

3.3 Effect of Treatment on Yield of Head Lettuce (Fresh Weight)

Table 4 showed that almost all treatments were significantly different compared with control. The high value of yield in fertilization treatments showed the roles of soil nutrients availability on the plant growth. The high dosage of fertilizer will increase soil nutrients and then will increase plant production. Nitrogen is the primary element of protein and nucleic acid forming and it directly involved in the protoplasm forming (Tisdale et al.1993). The dry poultry manure treatment with 37.5 g dosage showed the highest value on yield of Head Lettuce in 8 WAP.

Organic fertilizer including cow manure chicken litter and sheep manure may be used for crop production as a substitute of synthetic fertilizers (Ovsthus et al. 2015; Xie et al. 2018). Organic fertilizers improve soil fertility without leaving residual effects in the soil and are cheaper compared to synthetic fertilizers (Dandas et al. 2008; Naeem et al. 2006). Organic fertilizers contain sugars proteins amino acids and organic humic and non-humic acids which contribute directly or indirectly to plant growth and development (Fartusi. 2003).Chicken litter which is an excellent source of N. P. and K and provides many secondary nutrients and amino acids that plants require for enhanced photosynthesis cell division cell enlargement (Al-Jebarii. 2017).

TABLE 4
THE EFFECT OF STORAGE AND POULTRY MANURE DOSAGE ON YIELD OF HEAD LETTUCE (FRESH WEIGHT IN GRAM)

No.	Treatments	Time of Observation		
		4 WAP	6 WAP	8 WAP
1.	(1) without poultry manure (control)	3,8000 a	9,4000 a	16,3200 a
2.	(2) dry poultry manure with 12,5 g dosage	7,6975 b	21,5625 b	44,2725 c
3.	(3) dry poultry manure with 25 g dosage	12,8225 c	43,0250 d	75,2725 e
4.	(4) dry poultry manure with 37,5 g dosage	15,0225 cd	48,8750 d	98,3875 f
5.	(5) fresh poultry manure with 12,5 g dosage	7,3050 ab	22,9750 b	35,5075 b
6.	(6) fresh poultry manure with 25 g dosage	10,3100 bc	32,0750 c	60,5250 d
7.	(7) fresh poultry manure with 37,5 g dosage	17,5800 d	45,6500 d	74,1500 e

Note: Same letters represent insignificant values at 5 % level by Duncan's Multiple Range Test.

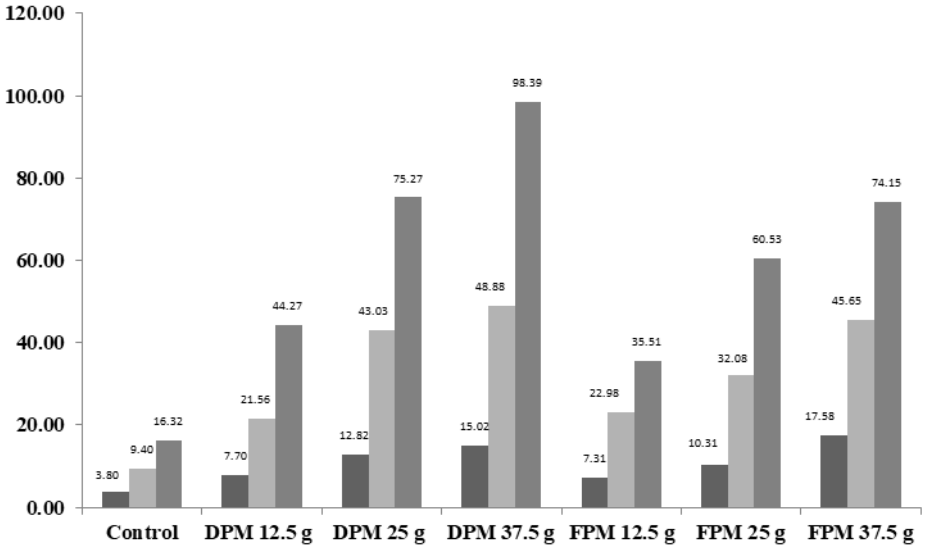

FIGURE 4: The Effect of Storage and Poultry Manure Dosage on Yield of Head Lettuce (Fresh Weight in Gram)

IV. CONCLUSION

The treatment combination of dry poultry manure with 37.5 dosage showed the highest value on soil nitrate and ammonium in 4 WAP.N-uptake in 6 and 8 WAP and the yield of Head lettuce in 6 and 8 WAP. The treatment combination of fresh poultry manure with 37.5 g dosage showed the highest value on soil nitrate and ammonium in 6 and 8 WAP.N-uptake in 4 WAP and the yield of Head lettuce in 4 WAP. Generally it showed that the dry poultry manure showed the better effects than the fresh poultry manure on yield of Head lettuce.

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Characterization of Persistent Organic Pollutants (POPs) and its adverse effects on environment and public health in Rwanda

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Abstract— *There is a low awareness level among the general populace and relevant stakeholders on Persistent Organic Pollutants (POPs) and their adverse effects on human health and the environment. This often results in the continued use of POPs in agriculture as pesticides, industrial chemicals, and production of unintentional POPs from incineration, open burning, and other practices that add to the POPs level in Rwanda. Thus, all stakeholders have a responsibility in the process but due to the lack of awareness about the issue they are not able to fulfill this role. With increased awareness, concrete steps can be taken towards the elimination of POPs in Rwanda. The identification of the stakeholders and their roles in the waste management in Rwanda, tool kit for POPs identification and quantification, Desk Review and Field visits have been used to characterize and assess the management of POPs in Rwanda. The most commonly encountered POPs in Rwanda, are organochlorine pesticides, industrial chemicals, most notably polychlorinated biphenyls (PCB), as well as unintentional by-products of many industrial processes, especially polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF). The POP pesticides are temporarily stored in the Nyanza-Kicukiro dumpsite. These POPs pesticides are Endosulfan 3% dust (1,748 kg) and Lindane (mixed with Thiram (Fernasan 45%WP): 1,280 kg. The country contains around 1,905.9 kg of PBDEs and both transport sector and electronic sector have almost the same contribution as their contents are around 935.9kg and 966.1 kg respectively. The production of iron and steel from metallic wastes (scraps) are producing the UPOP releases of 4000 g TEQ/a in air and 6000 g TEQ/a in residues and waste incineration of medical wastes released 42.1 g TEQ/a in air and 104.6 g TEQ/a in residue. And other sources are producing UPOP releases at low level. The contaminated sites are Nyanza, Nduba landfill, Nyabugogo wetland and Gikondo industrial Park. The workers who recycle and dispose of POPs are exposed to dangerous materials and the environment suffers from them. This paper is intended to characterize the POPs and waste management in Rwanda in order to characterize the persistent organic pollutants (POPs) and build capacities of vulnerable communities for the sound environmentally management of chemicals and wastes and transforming waste into resources of greater value for reuse. This paper can be considered as one of primary form of intervention related to persistent organic pollutants and waste management in Rwanda.*

Keywords— Persistent Organic Pollutants (POPs), PCB.

I. INTRODUCTION

1.1 Background

The Republic of Rwanda became a Party to the Stockholm Convention in order to work in liaison with the International Community in order to tackle problems arising from the Persistent Organic Pollutants (POPs). The Stockholm convention covers the management of POPs harmful to human and environmental health. The release of POPs is a factor of aggravation of poverty in developing countries and hinders the governments' efforts for a sustainable development (Stockholm Convention, 2009). Persistent Organic Pollutants (POPs) are chemical substances that persist in the environment, bio accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment (Maren Mellendorf, UNIDO). This group of priority pollutants consists of pesticides, industrial chemicals (such as PCBs) and unintentional by-products of industrial processes like dioxins and furans (UNEP, 2011).

In addition to their toxicity, POPs are Persistent chemicals in the environment, and do not easily degrade in the environment (that resist rapid degradation); undergo or travelling long distance globally (transport through air, water and migratory species across international boundaries far from their place of release); are bio accumulating in people and wildlife; They are

usually fat soluble and build up in higher trophic levels; they accumulate in terrestrial, marine and aquatic ecosystems far from their origin; as semi-volatile compounds, POPs undergo a series of evaporations and condensations in the environment, making them mobile.

The national challenge posed by chemicals in agriculture (pesticides & fertilizers) and waste management in Rwanda is multifaceted, with human health risks associated with it being a key area of concern. The general concern is that Rwanda might suffer from air, water and soil pollution, food contamination, soil microorganisms decline, vector-borne diseases for animals and plants/crops, diseases, insect pests and diseases of grains, seeds and crops with higher frequency and greater intensity. The sound management of chemicals and wastes is an important component of Rwanda's efforts to achieve sustainable, inclusive and resilient human development in Rwanda. It's imperative to advocate for integrating chemicals management priorities into national environmental and poverty reduction planning frameworks, helps access financial and technical resources, and provides assistance and implementation support to improve the holistic management of chemicals and waste at national level.

1.2 Problem justification

There is a low awareness level among the general populace and relevant stakeholders on Persistent Organic Pollutants (POPs) and their adverse effects on human health and the environment. This often results in the continued use of POPs in agriculture as pesticides, industrial chemicals, and production of unintentional POPs from incineration, open burning, and other practices that add to the POPs level in Rwanda. Thus, all stakeholders have a responsibility in the process but due to the lack of awareness about the issue they are not able to fulfill this role. With increased awareness, concrete steps can be taken towards the elimination of POPs in Rwanda. The locally generated domestic waste such as municipal wastes, kitchen waste, medical waste and industrial waste and unintentionally produced chemicals continue to be generated. Also, the capacity is still limited under both public and private sectors in terms of technology as well as human skills to properly handle and reduce discharge and/or transfer of waste into more useful resources. However, without sound management practices, chemicals and their hazardous wastes can pose significant risks to human health and the environment especially for the poorest members of the local community.

Further, at present, various activities relative to waste management such as waste collection, waste selection and recycling, and waste dumping are conducted by various entities without having knowledge or skills, techniques and any harmonized institutional framework. Some activities are done inefficiently and it is missing the chance to maximize reusing and recycling, and minimize landfill site discharge (Basel Convention, 2003). If left unchecked, this will have adverse impacts on environment in general and on human health in particular. Therefore, Sound waste management is one of the serious and pressing environmental issues that the urban areas in Rwanda are now facing. It's in this framework that this study was conducted to characterize the persistent organic pollutants (POPs) and build capacities of vulnerable communities through CBOs to address chemicals and waste management in Rwanda. The public awareness on POPs effects to human health and the environment will be raised. Safe and proper handling of chemicals and waste management promoted and therefore the production, use, and/or release of POPs should be reduced or eliminated.

II. MATERIALS AND METHODS

To get the current status of POPs management present in Rwanda different methodological approaches were used: identification of the stakeholders and their roles in the waste management in Rwanda; tool kit for POPs identification and quantification; desk Review and field visits.

2.1 Identification of the stakeholders and their roles in the waste management in Rwanda

The identification and analysis of stakeholders was an important step as it allowed to the team to draw out the opportunities and relationships that can be built on during the implementation of POPs management in Rwanda. The analysis of collected data also helped to identify who, where and when each group (stakeholders) intervenes.

TABLE 1
STAKEHOLDERS INVOLVED IN THE USE OF POPS MANAGEMENT

Use	Stakeholders	Their interventions
Electrical and electronic equipment (EEE) and waste electrical and electronic equipment (WEEE)	MoE/REMA	Coordination of wastes management activities Setup an education or a sensitization mechanism Monitoring, regulations Ensure the proper managements of EEE-wastes as well as the contaminated sites
	Basel Convention focal point (and stakeholders in Basel activities on e-waste)	Collaboration with the focal point of Stockholm convention for an harmonized EEE-wastes managements
	Importers of electronics	Comply with the Standards of EEE Contribute in their wastes management, generate wastes
	Users (private sector, NGOs, governmental institutions)	Contribute in EEE-wastes management Comply with the regulations, generate wastes
	Private sector: Retailers of electronics and second-hand electronics	Contribute in EEE-wastes management Comply with the regulations, generate wastes
	MINALOC (Provinces, Kigali City, districts and sectors)	Ensure the proper managements of EEE-wastes as well as the contaminated sites
	Refurbishes	Collect and repair WEEE
	MINICOM / RSB	Set up regulations as well as standards
	MININFRA	Set up regulations as well as standards
Transportation and end-of-life vehicles	MoE / REMA	Set up regulations and coordination of wastes management activities Setup an education or a sensitization mechanism Monitoring, regulations Ensure the proper managements of –wastes from vehicles as well as the contaminated sites
	Retailers of vehicles (in particular, second-hand vehicles):	Ensure the compliance with the required standards for vehicles
	RRA	Ensure appropriate coding of items and consolidation of statistics data into their data base
	Scraps recycler: SteelRwa, garages	Ensure a proper sorting of scraps
	Transport agencies: Virunga, KBS,Volcano express, Horizon express, Sotra tours, Kigali safaris, etc.	Ensure the compliance with the required standards by the convention
	RNP	Cooperate with RRA, RSB and REMA in combating and controlling the entry of unauthorized chemicals in the country.
	RURA	Regulate certain public Utilities, namely: telecommunications network and/or Telecommunications services, electricity, water, removal of waste products from residential or business premises, extraction and distribution of gas and transport of goods and persons.
	MoE / REMA	Set up regulations and coordination of wastes management activities
Other uses: Furniture Textiles Mattresses Construction materials	NIP coordinator and steering committee	Coordinate both NIP elaboration and implementation
	Importers of furniture, textiles, mattresses, and construction materials Transport agencies	Ensure the compliance of with the required standards Proper management of their wastes
	Retailers of furniture, mattresses and textiles and related second-hand articles GAKINJIRO, Mutara enterprise, etc.	Sorting of wastes, compliance with the environmental requirements
	Wastes collection companies	Collect, sort, transport and dump the collected wastes
	MoE/REMA	Set up regulations, guidelines, monitoring and evaluation
Contaminated sites	MINALOC (Provinces, Kigali city, districts, sectors)	Follow up, management and awareness campaign
	MoH	Rising the public awareness, follow of wastes managements provide the wastes management infrastructure and guidelines,
	Universities (UR, ICK, INES, UNIK, ULK, etc.)	Technical guidance, research on the contaminated sites and awareness campaign
	Importers and distributors	Generate wastes.
	NGOs	Generation of land filled wastes, provide funds for their disposal
	Users	Generation of land filled wastes, provide funds for their disposal.

2.2 Tool kit for POPs identification and quantification

POPs have been analyzed according to the source categories provided by the toolkit for identification and quantification of releases of dioxins, furans and other unintentional POPs, under article 5 of the Stockholm convention. The toolkit was used to calculate all relevant PCDD/PCDF sources.

2.3 Desk Review

A desk review of the available reports and documents on POPs management was carried out to assess the status of the POPs management in Rwanda. One of the key documents reviewed among others is the "National Implementation Plan of the Stockholm Convention on Persistent Organic Pollutants (POPs) in Rwanda: 2007-2025. Important reports on pesticides inventory and management have been reviewed. The review of literature also covered reports, publications, the legal, policy and institutional framework related to POPs management.

2.4 Field visits

The field visits targeted mainly the following key players: Institutions members of the POP steering committee where appropriate, REMA, Rwanda Revenue Authority, pesticides and veterinary products agro-dealers. The visits were performed at the stockholders' workplaces and discussions conducted with the main technician or the owner of the company according to a short indicative interview guide and the questionnaires have been used to collect data.

III. STUDY AREA

The study covered the sites of Rwanda including the landfills, dumpsites, hospitals located in 30 Districts, 4 provinces and the City of Kigali. The site visits have been conducted to assess the status of POPs management and wastes in general and how these affect the waste collectors and local communities.

IV. RESULTS AND DISCUSSIONS

4.1 The case of Rwanda for POPs management

The case of Rwanda considered in this study has shown some of the observations of POP issues including wastes from hospitals and industries, waste from septic tanks, latrines, manure and animal waste, refuse infest water, electronic waste, air and soil pollution are the most serious issues that Rwanda is dealing with in order to keep green environment. The workers collecting waste are extremely vulnerable to POPs accumulation due to the collection, transport, separation and treatment of wastes without appropriate protection equipment. These people are highly exposed to the POPs releases during waste incineration. In the cities of Rwanda, waste management is conducted by private corporations. At present, 13 companies (AGRUNI, COPED, UBUMWE, INZIRA NZIZA, ROAD ENVIRONMENT PROTECTION (REP), CESCO, COCEN, COVAGAYING, ISUKU KINYINYA, UMURIMO MWIZA, INDATWA, and BAHEZA) are operating in Kigali City. These companies take care of the collection and transport to the landfill of waste.

4.1.1 POP Pesticides in Rwanda

The analysis of the situation revealed that except dioxins and furans which are unintentional POPs, Rwanda never produced or reformulated the POP pesticides or industrial products. Pesticides can be found in large amounts on commercial farms. Some of pesticides may have expired or are no longer used by the farmer and could possibly leak out of their old containers and drums in which they are stored. It was revealed that in Rwanda, pesticides are used on crops such as coffee, rice, maize, Irish potatoes and vegetables, against insects that invade crops. Nearly 75% of imported fungicides (Mancozeb + copper oxychloride) are used on Irish potatoes and coffee and 75% of imported insecticides are applied to coffee and almost all of herbicides are used in tea plantations (Twagiramungu F., (2009), Environmental, health and safety management of disposing of unused and expired pesticides and fertilizers on behalf of RSSP / MINAGRI). The ministry of agriculture (MINAGRI) has banned a number of pesticides including POPs pesticides prohibited on national territory. The unlawful entry of obsolete pesticides banned can be observed on the borders with Uganda as Thiodan (Endosulfan).

Currently the POP pesticides are temporarily stored in the Nyanza-Kicukiro dumpsite. These POPs pesticides are Endosulfan 3% dust (1,748 kg) and Lindane (mixed with Thiram (Fernasan 45%WP): 1,280 kg (REMA, (2005), National inventory). Lindane and Endosulfan are mentioned as Toxic Pollutants Substances, and later on they have been listed as POPs by conference of parties of the Stockholm Convention respectively in May 2009 and May 2011.

4.1.2 POP-PBDEs

The POP-PBDEs in electrical and electronic equipment (EEE) and related waste (WEEE) were founded on the recent inventory that was conducted by the MINISTRY of ICT that put out the combined mass of EEE in use and WEEE generated yearly in Rwanda (REMA 2015, National inventory of POPs in Rwanda). The Sources of EEE/WEE observed in Rwanda are essentially the following: IT & Telecom Equipment, Large Household Appliances, Small Household Appliances, Consumer & Lighting Equipment, Electrical & Electronic Tools, Toys, Leisure & Sports Equipment, Medical Devices and Monitoring & Control Instruments. It is considered only the POP-PBDEs in transport sector (cars, jeeps, pickups, trucks and buses) and in EEE/WEEE as other uses of POP-PBDEs (e.g. furniture, mattresses, textiles, construction materials, rubber, and drilling operations) are thought to be of minor relevance. The non-relevance in this case of Rwanda is supported by the fact that most of the industries of this sector started after the ban of the production of PBDEs. In this context, the country contains around 1,905.9 kg of PBDEs and both transport sector and electronic sector have almost the same contribution as their contents are around 935.9kg and 966.1 kg respectively.

TABLE 2
AMOUNT OF POP-PBDES-C-OCTA BDE IN ELECTRICAL AND ELECTRONIC EQUIPMENT

Relevant EEE	Quantity of EEE present 2014(in use and in stock)	Total polymer fraction (mean)	c-OctaBDE content (mean) in plastics	Amount of POP-PBDEs-$_{c\text{-}OctaBDE}$
		$f_{Polymer}$ [in % by weight]	$C_{OctaBDE;Polymer}$ in [kg/ metric ton]	In [kg]
WEEE category 3 (without CRTs=Printer, Mobile, photocopying machine)	1,026,507.86+523,889.124	42%	0.225	97.0
CRT computer monitors	2095556.6	30%	2.54	1,596.8
WEEE category 4 (without CRTs=Radios)	2,150,239.53	24%	0.15	77.41
CRT-TVs	10,934,167.94	30%	0.87	2853.8
Total (kg)				*4,625.01*

Finally, the results were translated into Hexa BDE and hepta BDE mass using their respective proportions.

TABLE 3
HEXA BDE AND HEPTA BDE PRESENT IN EEE, WEEE AND IN POLYMERS IN RECYCLING

Homologues	Distribution homologues c-OctaBDE	POP-PBDEs in import for inventory year 2014(kg)	POP-PBDEs in stocks for inventory year 2014(kg)	POP-PBDEs entering the waste stream 2014(Kg)	POP-PBDEs in recycled polymers for inventory year 2014(kg)
Inventoried c-OctaBDE		Σc-OctaBDE= *4,625.01*	NA*	Σc-OctaBDE *=966.1*	NA*
HexaBDE	11%	508.75	NA*	106.3	NA*
HeptaBDE	43%	1,988.8	NA*	415.4	NA*
OctaBDE	35%	*1,618.8*	*NA**	*338.1*	*NA**

**** There is not a facility recycling polymers containing POP-PBDEs. Only PE is recycled.***

From the table above it is very important to note that, category 2 that concerns the small household appliances EEE or their wastes is missing as the data were not available during the inventory.

Although the absence of data is a gap in the inventory, even the POP-PBDEs inventory guideline recognizes the non-relevancy of POP-PBDEs of this category particularly when it arrives at the recalculation of c-Octa BDE concentrations. However, the management of wastes related to category 2 as well as other wastes is described in a specific chapter. The estimation of the quantity of POP-PBDEs-$_{c\text{-}Octa\ BDE}$ was done applying the formula earlier given in the previous paragraph. As the available data show only the quantity of EEE present in Rwanda and the quantity of WEE entering in waste stream yearly, only these two parameters were considered.

4.1.3 PFOS

Although PFOS and its derivatives are used in numerous manufacturing processes such electronics industries, Semiconductor industry, Photographic industry, Metal plating industry, chemically driven oil and gas production, mining industry, mining industry, and in Manufacture of plastic and rubber product; these industries are yet developed in Rwanda. Examples of PFOS or related substances applied to different consumer articles and products: Textiles and upholstery, synthetic carpets, leather, paper and paper board, industrial and household cleaning products, surface coating, paint and varnishes, medical devices, toner and printing inks, cleaning agents, waxes and polishes for cars and floors… The next two tables are showing recent importation of EEE and E-wastes discharge by 2014.

TABLE 4
EEE IMPORTATION (KG) TO RWANDA

Type	2010	2011	2012	2013	2014
Computers	358,186.00	227,351.00	410,629.42	295,975.62	261,063.74
PC printers	9,455.00	21,011.00	33,894.00	33,322.06	21,721.00
Mobile phones	0	168,015.00	318,231.60	0	963,922.86
Copying machines	55,956.00	74,588.00	88,010.00	48,248.20	40,858.00
Refrigerators	655,648.00	529,209.00	494,127.00	364,048.00	408,785.60
Air conditioners	23,966.00	39,320.00	163,922.40	82,839.15	146,673.05
Televisions	457,710.00	695,216.00	480,978.25	339,269.66	205,297.75
Washing machines	29,869.00	33,996.00		38,681.00	0
Stabilizers			184,789.26	172,513.07	169,616.40
Electric cooking stoves	78,434.00	103,061.00	126,386.50	156,109.00	186,969.60
Electric water heating systems	69,581.00	56,598.00	84,076.00	64,092.00	91,997.00

TABLE 5
TOTAL EEE (KG) AND POTENTIAL E-WASTE DISCHARGE (KG)

	Total usage weight (kg)	Potential E-waste per year (kg)
PCs (both laptops and desktops	2,619,445.62	599,725.68
PC printers	876,564.03	269,961.69
Mobile phones	668,024.96	115,489.54
Copying machines	793,893.10	192,930.27
Refrigerators	2,832,275.80	517,041.39
Air conditioners	1,596,692.16	1,121,062.30
Televisions	10,934,167.94	1,981,198.24
Washing machines	208,238.39	54,300.87
Stabilizers	2,140,652.74	421,873.85
Electric cooking stoves	4,754,262.86	1,285,046.49
Electric water heating systems	1,525,687.77	506,184.63

TABLE 6
CATEGORY OF EEE AND WEE

Category	Articles	Mass in Kg of materials	Potential E-waste per year (kg)
1	Fridges	2,832,275.80	517,041.39
	Air conditioners	1,596,692.16	1,121,062.30
	Washing machine	208,238.39	54,300.87
	Total	**4,637,206.35**	**1,692,404.56**
3	Desktop PC	2,619,445.62	599,725.68
	Laptop		
	Printer	876,564.03	269,961.69
	Photocopying machine	793,893.10	192,930.27
	Mobile phone	668,024.96	115,489.54
	Total	**142,32,340.41**	**45,62,916.30**
	CRT-TV	10,934,167.94	1,981,198.24
	Flat panel TV		
	Radio	2,150,239.53	483,852.96
	Total	**130,84,407.47**	**24,65,051.20**

POP-PBDEs were used in electrical and electronic equipment. The mass flow of these equipment, involves different stakeholders starting from their manufacturers, importers, users (government and private institutions), refurbishes, wastes collection companies, regulation institutions, local government, etc. Like in other developing countries the E-wastes managements in Rwanda needs more works as the lack of the recycling companies as well as appropriate technology hinder their Environmental Sound Management (ESM).

Old EE collected from governmental institutions are stored at GIKONDO under the supervision of Rwanda Housing Authority (RHA) which will plan how to auction them. Others are still in store of those institutions. All those e-wastes stored at GIKONDO are mixed with other waste including waste from office furniture. The visit to different institution either public or private revealed that E-wastes are stored in specific stores waiting to be auctioned, the practice that end up by handing the E-wastes and old E-equipment to the refurbishes. The same management practice is found in private sector. According to COPED, sometimes the e-wastes generated at household are included in other wastes in the wastes collection sites.

4.1.4 Vehicles Wastes from garages and households

Vehicles are concerned as they contain PBDEs and PFOS as mentioned previously. The wastes from vehicles are generally found in private garages and institutions garages. In different garages across the country, the scraps metals and replaced spare parts are collected and stored. When the stock is big, Steel Rwanda scraps dealers buy and take them to the plant for recycling. However, sometimes the clients like to take the replaced spare parts to their homes. Furthermore, in Kigali City wastes which are not taken to Steel Rwanda Ltd are collected by COPED and end up also by entering in Nduba dumpsite. Even metals are not containing POPs, the poor sorting of scraps from other parts with plastics as well as their contact with hydraulic oil make them to be part of items concerned by Stockholm convention.

4.1.5 PCB

4.1.5.1 PCBs in Rwanda

The field visit of equipment was conducted in REG/EUCL and private energy producers' hydro power plants, transmission and distribution network, and major industries based on information of equipment. The disposal options were assessed. A datasheet was used for the identification of the PCB-containing equipment were appropriately filled so that every transformer can be identified, location, company name or the user, name of the manufacturer, etc. It was carried out for the identification of the PCB-containing equipment based on information available and collected on the nameplate.

TABLE 7
MATERIALS CONTAINING PCBS

Branch	Inventoried equipment	Equipment supposed with PCB	%	Equipment leaking		Quantity of PCBs		Without nameplate or non-readable	
				PCB	Non PCB	Liquid	Waste	Total	Dielectric
Remera	118	20	17	0	0	118.893	20.419	139.402	6
Kacyiru	96	15	16	0	0	102.376	2.0439	104.420	3
Kanombe	97	15	15	0	0	95.175	6.5405	101.716	3
Gikondo	102	11	11	0	0	132.816	9.973	142.789	1
Muhima	119	11	9	1	0	178.448	12.445	190.893	1
Nyarugenge	75	18	24	0	0	34.935	59.715	94.650	4
Nyamirambo	39	3	8	0	0	30.937	13.914	44.851	1
Ngoma	252	5	2	0	2	144.979	32.310	177.289	7
Nyagatare	335	7	2	0	11	44.081	76.081	120.162	3
Bugesera	79	2	3	0	0	39.202	14.999	54.201	1
Rwamagana	106	1	1	0	0	37.725	13.914	51.639	1
Nyamagabe	127	1	1	0	0	56.25	20.634	76.884	1
Huye	88	11	13	2	0	57.837	20.439	78.276	1
Nyanza	45	6	13	0	0	3.619	6.5405	10.160	0
Ruhango	48	3	6	0	0	24.064	9.973	34.037	1
Muhanga	72	2	3	0	0	49.149	12.445	61.594	4
Karongi	58	18	31	1	1	150.46	59.715	210.175	3
Ngorero	60	9	15	0	0	33.46	13.914	47.374	3
Rubavu	85	26	31	2	0	76.045	32.310	108.355	4
Rusizi	102	18	18	0	0	182.638	76.081	258.719	3
Musanze	108	17	16	0	0	151.901	75.245	227.146	4
Rulindo	86	6	7	0	0	33.46	13.914	47.374	3
Gicumbi	46	4	9	0	0	43.807	20.634	64.441	1
Total	**2344**	**229**	**10**	**6**	**14**	**1780.907**	**665.64**	**2446.547**	**59**

4.1.6 Unintentional –POPs (UPOPs) in Rwanda

The data collected from human activities such as waste incineration of medical, municipal wastes, cement kilns and thermal processes have been analyzed according to the source categories provided by the toolkit for identification and quantification of releases of dioxins, furans and other unintentional POPs, under article 5 of the Stockholm convention. The toolkit was used to calculate all relevant PCDD/PCDF sources. The municipal solid wastes are not incinerated. Some are burned openly and they release PCDD/PCDF in flue gas, fly ash, bottom ash and wastewater. The municipal solid wastes are generated by household during normal daily life and it also commonly includes wastes produced in industrial, commercial and agricultural activities. They are composed of paper and cardboard, plastics, food and kitchen residues, cloth and leather, wood, glass and metal as well as dirt and other inert materials. Small quantities of hazardous materials, such as batteries, paints, drugs. According to information gathered from technical services encountered on land, these wastes contain infectious material, secretions, blood, safety boxes of (syringes, needles, cotton), gloves, saddle pots, buffers, dressing waste, packaging and chemicals. The incineration of medical wastes is operated in small and poorly controlled incinerator in health centres; this is a major source of PCDD/PCDF. Currently medical wastes are incinerated at hospital incinerators with two types of furnaces (main furnace and after burner). The current situation shows that the quantities of medical wastes from hospitals of Rwanda are 2,911,422 kg per years.

TABLE 8
THE QUANTITIES OF INCINERATED WASTES IN HOSPITALS (ESTIMATED ANNUAL AMOUNT IN KG)

No	Hospitals	Kg/year	Hospitals	Kg/year	Hospitals	Kg/year
1	Kigeme	1,769	CHUK	208,176	Kanombe	42,350
2	Ngoma	12,776	KING Faisal	38,900	Musanze	39,933
3	Munini	20,800	Kibagabaga	26,780	Nemba	6,948
4	Byumba	14,400	Huhima	144,357	Kinihira	37,960
5	Kibuye	47,830	Medico center/Biryogo	3,600	Ruli	7,300
6	Kibogora	109,500	Masaka	43,600	Health centers	768,325
7	Kirehe	36,700	Kalisimbi	138,047	Rutongo	12,775
8	Gihundwe	18,437	ADPER Nyamata	12,168	Muhororo	65,700
9	Kabaya	36,400	Remera/ Rukoma	29,200	Gitwe	13,900
10	Murunda/Rutsiro	31,200	Kabgayi	44,200	Nyagatare	8,473
11	Rubavu	39,600	Nyanza	58,800	Kiziguro	18,250
12	Shyira/nyabihu	26,000	Kinazi	3,100	Gahini	166,400
13	Rwamagana	78,000	Musha	455,000	Butaro	43,768
	Total	473,412		1,205,928		1,232,082
Overall total: 2,911,422						

4.2 Production of ferrous and non-ferrous metals

The sub category of Iron and steel production plants is produced in two plants located at Rwamagana (SteelRwa) and IMANA Steel located at Bugesera/Gashora. Annual production is 400,000,000 tones / year of iron and steel. This activity can be potential source of PCDD / PCDF as thermal processes contaminated non-ferrous metal scrap influenced by the degree of using scrap metal contamination and also retention and treatment of gas flow.

TABLE 9
QUANTITIES OF UPOPS RELEASES IN AIR, WATER, LAND, PRODUCT AND RESIDUES

Group	Source Groups	Air	Water	Land	Product	Residue
1	Waste Incineration	42.1	0.0	0.0	0.0	104.6
2	Ferrous and Non-Ferrous Metal Production	4000.0	0.0	0.0	0.0	6000.0
3	Heat and Power Generation	0.0	0.0	0.0	0.0	0.0
4	Production of Mineral Products	0.1	0.0	0.0	0.0	0.0
5	Transportation	0.0	0.0	0.0	0.0	0.0
6	Open Burning Processes	0.5	0.0	0.0	0.0	0.0
7	Production of Chemicals and Consumer Goods	0.0	0.0	0.0	0.0	0.0
8	Miscellaneous	0.0	0.0	0.0	0.0	0.0
9	Disposal	0.0	0.0	0.0	0.0	0.0
10	Identification of Potential Hot-Spots				0.0	0.0
	Total	**4,042.7**	**0.0**	**0.0**	**0.0**	**6,104.6**
	Grand Total	**10,147**				

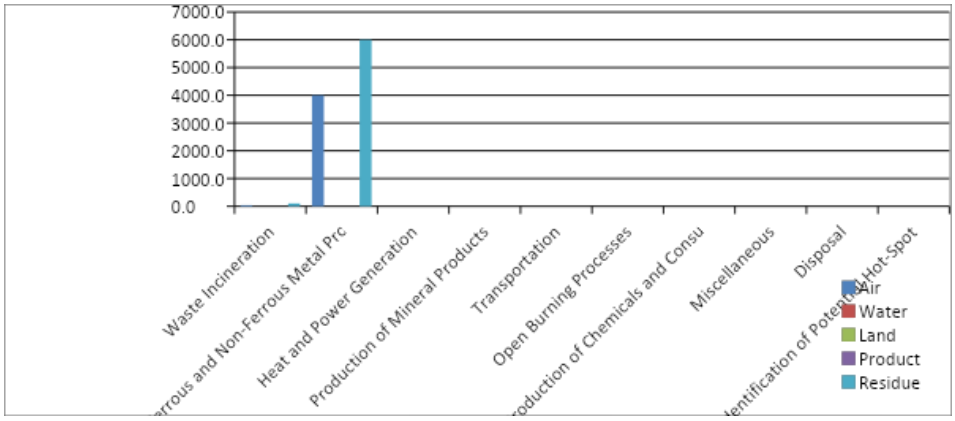

FIGURE 1: Production of iron and steel from metallic wastes (scraps)

According to the graphs above the production of iron and steel from metallic wastes (scraps) are producing the UPOP releases and the second production is waste incineration of medical wastes. And other sources are producing UPOP releases at low level.

V. THE CONTAMINATED SITES (HOTSPOTS)

5.1 Former public waste dumpsite of Nyanza- Kicukiro

This waste dumpsite is located at the top of the hill called Nyanza Kicukiro, in Kagarama Sector, District of Kicukiro. The site contains all kind of waste from Kigali town for long time ago up May 2012, the time the town's wastes were relocated to the Nduba dumpsite.

5.2 Public waste dumpsite of Nduba

This public waste dumpsite located in Nduba Sector, Gasabo District; has replaced the Nyanza-Kicukiro site in May 2012. The site receives all kind of urban waste without a prior sorting. The dumpsite receives an average of 70 trucks (5 tones / truck) per day. Nduba dumpsite was initially designed for receiving in general all kinds of wastes segregated at the origin in order to allow an easy recycling process for some of them. Since this site was opened, no infrastructure development is going on as planned. While the wastes collection practices require wastes to be sorted at generation site, wastes in Nduba are mixed and good variety of hazardous wastes are dumped. Currently, the site employs 90 workers who separate plastic wastes to be recycled from other wastes and dump the latter in appropriate pits. Among these workers who are daily dealing with these wastes, are 23 women (25%). Furthermore, companies involved in wastes collection and their transport, around 500 persons are involved.

5.3 Nyabugogo wetland and River

Nyabugogo wetland is also another place that is required to be subjected to laboratory test as it has been acting as the sink of all categories of wastes collected by the runoff either from the city, surrounding areas as well as the former industrial area of Gikondo.

FIGURE 2: Contaminated site of Gikondo/Industrial Park

The latter also makes another potential contaminated site. In fact, the former GIKONDO industrial park was located upstream of Nyabugogo wetland that gives the name to the river that drain surface water from upstream areas. Many industries, that were in that area lacked the on-site waste treatment, which sometimes results in illegally sending untreated discharge into rivers and wetlands. The next map is showing the interconnection between Nyabugogo wetland and Nyabugogo River with some key pollution hot spots.

5.4 Other Potential contaminated sites

Besides the enumerated dumpsites their other places such where activities that involved articles containing the new POPs took place for long period that need to be subjected to laboratory test for confusion removing. These include for example Agakiriro and other places in Kigali where furniture manufacturing took place in the past years.

VI. RECOMMENDATIONS

The limited knowledge and skills on POPs, lack of information access and analytical capacity of POPs are considered as crucial issues for waste collectors and local communities who are vulnerable to POPs and wastes to fulfill the obligations of the Stockholm Convention. In order to reduce or eliminate the POPs, the capacity building of vulnerable communities is needed in Rwanda to save their lives, public health and environment in general. Therefore, the following recommendations are formulated to an opportunity for waste collectors and local communities to become familiar with POPs information and environmentally sound management of chemicals and wastes:

- It should be better to organize the permanent training of waste collectors and local communities to apply Best Available Techniques/Best Environmental Practices needed to reduce the production of POPs and waste management and implement technical environmentally sound management of wastes. Capacity building of waste collectors and various stakeholders intervening in waste management should be effective and efficient in the management of chemicals and wastes
- Awareness promotion should be organized separately in Hospitals, industries, local communities… and various stakeholders including CBOs, NGOs and local communities should participate actively and play key role in chemicals and waste management
- Introducing the measures of alternative technologies to improve the incineration systems (eradication lowly incineration furnaces, low technological condition) and enforce the use of gas tributaries of control systems.
- The use of approved incinerator designs that can achieve appropriate combustion conditions (e.g., minimum temperature of 800^{o} C, maximum temperature 1500 ^{o} C. currently the medical wastes are burned on the temperature between 800-900 ^{o} C
- The location for the incinerator should be considered to minimize potential risks to public health and the environment (Minimizing the number of people potentially exposed)
- Further studies should be conducted on assessment of POPs management and analytical analysis of POPs potential in Rwanda and other POPs related researches.

VII. CONCLUSION

In general, in Rwanda, there are the releases of POPs/chemicals and wastes. This affects the environment and public health negatively according to the frequency and period of exposure. The vulnerable communities (waste collectors and local communities) should be trained on chemicals and waste management, Best Available Techniques/Best Environmental Practices and proposed together the way forward to apply with BAT/BEP measures needed to reduce or eliminate the releases of POPs and technical guidelines of environmentally sound management of wastes including chemicals. The study proposed the recommendations to be put into action for the efficient results to adapt Best Available Techniques/Best Environmental Practices (BAT/ BEP) to reduce the emissions of POPs/chemicals and waste management for protecting the environment and public health.

Therefore, the collaboration and ownership of various stakeholders including local authorities, communities, Civil Based Organizations, Private Sector and academic institutions should be important for effective and efficient management towards POPs free environment and waste management for sustainable development. Without environmentally sound management of wastes; public health can lead to significant environmental degradation and pollution. The contribution of local communities,

especially the waste collectors in cooperatives and companies should be more effective to achieve the management of chemicals and wastes and pollution control thus save the environment.

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Quality Characteristics, Phenotypic correlations and Principal Component Analysis of Indigenous Free Range Chicken Eggs in Lusaka, Zambia

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Abstract— *The aim of this study was to characterize indigenous chicken eggs and create an inventory that will set a base for designing breeding programs to improve egg quality traits. 338 eggs of mixed breeds of indigenous chickens from small scale farmers in Lusaka were collected and used in this study. A number of external and internal traits were measured manually. The eggs had a weight of 49±0.44g with a length of 54.55mm and 40.31mm wide. Other traits measured included egg shell weight and length, with the egg shell accounting for 12.78% of the total weight of the egg. The egg albumin and egg yolk weighed 26.21g and 16.55g respectively. The egg weight positively correlated with all the traits studied. A principal component analysis on these traits extracted three principal components that accounted 75.80%. The diversity shown by these eggs shows a huge potential for improvements of egg quality characteristics through proper selection and breeding.*

Keywords— egg quality, indigenous chickens, egg shape index, principal component analysis, Lusaka.

I. INTRODUCTION

Eggs are a biological structure intended for reproduction found in female animals. They protect and provide diet to the developing embryo. Even after hatching, eggs remain a source of nutrition for few more days. Some animals produce eggs external to their bodies like birds while others produce eggs inside their bodies. In developing countries, eggs as the most important protein source to man cannot be overemphasized because eggs contain multiple essential nutrients. As a major product from poultry, eggs are composed of egg albumin, egg yolk and the shell in 58, 31 and 11 percentages. More than half of the egg protein is in the albumin while most of the vitamins and all fats are in the egg yolk (Abanikannda *et al.* 2007)

The egg quality depends mainly on consumer preference with respect to various traits that include freshness, mass, cleanliness, egg weight, volume, shell quality and color, yolk index, and shell thickness (Narushin 1997). In the recent past, the trait that has drawn so much attention from researchers is the egg shape (Nedomova *et al.* 2009; Duman *et al.* 2016) which is mainly determined by shape index. The shape index (SI) of the egg is the quotient of the width and the length of the egg. It is the standard by which eggs are graded. Eggs with shape index of less than 72 are classified as sharp, those with SI between 72 and 76 are classified as standard eggs while round eggs have egg index of above 76. Unusually sharp and round eggs can never be graded in AA (top grade) or A (second to AA) this is because they are difficult to pack in cartons and can easily break during freight than those classified as standard eggs (Galic *et al.* 2019).

The indigenous chicken egg farming in Zambia is still a developing one like in any other developing country. And there is very limited commercialization in this sector with only 0.5% of the total population of indigenous chickens being under commercialized production systems (MFL 2019). Chances of developing this sector are so limited due to among many reasons the poor genetic potential of indigenous chickens. Indigenous chickens will lay between 20 and 80 eggs per. This is very low compared to the commercial counterparts that will lay up to 300 eggs per year (Guèye 2000; Wong *et al.* 2017; Dumas *et al.* 2018). This can however, be improved by design of proper breeding programs.

In order to breed towards improving the quality of eggs, there is need for breeders to understand the available phenotypes and the relationships that exist between egg quality characteristics. Studies on Several intraspecific variations in egg composition have been conducted (Hill 1995; Dzialowski & Sotherland 2004). Intraspecific variations in egg traits have been attributed to numerous factor amongst them size and nutritional standing of hen, feed handiness, heritability, order of laying and a blend of these factors (Schreiber & Lawrence 1976; Abanikannda & Leigh 2007). In order to make sense of these relationships and make informed decisions, as breeders we find ourselves in situations where we deal with large numbers of correlated traits

and this data would be complex to handle. Principal component analysis (PCA) a multivariate analysis procedure becomes handy to analyze these data. PCA analyses data where observations are described by numerous inter-correlated quantifiable reliant variable (Abdi & Williams 2010). The fundamental theory of PCA is that it reduces the dimensionality of data sets with a huge quantity of related variables at the same time holding as much disparity as there can be of the existing in the data. This is attained by changing to a different set of variables, (the principal components, PCs) which are not correlated but organized so much that the highest of the dissimilarity extant in the original variables is maintained in the first few components (Jolliffe 2005). PCA has been used several times to study variations in egg traits (Sarica *et al.* 2012; Bing-Xue *et al.* 2013; Ukwu *et al.* 2017).

This study aimed at characterizing indigenous chicken eggs in Lusaka, Zambia and use PCA to analyze these characteristics. The results of this study would serve as an inventory of the egg production genetic potential possessed by these chickens on which decisions on the designing of breeding programs as well as selection and breeding would be based.

II. MATERIALS AND METHODS

2.1 Description of site

The study was conducted in Lusaka district in Zambia's Lusaka province in August 2018. Lusaka approximately covers 360 km^2 of area sitting on 15°25′S and 28°17′E. Lusaka has a high altitude with humid subtropical climate. Its coolest month is July whose mean temperatures drop to 14.9 °C. Their summer is very hot and has relatively warm winters. The hottest month is October whose daily mean temperatures go up to 32 °C.

2.2 Data Collection

A total 338 fresh eggs were collected from Lusaka west area in Lusaka district, a place with a concentration of small scale poultry production. These were less than 3 days old from day of laying. The breeds used were of mixed breeds and there is limited documentation on their characterizations if any exist.

2.3 Collection of parameters

The following traits were measured using the standard procedures (Monira *et al.* 2003; Fayeye *et al.* 2005).

Egg length (mm): Through the use of digital Vernier calipers this was measured as the distance between the broad end and the narrow end.

Egg width (mm): A Vernier caliper was used to measure the distance across the middle of the egg.

Egg weight (g): Individual eggs were weighed on a digital scale with accuracy of 0.01g

Shell weight (g): After carefully opening the eggs from the narrow end to allow its contents come out without mixing, the shell was weighed together with the membrane on an electronic scale with 0.01 accuracy.

Shell thickness (mm)**:** A micrometer gauge was made use of to quantify the thickness of the egg shell. The shell thickness was taken at the narrow end, the middle and broad end with their average recorded as thickness of the shell**.**

Albumin weight (g) and yolk weight (g): The fresh eggs were opened at the sharp end enough to allow passage of both the yolk and egg albumin ensuring they don't mix. The yolk and albumin were carefully separated into pre weighed petri dishes. The variance between the heaviness of the unfilled and the weight of the petri dish containing the albumin or yolk was the weightiness of the albumin and yolk respectively.

Yolk height (mm): The height of the yolk was taken using depth gauge of the digital Vernier calipers.

Yolk width (mm): The yolk's width was also taken at the widest horizontal circumference using digital Vernier calipers.

Egg surface area (cm^2) was computed as $S=4\pi r^2$. Radius (r) was calculated as ¼ (length + width) of the egg.

Yolk index: The ratio of the height of the yolk to the yolk width was taken as the yolk index.

Yolk ratio was estimated as yolk weight as the percentage of full weight of the egg.

Egg shape index (%): The quotient (multiplied by 100) of the egg width (W) and egg length (L) was taken as the shape index of the egg as below.

The formula is Egg shape index = $\frac{egg\ widt\ h}{egg\ lengt\ h}$ x 100 (Markos *et al.* 2017).

2.4 Statistical Analysis

Means, standard error of the mean and coefficients of deviation of egg measurements in Lusaka were evaluated by means of the descriptive statistic of Minitab 18. Pearson correlation coefficients amongst these egg traits were determined. And the correlation matrix remained the main data necessary for Principal component analysis (PCA). To assess the legitimacy of the factor scrutiny of the number sets, Bartlett's test of sphericity was computed. The appropriateness of the statistics set to do analysis was additionally confirmed by KMO (Kaiser-Meyer-Olkin) extent of sampling competence which tested if the correlations between variables stayed trivial. A KMO quantity of 0.60 and higher was taken as adequate (Eyduran *et al*., 2010). Then Principal Component Analysis for egg quality traits was performed using Minitab 18 statistical software.

III. RESULTS AND DISCUSSION

3.1 Egg quality traits

Table 1 shows the descriptive statistics of the egg quality traits of indigenous chickens in Lusaka, Zambia. The eggs weighed 49.72±0.44g, with a length of 54.55±0.17mm and a width of 40.31±12mm. The egg radius was 2.37±0.01mm and the surface area was 70.79±0.37cm^2. The eggs in this study had shells with a mean weight of 6.34±0.05g, a thickness of 0.36±0.01mm and a shell ratio of 12.78±0.06%. The albumins in this study had recorded a mean weight of 26.21±0.30g. The eggs had egg yolks with a height, width and weight of 15.77±0.30mm, 40.27±0.30mm and 16.55±0.22g respectively. The egg shape index was found to be 73.96±0.23% with the yolk index recording 39.39±0.67%.

TABLE 1
DESCRIPTIVE STATISTICS OF EGG QUALITY TRAITS OF INDIGENOUS CHICKENS IN LUSAKA.

Variable	Mean	SE Mean	COV
External traits			
Length (mm)	54.55	0.17	4.13
Width (mm)	40.31	0.12	3.9
Weight (g)	49.72	0.44	11.85
Radius (mm)	2.37	0.01	3.48
surface area (cm^2)	70.79	0.37	7.05
Internal traits			
Shell weight (g)	6.34	0.05	11.68
Shell thickness (mm)	0.36	0.01	10.55
Shell ratio (%)	12.78	0.06	6.6
Albumen weight (g)	26.21	0.3	15.46
yolk height (mm)	15.77	0.3	25.79
Yolk width (mm)	40.27	0.3	10.04
Yolk weight (g)	16.55	0.22	17.93
Egg shape index (%)	73.96	0.23	4.18
Yolk index (%)	39.39	0.67	23

The weight of the eggs in this study was found to be higher than the 46.5g in Kenyan indigenous chickens (Wambui *et al.* 2018), 45.89g in Malawian chickens (Gongolo & Tanganyika 2018), and 48.21g in Botswana (Kgwatalala *et al.* 2016) but lower than the one found in Turkey (Duman *et al.* 2016) and the 57.78g obtained in India (Rath *et al.* 2015). According to Shalev and Pasternak (1993) egg weight is affected to a large extent by the environment and feed restriction. Parental average weight also plays a vital role (Abudabos *et al.* 2017) but the genetic effect also cannot be ruled out. The egg length in this study was similar to what Rath et al (2015) and Kgwatalala et al. (2016) reported. Other studies have provided results of eggs width comparable to what was obtained in the present study (Abanikannda & Leigh 2007; Kgwatalala *et al.* 2016; Gongolo & Tanganyika 2018). From the shape index it can interpreted that the eggs in Lusaka were standard eggs and would get a good grading as it falls within the 72-76 range for standard eggs (Duman *et al.* 2016). Standard eggs fit well in trays during packaging and freight. The shell weight in this study agrees with that found in other studies (Kgwatalala *et al.* 2016) but higher than obtained in Malawian chickens (Gongolo & Tanganyika 2018). The shell thickness in this flock concurs with that obtained by Nonga et al (2010) but is higher than what other researchers reported (Rath *et al.* 2015). These differences could

be due to the differences in breeds used and nutritional strategies employed. Eggs with a shell thickness of atleast 0.33mm stand up to 50% chances of withstanding standard handling without breaking during packaging and transportation (Stadelman 1995). The shell ratio in this study was higher than the ones obtained in leghorns (Sreenivas *et al.* 2013; Rath *et al.* 2015). The yolk height in our study is lower compared to the one obtained in the naked neck, normal feathered and dwarf chickens of Botswana, and the white leghorns (Rath *et al.* 2015; Kgwatalala *et al.* 2016). In comparison to other studies, the current findings on the yolk weight are akin to the ones obtained by Rath et al (2015) but higher than that obtained in the three strains studied by Kgwatalala et al.(2016) and Nonga et al.(2010). From the yolk index obtained in this study which is in the range 0.33- 0.50, a conclusion can be drawn that the eggs from this flock were fresh and of good quality (Ihekoronye & Ngoddy 1985).

3.2 Phenotypic correlations between egg quality traits

Table 2 displays the Pearson correlation coefficients of different egg traits with respect to each other. In this study Egg weight recorded a strong to moderate positive correlation with all the traits studied. Egg width and shell weight had the highest correlation coefficient with r =0.829 and 0.835 respectively. Egg shape index and yolk index had the lowest correlation coefficients to egg weight with r =0.071 and 0.281 respectively. The correlation between yolk height and yolk index (r =0.936) was the highest in this study. Egg shell index and egg length showed a strong negative relationship (r =0.556).

TABLE 2
CORRELATION MATRIX OF EGG QUALITY TRAITS OF INDIGENOUS CHICKENS IN LUSAKA.

	Egg weight	Egg length	Egg width	Shell weight	shell thickness	Albumin weight	yolk height	yolk width	Yolk weight	Egg shape index
Egg Length	0.721									
Egg width	0.829	0.468								
Shell weight	0.835	0.598	0.737							
Shell thickness	0.494	0.229	0.381	0.582						
Albumin weight	0.405	0.237	0.554	0.244	0.054					
Yolk height	0.481	0.353	0.073	0.434	0.342	-0.151				
Yolk width	0.503	0.242	0.503	0.459	0.284	0.197	0.096			
Yolk weight	0.739	0.524	0.651	0.676	0.24	0.038	0.481	0.353		
Egg Shape Index	0.071	-0.556	0.473	0.105	0.131	0.279	-0.261	0.237	0.099	
Yolk Index	0.281	0.244	-0.113	0.256	0.244	-0.213	0.936	-0.246	0.32	-0.33

The positive relationship of the weight of the egg with all the other measured traits agrees with what was found in similar studies (Abanikannda & Leigh 2007). This positive relation between egg weight, length, width, shell weight and thickness of the shell, albumin weight, yolk height, and yolk width as well as yolk weight suggests that selection for breeding for any of these traits would result in associated improvement in the other traits. This is suggestive that their action is more or less additive in nature, implying a combined effect. This study established a negative relationship between egg shape index and egg length confirming that the determination of egg shape index is more of a function of egg width (Mróz *et al.* 2014). The egg shape index and the egg weight were highly correlated. This is for the reason that the heavier part of the egg (egg albumin) occupies the broader (wider) part of the egg which explains a heavier egg. This finding agrees with other studies by Duman et al.(2016). The findings of Shi et al (2009) also agree with those of the current study. However, the outcomes of the present study disputes the conclusions of Alkans et al. (2010) who found a significantly negative association between the egg weight and the shape index of the egg.

3.3 Principal component analysis

The Eigen values, communalities and percentage of variation of extracted components are shown in Table 3. Bartlett's test was conducted to determine the rightness of the data for PCA. The Bartlett's test was highly significant (P=0.00) indicating suitability of the data for PCA. Next the Kaiser-Meyer-Olkin (KMO) sampling competence was completed and got 0.68 this was above 0.60 at which any value above is considered an adequate sample (Eyduran *et al.* 2010). Three principal components were extracted and these had Eigen values of 6.40 (PC1), 2.51 (PC2) and 1.70 (PC3). These Eigen values showed amounts of variance accounted for by each factor. They each accounted for 45.73% (PC1), 17.96% (PC2) and 12.11% (PC3) of the total variability. Cumulatively the three factors accounted for 75.80% of the total variance. PC1 was

characterized by high positive loading on egg weight, Egg length, egg width, egg radius, shell weight , yolk weight and egg surface area . PC1 had moderate loadings on shell thickness, albumin weight, and yolk height and yolk width. Low loadings of PC1 were observed on shell index, yolk index and shell ratio. The second factor (PC2) had low loadings on egg weight, egg length, egg radius, shell weight, shell thickness, yolk width, yolk weight, egg surface area, and shell ratio. However PC2 had moderate to high loadings on egg width, albumin weight, yolk height, shell index and. PC3 had high loading on shell ratio and moderately on egg length and shell thickness and low loadings on the rest of the traits studied. The large Communalities recorded here ranging from 0.43 to 0.97 indicated that the majority of variation was accounted for by the factor solutions. In a study to analyze egg quality traits of eggs of ISA brown layer chickens in Nigeria, Ukwu et al.(2017) extracted three principal factors that accounted for 85.80% of the total variance. In another study of egg quality traits in Chinese native duck breeds, Bin-Xue et al (2013) extracted two factors that accounted for 65.32% of the total variance. However, this study extracted three components. PC1 which seemed to be a description of external Egg quality traits and PC2 which was a description of internal egg traits. Just like in the findings of Ukwu et al. (2017), PC3 in this study was a description of egg shell quality.

TABLE 3
EIGEN VALUES, PERCENTAGE OF TOTAL VARIANCE, ROTATED COMPONENT MATRIX AND COMMUNALITIES OF EGGS OF INDIGENOUS CHICKENS IN LUSAKA.

	PC1	PC2	PC3	Communalities
Egg weight	0.97	0.02	0.02	0.94
Egg Length	0.80	-0.26	-0.45	0.91
Egg width	0.84	0.47	0.11	0.94
Egg radius	0.95	0.05	-0.26	0.96
shell weight	0.87	-0.02	0.37	0.90
Shell thickness	0.50	-0.08	0.52	0.53
albumin weight	0.40	0.54	-0.28	0.52
Yolk height	0.46	-0.75	0.24	0.83
Yolk width	0.51	0.37	0.19	0.44
Yolk weight	0.77	-0.12	0.14	0.63
Shell index	-0.01	0.69	0.56	0.78
yolk index	0.26	-0.86	0.19	0.83
egg surface area	0.95	0.05	-0.26	0.97
Shell ratio	-0.15	-0.06	0.63	0.43
Eigen value	6.40	2.51	1.70	
% variance	45.73	17.96	12.11	
Cumulative % Variance	45.73	63.68	75.80	

As far as the consumption of eggs is concerned, eggs have been accepted world over as a main ingredient of the human diets as a staple food in some cases. Zambia is no exception as it is also in the baking industry. With the rising in populations comes increased demand for food eggs inclusive. The Zambian egg industry is not yet up to speed with the rising in demand. There is recently a growing trend for people to fancy indigenous chicken eggs. But the quantity and quality of these eggs are still yet to improve. Egg quality is those characteristics of an egg that would influence the acceptability to buyers and is the most vital price determinant in both hatching and table eggs (Kgwatalala *et al.* 2016). Several factors influence the quality of eggs. These could be the breed, relative humidity, management, temperature and the season (Rajkumar *et al*. 2009). But to uphold this quality of eggs, unceasing genetic appraisal of diverse egg quality characters has become vital in modern market oriented production (Rath *et al.* 2015). Understanding the egg quality traits and how they relate to each is a basis for formulation of sound breeding. This study has created an inventory of egg quality traits as prevalent in Lusaka, Zambia and also analyzed how these relate to each other. Based on these traits, plans of how to improve egg quality traits can now be exploited.

IV. CONCLUSION

This study successfully reported the genetic inventory of indigenous chickens with regards to egg quality traits. These plus the further analysis reported here of the relationships between these traits forms a good base for designing a sound breeding for improvement of these traits.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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The Changing of Soil Reaction and Exchangeable Aluminum on two Different Soil Order due to Dolomite Application

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Abstract— *The objective of the experiment was to know the effect of Dolomite application on soil reaction and exchangeable Aluminum in two different soil orders. The method was experimental using Factorial Randomized Block Design, which consists of two Factors. The First factor were soil orders consist two levels, i.e. T1= Ultisols Kentrong, dan T2 = Inseptisols Jatinangor, while the second were dolomite dosages, consist four levels, i.e. dO = 0 ton ha^{-1}, d1 = 1 ton ha^{-1}, d2 = 2 ton ha^{-1}, d3 = 3 ton ha^{-1}, d4 = 4 ton ha^{-1}.The result of the experiment showed that on Ultisols Kentrong, dolomite applications significantly increased the value of soil reaction (pH) after two weeks incubation. The treatment of 3 ton/ha showed pH 4.73 or 8 % higher that control. Otherwise, the applications of dolomite also decreased the exchangeable Aluminum. The treatment of 3 ton/ha showed value 7.01 of exchangeable aluminum or 21 % lower than control. In Inceptisols Jatinangor, dolomite applications increased the value of soil reaction (pH) after two weeks incubation and the treatment of 3 tonha^{-1}showed pH 5.83 or 11 % higher than control. Otherwise, the application of dolomite decreased the exchangeable aluminum although were not significantly different for that parameters in this soil order. Based on statistical analysis, it proved that liming unable applied effectively on whole soil types or orders due to its relation with the level of soil acidity.*

Keywords— Soil Reaction, Exchangeable Aluminum, Ultisols Kentrong, Inceptisols Jatinangor.

I. INTRODUCTION

The soil productivity is one of the serious problems in agriculture production, because we need to increase the food availability to represent a rapid growth of population. In fact, Indonesia has great opportunities to increase of agriculture production due to availability of land resources, although there are many limit factors in its development. Soil acidity is one of the limit factors in tropical land development. High rainfall leach out the basic minerals in soils. Fertilizers and organic matter from manure and compost tend to accelerate this acidulation process (Tan, 2000). The results of long-term experiments in many countries of the world show that regular application of farmyard manure limits soil acidification and intensive mineral fertilization; especially with nitrogen and potassium, it results in a decrease in pH value, and even in soil degradation (Gomonova et al. 2007, Shahid et al. 2013).Liming is helpful because it neutralizes active protons (H +) in the soil solution, alters the exchangeability and potential acidity associated with the presence of toxic Al and Mn (Raijet al., 1977) in soil solution.

Soil acidity is commonly indexed by the soil reaction; the index is used together with other soil characteristics such as texture, organic matter, and clay mineralogy to estimate the degree of soil acidity and the effect of soil acidity on plant behavior (Kidder, 2003). One of the primary factor that effect on plant growth environment is soil reaction due to its effect to plant nutrients availability. In base soil reaction, the availability of K, Ca, Mg and N are very high while Fe and Mn are low, otherwise in acidic soil reaction, the availability of P and Alis optimum, while micro nutrients are dissolved (Foth, 1994).

Ultisols and inceptisols are the acidic soil, the soils widely distributed in Indonesia, approximately 42, 27 % for Inceptisols and 20, 25 % for Ultisols, or about 119.389.914 ha for both, a great number of land resources. Both Ultisols and Inceptisols may develop from similar parent material but strongly distinguished by the climate, vegetation, and age (Buol, et al, 1990).

Inceptisols develop on fairly steep slopes, young geomorphic surfaces, and on resistant parent materials, there is no Fe or aluminum oxide formation indicated soil acidity, while ultisols develops in warm, humid temperate, typically on old and stable landscapes. They have an acidic argillic horizon due to the formation of Fe oxides with less than 35% base saturation. It indicate that ultisols has a higher acidity than Inceptisols. Liming aim to reduces soil acidity, by increase of pH value. This is the primary reason for applying lime to acidic soil such as Ultisols and Inceptisols (Kidder, 2003).

II. MATERIAL AND METHOD

The incubation experiment was conducted at the greenhouse. The method was experimental using factorial randomized block design that consists of two factors. The first factors was soil types consist two levels, i.e. T1= Ultisols Kentrong, and T2 = Inceptisols Jatinangor, while the second was dolomite dosages, consist four level, i.e. d0 = 0 ton ha^{-1}, d1 = 1 $tonha^{-1}$, d2 = 2 $tonha^{-1}$, d3 = 3 $tonha^{-1}$, d4 = 4 $tonha^{-1}$.

Air dried soil of ultisols and inseptisols with amount of 12 kg sieved by 2 mm mess and applied the treatment of dolomite dosages get into the polybags then given the watered reach to field capacity condition. The soil in polybags was incubated for 2 weeks and soil reaction (pH) and exchangeable aluminum were analyzed pre and post treatments from unit of soil sample. Completed data was statistically analyzed, followed by mean separation with Duncan's New Multiple Range Test.

III. RESULT AND DISCUSSION

3.1 Soil Reaction (pH)

The result shows that dolomite applications significantly increased the soil reaction on Ultisols Kentrong after two weeks incubation. The treatment of 3 ton/ha showed pH 4.73 or8% higher than control, while on Inceptisols Jatinangor the dolomite applications insignificantly increased the soil reaction. The treatment of 3 ton/ha showed pH 5.83 or 11% higher than control.

The increasing of soil pH due to the increasing of Ca^{2+}sourced from dolomite applications. Dolomite applications increase the availability of calcium that created neutralization effect due to substitution reaction between H^+ and Ca^{2+} (Tisdale, 1993).Liming increase bases caution dan soil pH.Alsolubility is strongly influenced by soil pH. Increase soil pH will decrease of Al solubility in soil (Ritchie, 1995).

Liming soil also modifies the distribution of charges in the soil particles, especially in the juvenile soil class (Inceptisols), which shows a predominance of electrical charges (positive or negative) depending on pH or variable charges associated with the ferrol, aluminol and silanol surfaces complex groups on the surface of minerals and the carboxylic and phenolic surface complex groups on the surfaces of soil organic matter (Sposito, 2008).

TABLE 1.
EFFECT OF DOLOMITE APPLICATIONS ON SOIL REACTION OF ULTISOLS KENTRONG AND INCEPTISOLS JATINANGOR

Treatments	Soil Reaction (pH)	
	Ultisols Kentrong	Inceptisols Jatinangor
d_o= Control	4.36 a	5.23 a
d_1 = 1.0 ton ha^{-1}	4.54 b	5.43 a
d_2 = 2.0 ton ha^{-1}	4.67 b	5.62 a
d_3 = 3.0 ton ha^{-1}	4.73 c	5.83 a
d_4 = 4.0 ton ha^{-1}	4.90 c	5.83 a

Note: same letters represent insignificant values at 5 % level by Duncan's Multiple Range Test.

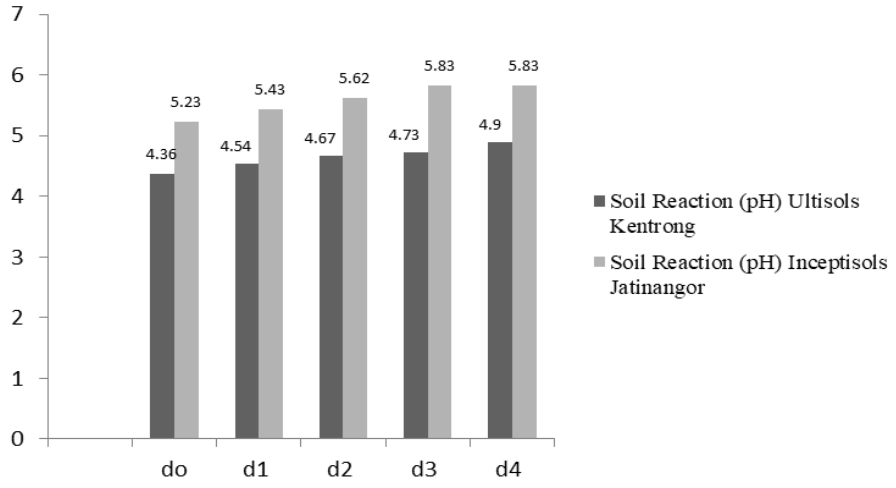

FIGURE 1: EFFECT OF DOLOMITE APPLICATIONS ON SOIL REACTION OF ULTISOLS KENTRONG AND INCEPTISOLS JATINANGOR

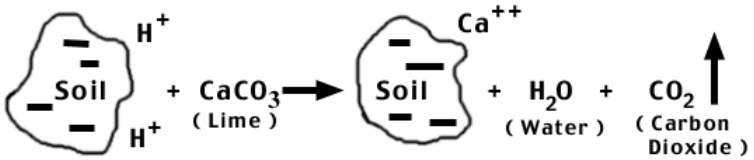

FIGURE 2: CHEMICAL ILLUSTRATION OF LIMING PROCESS

3.2 Exchangeable Aluminum

The result showed that the dolomite applications significantly decreased exchangeable aluminum on Ultisols Kentrong after two weeks incubation. The treatment of 3 ton/ha showed value 7.01 or 21% lower than control, while on Inceptisols Jatinangor the treatments insignificantly decreased the exchangeable aluminum.

The decreasing of exchangeable aluminum due to liming application that increase soil reaction (pH) and sediment of exchangeable aluminum as $Al(OH)_3$ (Tan, 2000). Liming process equivalent to 2.25 t ha^{-1} on acid soil (pH 4.5) decreased Al-exchangeable (Costa and Rosolem, 2007). Furthermore, the study showed that liming increased Ca concentration and reduced Al exchangeable and Al saturation at 20 cm and 40 cm soil depth after 9 months and two years of application, respectively (Caires et al., 2008). Although it takes a long time, the movement of lime into the deeper layers may occur through (1) the process complexes formation of Ca or Mg with soluble organic matter so that it can move to deeper soil layers, (2) the activity of organism, especially macro fauna and (3) lime with a micro size is relatively soluble (Miyazawa et al., 2002; Chan, 2003).In electronegative soils, pH decreases with increasing soil solution salt concentration, due to ion exchange between salt cautions and the H^+ and Al^{3+} ions of the exchange complex (Sousa et al., 2007).

TABLE 2
EFFECT OF DOLOMITE APPLICATIONS OH EXCHANGEABLE ALUMINUM OF ULTISOLS KENTRONG AND INCEPTISOLS JATINANGOR

Treatments	Exchangeable Aluminum (cmol/kg)	
	Ultisols Kentrong	Inceptisols Jatinangor
d_o= Control	8.83 a	0.81 a
d_1 = 1.0 ton ha^{-1}	7.68 b	0.78 a
d_2 = 2.0 ton ha^{-1}	7.38 b	0.76 a
d_3 = 3.0 ton ha^{-1}	7.01 bc	0.74 a
d_4 = 4.0 ton ha^{-1}	6.78 c	0.73 a

Note: same letters represent insignificant values at 5 % level by Duncan's Multiple Range Test.

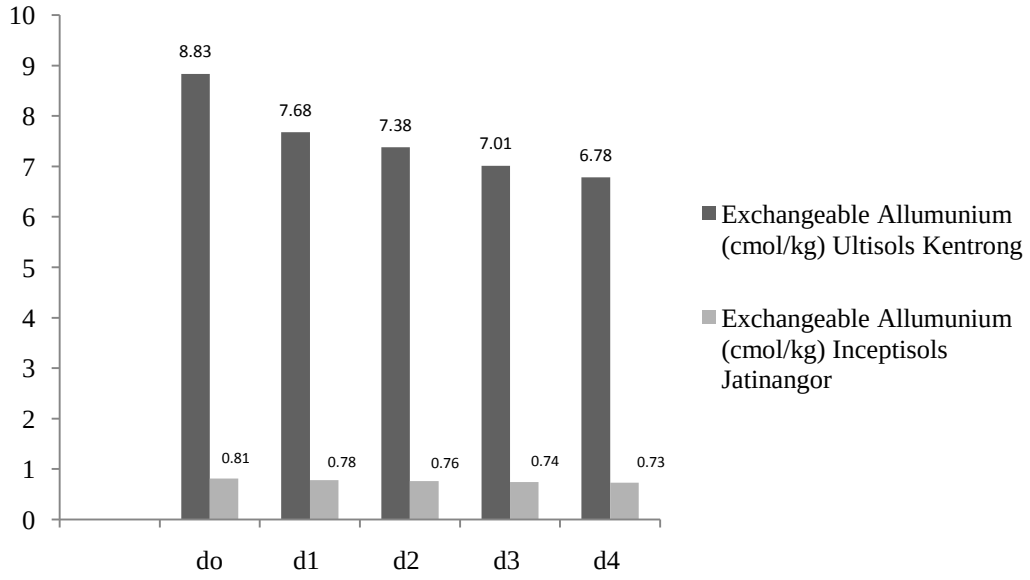

FIGURE 2: EFFECT OF DOLOMITE APPLICATIONS OH EXCHANGEABLE ALUMINUM OF ULTISOLS KENTRONG AND INCEPTISOLS JATINANGOR

IV. CONCLUSION

The Dolomite applications showed the changing on soil reaction and exchangeable aluminum in two different soil orders, both Ultisol Kentrong and Inceptisols Jatinangor, by the different responses. Ultisols Kentrong showed significant responses both on soil reaction and exchangeable aluminum, while Inceptisols Jatinangor showed insignificant responses on that soil reaction and exchangeable aluminum. It concluded that liming process unable applied effectively on the whole soil order due to it relation with the level of soil acidity.

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Socioeconomic factors associated with the use of clean energy for cooking in informal settlements of Kigali City, Rwanda

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Abstract— *Energy plays a vital role in human life as it serves in many different activities such as heating, cooking, transportation and lightingetc. This research aimed to determine household's socio-economic factors associated with energy choice in informal settlements of Kigali city, Rwanda. The research was conducted in three sectors namely Gatenga located in Kicukiro district, Kimisagara located in Nyarugenge district and Kimironko in Gasabo district. Cluster sampling technique has been adopted to categorize the study area into different residential zones on the basis of socio-economic status where a sample of 107 participated in the research.*

Chi-square test and Cramer's V statistics was used to test the correlation between the household's socio-economic factors and choice of energy. The research findings confirmed that most dominant energy type used for cooking in the study area ischarcoal which is non-clean energy. Also, family size and monthly income of the household influenced the choice of energy type used for cooking in informal settlement of Kigali City.

Keywords— Socio-economic factors, clean energy, informal settlements.

I. INTRODUCTION

Globally 2.5 Million people depend on biomass such as agriculture waste, fuel wood, chacoal and animal dung to meet their energy needs, these resources account for 90% of energy consumption in many developing countries (Kanagawaand Nakata, 2007). In developing countries 52% of the population depends on biomass as a primary fuel for cooking, this proportion of population depending on biomass is highest in sub-Saharan Africa(IEA, 2006).

In east Africa countries, energy is typified by high levels of reliance on biomass coupled with low levels of electricity consumption. Charcoal and bio-fuels/waste, a classification that encompasses traditional biomass like wood and crop residues for cooking and heating, is the source of 65% of the total final energy consumption in Kenya and 93% in Burundi(EACREE, 2018).

According to the Rwanda Energy Policy and Strategy of 2011, biomass dominate energy usage with the rate of 85% which coming from directly used wood (57%), wood converted into charcoal (23%) and crop waste and other agriculture residue with rate of 5% (NISR, 2012). Firewood is still the source of fuel used for cooking by the vast majority of the rural population at the rate of 93% in 2017. In the urban areas, charcoal is used by 65% of households, followed by firewood 26%. While rural households have not changed the source of fuels they used for cooking in the last three years, a small change can be observed in the urban areas shifting from firewood 29% to 26% and charcoal 68% to 65% towards gas use 1% to 5% in 2014 and 2017 respectively (EICV5, 2018).

The research intended to assess socioeconomic factors associated with the use of clean energy for cooking in informal settlement of Kigali City and specificallyundertaken with the following objectives:

- To evaluate different types of clean energy used for cooking in informal settlement of Kigali city
- To find out socioeconomic factors that influence the selection of used energy for cooking in informal settlement of Kigali city.

This research project was carried out in three districts of the City of Kigali namely Kicukiro, Gasabo and Nyarugenge especially some villages with informal settlement. The study area was selected based population density. The area in which the study was conducted are Gashyekero located in Gatenga sector of Kicukiro District, Rukurazo located in Kimironko sector of Gasabo District and Amahumbezi located in Kimisagara Sector of Nyarugenge District. This research was carried

out within a period of seven months period from June to December 2019 which includes data collection, data analysis, report writing and presentation of research findings.

II. MATERIALS AND METHODS

2.1 Study Population

This research was conducted in three sectors of Kigali, one in each district based on population density per sector and the most densely populated sector of each District will be selected. As each sector of Kigali city present a number of households living in urban conditions and other part of households living in settlement, study population was selected based on inhabitants per square meter of sector but sample was selected in cells which present the highest informal settlement within the study population.

The research population is 1647 households distributed in Rukurazo inhabited by 496 households, Amahumbezi inhabited by 538 households and Gashyekero inhabited by 613. Generally, the study area represents the most densely populated sector in each District.

2.2 Sample size

A sample of household was selected within study population and the sample size was calculated based on the number of households present in each of three settlements which constitute the study population. Number of households interviewed was selected randomly within strata. The sample size was determined by Nassiuma formula (Nassiuma, 2000);

$$\text{Sample size } (n) = (NCv^2) / [Cv^2 + (N-1)\, e^2 \quad (1)$$

Where:

N = Number of population

CV = Coefficient of Variation (0.5)

e = Tolerance at desired level of confidence (0.05) at 95% confidence level

Therefore, $n = 1647\ (0.5^2) / [0.5^2 + (1646)\ 0.05^2] = 107.3 \sim 108$

By applying Nassiuma formula and contingency, the sample size of this research was equal to 108 households of three informal settlements Kigali city where 32 households was selected in Rukurazo settlement of Kimironko sector 40 was selected in Gashyekero settlement of Gatenga Sector and 36 households was selected in Amahumbezi settlement located in Kimisagara sector.

2.3 Data collection and analysis

All data collected from the field were transcribed by converting all data into textual form. Quantitative data from the questionnaires and the interview checklist checked for data integrity,completeness and consistency before entry and subsequent analysis then entered in SPSS(Statistical package for Social Sciences) 16.0 for analysis.Analysis of chi-square test and p value as a statistical technique were calculated to show difference between two or more variables to test the significance. The chi square test was performed by comparing two types of variablesand as well as the variation within each of the samples.

III. RESULTS AND DISCUSSIONS

3.1 Summary of findings from the research

The table 1 show that the research was conducted in households headed by medium generation ranged between 36-45 years old at the rate of 34.6%. In terms of marital status, 69.2% of visited households were married and only 1.9% were divorced. Also, the research found that 55.1% of visited households composed by 3 to 5 persons and only 1.9% of visited households composed by more than 8 members. The research found that 40.2% of visited households earn less than 50,000 FRW per month and only 0.9% earn more than 200,000 FRW per month. Results from this research confirm that most of households live in informal settlements are generally poor.

TABLE 1
SUMMARY OF FINDINGS FROM THE RESEARCH

Item	Data					
Age	**Class (years)**	25-35	36-45	46-55	56-65	Above 65
	Result (%)	17.8	34.6	29.9	11.2	6.5
Marital Status	**Category**	Single	Married	Divorced	Widowed	Separated
	Result (%)	5.6	69.2	1.9	17.8	5.6
Size of HH	**Class (#)**	Less than 3	3-5	6-8	More than 8	
	Result (%)	15.9	55.1	27.1	1.9	
HH Monthly income	**Class (FRW)**	Less than 50,000	50,001-100,000	100,001-200,000	Above 200,000	
	Result (%)	40, 2	31,8	27.1	0.9	

3.2 Energy types used in informal settlements of Kigali City

The type of energy used for cooking in the studies areas are firewood, charcoal and gas where charcoal was dominant energy with 77.6% followed by gas with 20.6% while very few of the respondents used firewood with 1.9% as indicated by figure1. Among the respondents, no household found using solar, biogas and electricity as the household income for the studied areas cannot afford their cost. These research findings are similar to the Ndolo's findings, where they have found that most of cooking energy used was charcoal in Gatwekera of Kibera, Nairobi City of Kenya(Ndolo, 2014).

TABLE 2
TYPE OF ENERGY USE FOR COOKING

Type of Energy for cooking	Frequency	Percent
Firewood	2	1.9
Charcoal	83	77.6
Gas	22	20.6
Total	107	100.0

3.3 Social Economic factors influence the use of Energy for Cooking

3.3.1 Factor 1: The size of family Vs type of energy use for cooking

The research resulted that LPG which is clean is using by family composed by less than 6 members. This confirm that the size of family influence the choice of energy use for cooking. These research findings are similar to the Ndolo's findings, where they have found that, size of the households is one of social factors that influence the choice of cooking energy type (Ndolo, 2014).

TABLE 3
THE SIZE OF FAMILY VS TYPE OF ENERGY USE FOR COOKING

Type of Energy		Firewood		Charcoal		Gas	
		Count	Percent	Count	Percent	Count	Percent
Size of Family	Less than 3 people	2	100	8	9.7	7	31.8
	Between 3 to 5 people	0	0	44	53	15	68.2
	Between 6 to 8 people	0	0	29	34.9	0	0
	More than 8 people	0	0	2	2.4	0	0
Total		2	100	83	100	22	100

3.3.2 Factor 2: Monthly income of the household Vs type of energy use for cooking

The survey showed that a big number of households that use charcoal as cooking energy are those who earn the monthly income up to 200,000 FRW. Firewood is used in the families earning monthly income less than 100,000 FRW while gas is only used by the families earning monthly income more than 100,000 FRW.

The selection of energy type for cooking depends on monthly income due to other factors related to the required infrastructure, equipment and materials. Many households choose charcoal (77.6%) for cooking as it does not require appropriate infrastructure and specified equipment and materials compared to the requirements needed for clean energy use. The initial cost for gas is higher compared to the firewood and charcoal ones. The families earning monthly income less than100, 000 Rwandan francs are not able to afford the initial cost of clean energy. Thesehave also been found in Kenya by Ndolo and Nyankone and Waithera where the researchers found that the household income generation, cost of energy and monthly expenses contribute to the choice of cooking energy type (Ndolo, 2014) and (Nyankone and Waithera, 2016). This research findings showed that households which earn monthly income more than 100,000 Rwandan Francs can easily afford gas compared with what Ndolo found in Kibera which is around 15,000 Kenyan shillings monthly income.

TABLE 4
MONTHLY INCOME OF THE HOUSEHOLD VS TYPE OF ENERGY USE FOR COOKING

Type of Energy		Firewood		Charcoal		Gas	
		Count	Percent	Count	Percent	Count	Percent
Monthly Income (FRW)	Less than 50,000	1	50	42	50.6	0	0
	Between 50,001-100,000	1	50	33	39.7	0	0
	Between 100,001-200,000	0	0	8	9.7	21	95.4
	Between 200,001-300,000	0	0	0	0	1	4.6
Total		2	100	83	100	22	100

3.3.3 Factor 3: Monthly cost for cooking energy

The research shows that the family with high income has a choice of different energy type which includes clean energy. It was resulted that charcoal is more expensive than LPG but visited households confirmed that initial cost for LPG infrastructure limit them to use clean energy for cooking. These results showed the similarity with Kiyawa and Yakubu which confirm that the choice of energy was influenced by the household's income and the family size where families with large size and those with low income tend to use charcoal which is none clean energy for cooking and the families with small size tend to use gas which is considered as clean energy except the families who earned the monthly income less than 100000 Rwandan francs (Kiyawa and Yakubu, 2017).

TABLE 5
MONTHLY COST FOR COOKING ENERGY

Type of Energy		Firewood		Charcoal		Gas	
		Count	Percent	Count	Percent	Count	Percent
Cost of cooking Energy per month	Between 5,001-10,000	2	100	6	7.2	0	0
	Between 10,001-15,000	0	0	8	9.7	1	4.6
	Between 15,001-20,000	0	0	42	50.6	19	86.4
	Between 20,000-30,000	0	0	27	32.5	2	9
Total		2	100	83	100	22	100

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusion

The research findings showed that the choice of type of energy used for cooking in informal settlements of Kigali City is influenced by family size and monthly income of the household. The research findings confirmed that clean energy use in informal settlements of Kigali city is used to a small extent where dominant type energy used for cooking is charcoal; this is due to its accessibility and affordability. Even if charcoal is most used energy type for cooking in informal settlements of

Kigali City, charcoal is very expensive than LPG on monthly basis but 77.6% people prefer to use charcoal as they can buy a small basket of charcoal to cook one meal which is different from buying a cylinder of LPG at one moment.

4.2 Recommendations

To address challenges associated with the use of clean energy use in informal settlements of Kigali City, some recommendations were proposed as follow:

- To reduce or remove taxes for LPG traders;
- To mobilize National Environmental found to support poor family in regards with clean cooking energy especially for the first installation;
- The Government can work closely with financial institutions to provide loans with low interest for clean energy equipment
- Households living in informal settlements are requested to save money for longtime that help them to get clean energy initial cost

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Effect of Different Sources of Nutrient on Growth and Yield of Okra (Abelmoschus esculentus L. Monech)

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Abstract**—** *The experiment was carried out at Nepal Polytechnic Institute field, Bharatpur, Chitwan, Nepal to study the effect of different nutrient sources on growth and yield of okra (Abelmoschus esculentus L Monech). Five different treatments; poultry manure, FYM, goat manure, chemical (as per N equivalent) and no fertilizer (control) were replicated four times. The experiment was arranged in Randomize Complete Block Design (RCBD). The okra variety ArkaAnamika was used for experiment. The data were collected on the growth and yield parameters including plant height (cm), canopy (cm), numbers of leaves per plant, numbers of branches per plant, fruit length, diameter and yield. Results indicated that different nutrient sources had significant (P<0.05) affected on plant height, canopy, leaf number, branches and also in yield parameters. Based on the findings of the experiments, it can be concluded that application of poultry manure significantly increased the growth and yield performances on Abelmoschus esculentus L. Monech (okra) compared to other types of fertilizers. As the study reflected the use of no fertilizer results in the lowest vegetative growth and yield performances which indicates to use some nutrient sources for better growth and production of okra.*

Keywords**—** ***fertilizer, okra, growth, yield.***

I. INTRODUCTION

Okra, *Abelmoschusesculentus* L. Monech is a popular vegetable in tropic and countries of the world grown for its pod (Folorunso & Ojeniyi, 2003). It is a member of the hibiscus family, Malvaceae and has the typical floral characteristics of that family. It is originated from tropical Africa and was first cultivated in Egypt in 12thcentury (Maurya et al., 2013). The okra plant requires warm temperatures and is unable to withstand low temperature for long or tolerate any threat of frost. Optimum temperature is in the range of 21 to 30 degrees Celsius, with minimum and maximum temperatures of 18 degrees Celsius and maximum 35 degrees Celsius respectively.

Vegetables and vegetables based cropping systems show those vegetable crops are well responsive to nutrient supply through organic manures and chemical fertilizers (Kale et al., 1991) . Soil nutrient level gets decreased over time when crop plants get harvested, and these nutrients get replenished either through natural decomposition process or by adding fertilizers. Hence fertilization is an essential component of modern agriculture. Fertilizers provide different nutrients, one of them are the main macronutrients i.e. nitrogen (N), phosphorus (P), potassium (K), second are three secondary macronutrients i.e. calcium (Ca), magnesium (Mg) and sulfur (S), others are micronutrients. Today fertilizer has become essential to modern agriculture to feed the growing population. Use of fertilizers, especially, the chemical fertilizers has brought in blessings to humanity, which helped contain hunger and death in different corners of the world. However, the use of inorganic fertilizers alone may cause problems for human health and the environment (Arisha & Bradisi, 1999).

In recent year use of organic manures like FYM, poultry manure, goat manure is gaining prominence. The organic manuring has positive effect on soil texture and water holding capacity (Kale et al., 1991).It also provides food for soil micro-organisms. This increases the activity of microbes which in turn helps to convert unavailable plant nutrient to available form. Organic manure generally ameliorates the entire soil physical, chemical and biological properties of the soil as it energies the activities of soil microbes, which help in the liberation of plant nutrients and the healthy growth of the plants. Organic manure has also been found to sustain yield under continuous cropping and improve the fertility of a degraded soil (Eghareyba & Ogbe, 2002).

II. MATERIALS AND METHODS

2.1 Experimental site

The experiment was carried out at Nepal Polytechnic Institute field, Bharatpur-11, Bhojad, Chitwan, Nepal from April to June, 2019.The climate of the experiment site is sub-tropical. During summer the temperature may go as high as 40^0C while in winter, it may fall as low as 6-10^0C. Rainy season start from June and continue up to September, June-July receives highest rainfall (up to 150mm).

2.2 Experimental design

The experiment was arranged in Randomized Complete Block Design (RCBD) of five treatment replicate four times. Seeds were planted at a spacing of 50cm (R × R) and 30cm (P × P) and two seeds were put per hole and later were thinned to one seedling after their germination. There were four rows with six plants per row and a total of 24plants were accommodated in each plot. The area of each plot is 1.8m × 2m whereas the experimental area was 10.2m × 13m. Similarly, spacing of 50cm was maintained between the plots and also 50cm in between blocks was maintained.

2.3 Agronomic practices

The land was ploughed and harrowed to bring to fine tilth and leveling was done at Nepal Polytechnic Institute field. The test crop was ArkaAnamika which was obtained from Sahayogiagrovet. The seeds were soaked a night before planting to aid quick germination. Seeds were sown at the recommended spacing of 30cm apart on a row at a depth of 2cm with two seed per hole which was later thinned to one at the first weeding done after 15 days of sowing. Weeding was conducted manually at 15DAS and 35DAS in order to reduce weed competition. Harvesting was carried out after two months from sowing by hand picking of the fresh pods.

TABLE 1
TREATMENTS USED FOR EXPERIMENT

S.N	Treatments	Notations	Manure applied (kg/plot)
1	Poultry Manure	T1	10
2	Farm Yard Manure	T2	28.8
3	Urea + SSP + MOP	T3	0.15652 + 0.4065 + 0.036
4	Control	T4	
5	Goat Manure	T5	10

2.4 Measurement of data

To measure growth parameters, four plants were selected, one from each row to study the different parameters. Plant height was measured from base of the plant to its tip. It was measured from 25DAS to 55DAS.Plant canopy was measured by using meter scale and measured by taking diameter of canopy across two axes, after which mean was taken. The number of leaves was measured by counting fully opened leaves. Numbers of branches per plant were counted from 40 days from sowing till 55DAS at 15days interval.

To measure yield parameters plants from the middle rows were selected. Fruit diameter was measured from six plant selected randomly. It was measured with vernier caliper. The fruit length was measured by the help of measuring scale at harvesting. Fruit yield was recorded from the middle rows at three days interval. The obtained fruits were weighed with the help of weighing balance. The recorded data were then summed and expressed in tons/ha.

2.5 Statistical analysis

The recorded data was systematically arranged in Microsoft excel, which was used for simple statistical analysis, constructing graph and tables. The compiled data were subjected to Analysis of Variance (ANOVA) using Gen-Stat 15th edition. ANOVA was constructed and significant data were subjected to Duncan Multiple Range Test (DMRT) for mean separation with reference to Gomez and Gomez (1984).

III. RESULTS AND DISCUSSION

3.1 Effect of different nutrient sources on plant height:

The results obtained from the experiment are analyzed and presented in this section. The height of the plant was significantly influenced by the different nutrient sources at 25, 40 and 55 DAS. At 55 DAS the highest plant height was found in poultry manure (76.44 cm) which was significantly at par with the chemical (68.5cm) and goat manure (65.5cm). The significantly lowest height was found in controlled (36.9 cm). Okra grown on poultry manure performed better in terms of height of the plant. This shows that poultry manure was readily available and in the best form for easy absorption by the plant roots, hence there was a boost in morphological growth of the plant. The result corroborated with the findings of (Ajari et al., 2003) in okra production in which they reported that organic manures especially poultry manure could increase plant height of crops when compared with other source of manure.

TABLE 2
EFFECT OF DIFFERENT NUTRIENT SOURCES ON PLANT HEIGHT

Treatment	Plant height		
	25 DAS	40 DAS	55 DAS
Poultry manure	18.38[a]	46.8[a]	76.44[a]
Chemical	17.50[a]	41.4[ab]	68.5[ab]
Goat manure	15.06[b]	38.6[b]	65.50[ab]
FYM	14.25[b]	33.8[c]	56.94[ab]
Control	12.50[b]	24.5[c]	36.94[c]
SEM(±)	0.548	2.39	3.82
LSD(0.05)	1.688	7.36	11.76
CV%	7.1	12.9	12.5
Grand mean	15.54	37	60.9
Significance level	**	**	**

3.2 Effect of different nutrient sources on plant canopy

The plant canopy was significantly influenced by different nutrient sources at 25, 40 and 55DAS. At 55DAS the maximum mean canopy was found in poultry (79.2cm) which was statistically at par with chemical (69cm). The significantly minimum leaf canopy was found in controlled (43.4cm). The leaf canopy of goat manure was intermediate (67.4cm) which was statistically at par with FYM (60.9cm). The finding was supported by the results of (Ufera et al., 2013) who stated that the maximum leaf canopy was produced by the application of poultry manure. The effect of poultry manure enhanced the vegetative growth of okra (Alphonse & Saad, 2000) which might be due to having more nutrient content, rapid mineralization, optimum C/N ratio, growth promoting substances leading to better growth. These results are agreement with findings of (Makindae & Ayoola, 2012).

TABLE 3
EFFECT OF DIFFERENT NUTRIENT SOURCES ON PLANT CANOPY

Treatments	Canopy		
	25DAS	40DAS	55DAS
Poultry manure	21.50[a]	51.44[a]	79.2[a]
FYM	19.50[ab]	47.38[a]	69[ab]
Chemical	16.62[bc]	37.50[b]	67.4[b]
Control	14.94[c]	30.62[c]	60.9[b]
Goat manure	17.50[bc]	45.38[a]	43.4[c]
SEM(±)	0.905	2.217	3.33
LSD(0.05)	2.789	6.832	10.25
CV%	10.1	10.4	10.4
Grand mean	18.01	42.46	64
Significance level	**	**	**

3.3 Effect of different nutrient sources on number of leaves

Number of leaves was significantly influenced by different nutrient sources at 25, 40 and 55DAS. At 55DAS the maximum number of leaves per plant was found in poultry manure (40.62). The significantly minimum number of leaves per plant was recorded in control (17.1). The number of leaves per plant for chemical was intermediate (35) which was statistically at par with goat manure (33.94) and FYM (30).Reports from (Akanbi et al., 2000) stated that nutrient availability especially nitrogen determine plant vegetative growth. The increase of number of leaves per plant with organic fertilizer application stressed its importance during growth of plant (Tindall, 1992).

TABLE 4
EFFECT OF DIFFERENT NUTRIENT SOURCES ON NUMBER OF LEAVES

Treatments	Number of leaves		
	25DAS	40DAS	55DAS
Poultry manure	7.44[a]	19.75[a]	40.62[ab]
Chemical	7.00[a]	17.06[b]	35[b]
Goat manure	6.87[a]	16.00[b]	33.94[b]
FYM	6.68[ab]	15.44[b]	30[b]
Control	6.06[b]	9.56[c]	17.1[c]
SEM(±)	0.261	0.821	1.707
LSD(0.05)	0.804	2.530	5.260
CV%	7.6	10.6	10.8
Grand mean	6.86	15.56	31.49
Significance level	*	**	**

3.4 Effect of different sources of nutrient on number of branches

The numbers of branches were significantly influenced by different nutrient sources at40 and 55 DAS. At 55 DAS the maximum numbers of branches were found in poultry manure (4.06) which was statistically at par with chemical (3.44), goat manure (3.31) and FYM (3.19). The lowest numbers of branches were recorded in control (1.81). The application of poultry manure recorded the highest number of branches (Onwu et al., 2014). Similar results had been found by Nweke et al. (2013) who showed that poultry manure recorded the highest value in number of branches per plant i.e. 4.67 in okra and was significantly different from other treatments viz. goat manure, pig manure and control treatment.

TABLE 5
EFFECT OF DIFFERENT SOURCES OF NUTRIENT ON NUMBER OF BRANCHES

Treatments	Number of branches	
	40DAS	55DAS
Poultry manure	3.31[a]	4.06[a]
FYM	3.00[a]	3.25[a]
Chemical	3.12[a]	3.38[a]
Control	1.19[b]	1.62[b]
Goat manure	3.56[a]	3.75[a]
SEM(±)	**0.344**	**0.368**
LSD(0.05)	**1.059**	**1.133**
CV%	**24.2**	**22.9**
Grand mean	**2.84**	**3.21**
Significance level	**	**

3.5 Effect of different nutrient sources on fruit length

The fruit length was significantly influenced by the application of different nutrient sources. The highest fruit length was found in poultry manure (19.94cm) which was statistically at par with chemical (19.23) and goat manure (18.81). The lowest fruit length was observed in control (14.64). This agrees with the study of (John et al., 2004) who reported that PM contains essential nutrients which are associated with higher photosynthesis activities that promotes root and vegetable growth. Poultry outperformed NPK for all the reproductive traits measured. This agrees with the work of (Dauda et al., 2008).

TABLE 6
EFFECT OF DIFFERENT NUTRIENT SOURCES ON FRUIT LENGTH

Treatment	Fruit Length
Poultry manure	19.94[a]
Chemical	19.23[a]
Goat manure	18.81[a]
FYM	17.224[b]
Control	14.64[c]
SEM(±)	0.493
LSD(0.05)	1.520
CV%	5.5
Grand mean	17.97
Significance level	**

3.6 Effect of different nutrient sources on fruit diameter

The fruit diameter was significantly influenced by different sources of nutrient. The maximum fruit diameter was found in poultry manure (2.13). The significantly minimum fruit diameter was recorded in control (1.97cm). This agrees with the study of (John et al., 2004) who reported that PM contains essential nutrients which are associated with higher photosynthesis activities that promotes root and vegetable growth. Poultry outperformed NPK for all the reproductive traits measured. This agrees with the work of (Dauda et al., 2008).

TABLE 7
EFFECT OF DIFFERENT NUTRIENT SOURCES ON FRUIT DIAMETER

Treatment	Fruit Diameter
Poultry manure	2.13[a]
Chemical	2.00[b]
Goat manure	1.99[b]
FYM	1.94[b]
Control	1.79[c]
SEM(±)	0.0387
LSD(0.05)	0.1193
CV%	3.9
Grand mean	1.97
Significance level	**

3.7 Effect of different nutrient sources on fruit yield

The maximum yield was recorded in poultry manure (14.91 tn/ha) which was statistically at par with chemical (12.78 tn/ha) and goat manure (12.74 tn/ha) whereas the significantly minimum yield was recorded in control (7.03 tn/ha). The results obtain were in with the findings of (Premshekar & Rajashree, 2009) in which they reported that higher yield response of crops due to organic manure application could be attributed to improved physical and biological properties of the soil resulting in better supply of nutrients to the plants.

TABLE 8
EFFECT OF DIFFERENT NUTRIENT SOURCES ON FRUIT YIELD

Treatment	Fruit yield (tn/ha)
Poultry manure	14.91[a]
Chemical	12.78[ab]
Goat manure	12.74[ab]
FYM	10.44[b]
Control	7.03[c]
SEM(±)	1.408
LSD(0.05)	3.068
CV%	17.2
Grand mean	11.58
Significance level	**

IV. CONCLUSION

The research was carried out to evaluate the effect of different sources of nutrient on growth and yield of okra. The application of poultry manure, FYM, chemical and goat manure had a significant effect on growth and yield of ArkaAnamika variety of okra. Poultry manure produced maximum plant height (76.4cm), fruit length (19.94cm), fruit diameter (2.13cm) as well as fruit yield (14.91 tn/ha) in okra among all other nutrient sources. The results obtained revealed that okra responded well to the application of poultry manure compared to other different fertilizers and control treatment in the study. Therefore poultry manure could be used as the good organic nutrient source for increasing the productivity of the okra among different fertilizers.

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An exploratory study on farmer's vernacular knowledge about the land characteristics, soil quality and crop suitability in Lower Ganga Flood Plain: Bangladesh Perspective

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Abstract— *Local people and small scale farmer had a broad understanding of their land characteristics and soil quality to choose crop. Though Maximum farmers in our country are illiterate and little educated; they have no enough scientific knowledge about land type, soil quality and crop suitability. But they possess vast indigenous knowledge by living in a same environment for a long period of time. They have developed some strategies that helped them to attain a higher degree of satisfaction in farming. So therefore it is very important to explore the farmer's vernacular knowledge about the land type, soil quality and crop suitability. To address this indigenous knowledge this study investigates the farmer's vernacular knowledge about the land type, soil quality and crop suitability in Lower Ganga Flood Plain in Bangladesh. The information was collected from one Mouza in Nagarkanda upazila, Faridpur district Lower Ganga Flood Plain in Bangladesh. Qualitative and quantitative both data were used in this study. The data were collected from primary sources (such as questionnaire survey, FGD) and secondary data sources (such as books, journals, and published and unpublished research reports). Data were analyzed by exploratory statistics. Graphs and graph tables were created by MS excel. By analyzing the Field data it was investigated that farmers of the study area recognized four elevation levels of land; i). High Land (Vitta) ii). Medium Land (Taner Jomi) iii). Low Land (Nall/Dhop) iv).Very Low (Beel) based on its elevation, flood depth, land use, and crop suitability. The farmers of the study area possess considerable knowledge of the soils quality, moisture conditions of that area. The farmers of the study area distinguish soil into three categories primarily on the basis of color, texture, organic matter content, drainage, and fertility of soils. They use indigenous methods such as visual observation while color, tasting by tongue, feeling, vegetation cover and rubbing with fingers to determine various soil properties. Thus Farmers' knowledge of soils is, therefore, a vast resource we summarized in this paper.*

Keywords— Agriculture, Crop suitability, Farmer, Local Knowledge, Land, Soil.

I. INTRODUCTION

Bangladesh is one of the most densely populated countries in the world with an area of 147,570 sq. kilometers. The economy of Bangladesh primarily is dependent on agriculture [6]. To meet the increasing demand of growing population crop field is used intensively where farm characteristics, soil quality are the main prerequisites for sustainable crop production. The success of maintaining or enhancing land, soil quality and crop suitability depends on our understanding of how the soil responds to agricultural land use and crop pattern. Concern about land type, soil quality and are not limited to agricultural scientists, natural resource managers, and policymakers, but also farmers have a vested interest in land type soil quality crop suitability [1]. Local or indigenous cultures and people hold significant knowledge of soils, land and crop suitability, attained by experience and testing through many generations of living close to the land [10]. The environmental knowledge embedded in local cultures provides a long-term perspective on land use and management not otherwise available. The long-term experience of local cultures with resource use and management, including successes and failures, is embodied in local cultures and can help in evaluating land use in relation to soil quality and sustainable agriculture. (Sandor, 2002). Local soil knowledge is clearly a cross or mix between knowledge and practice, and the two are frequently difficult to separate. A better understanding of the diversity among the farmer's local knowledge of land, soil management and crop suitability is essential to formulate a sustainable national agricultural development policy [2].

Historically, agricultural researchers and policymakers of Bangladesh have neither recognized the importance of farmers' local knowledge of soil management nor integrated them in farming systems research. Therefore, the potential contribution of such a vast resource to achieve sustainability of the country's farming systems remained untapped, and the agricultural researchers have not been very successful in developing a sustainable farming system that is suitable for different environmental conditions. Farmers possess vast knowledge of local soils and land management, and practice multiple cropping under different environmental conditions [2]. The challenge for researchers is to investigate farmer's indigenous knowledge about land characteristics and soil quality for crop suitability to achieve high production.

Several participatory approaches have been developed to involve farmers in an interdisciplinary approach to agricultural research. These give greater attention to actual farming practices, farmers' needs and farmers' knowledge. Although many studies have investigated the indigenous knowledge of farmers to improve agricultural sustainability, but there were no in-depth investigation in lower Ganga flood plain in Bangladesh. This study attempt to explore the farmer's vernacular knowledge about the land characteristics, soil quality and crop suitability in Nagarkanda Upazila (Lower Ganga Flood Plain) in Bangladesh.

II. LOCATION OF THE STUDY AREA

The study was conducted in four villages of Nagarkanda Upazila of Faridpur district in Lower Ganga Flood Plain in Bangladesh. The latitudinal extension of the study site is from 23°19´ North to 23°24´ North and longitudinally it stretches from 89°43´ East to 89°56´ East (Figure 1). Nagarkanda Upazila (Faridpur district) with an area of 379.02 sq km, is bounded by Faridpur sadar and char Bhadrasan upazilas on the north, Muksudpur and Boalmari upazilas on the south, Bhanga and Sadarpur upazilas on the east, Char Bhadrasan upazila on the northeast and Boalmariupazila on the west [19]. My study area is consisted of 17 union parishad. Data were collected from four villages (Boronaudubi, Poradia bazar, Suturkanda and Balia) of kachail union. In that area about 80% people depends on agriculture. The whole area of the study site is plain land and lies in the recent flood plain physiographic unit of Bangladesh. Total land area of my study area is 15444 acres. And here high land is 1403 acres which remain 9% of the total area, medium land is11938 acres and it occupies 77% of the total area which indicates that the study area is a medium high land dominated flood plain area .The low land of my study area is 2103 acres (14%) of the total area [6].

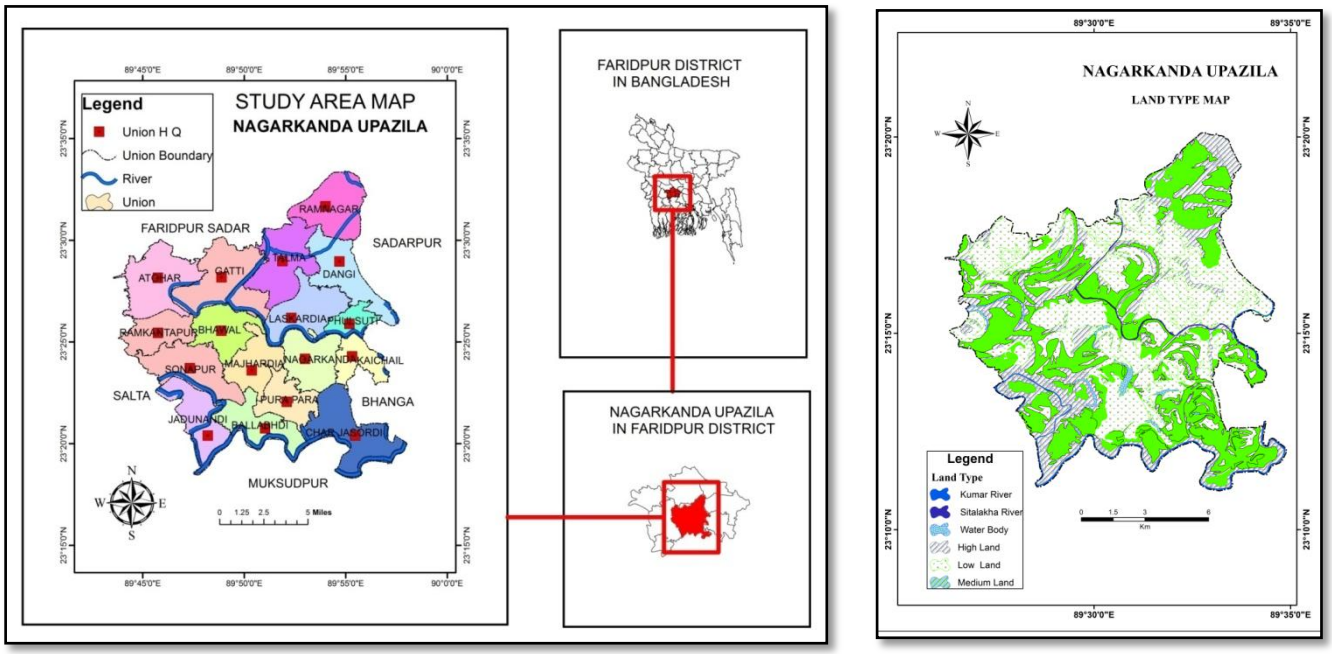

FIGURE 1: Location, Land type of the study Area
Sources: SRDI Report, 1999, complied map by author

Two main river Kumar and Shitalaka flow through this area and causing flood during the rainy season**.** Soils of this region are silt loams and silty clay loams on the ridges and silty clay loam to heavy clays on lower sites. General soil types predominantly include calcareous dark grey and calcareous brown floodplain soils. Annual average temperature varies from maximum 35.8c to minimum 12.6c and annual rainfall is 1546 mm [19].

III. DATA AND METHODOLOGY FOR STUDY

Farmer's local knowledge about land type of area are the main sources of information for this research. In addition, the research utilizes different types of secondary data, including land type of Bangladesh, land type of the study area, land characteristics, floodibility of land; crop suitability etc. information are obtained from different secondary sources. A detail in-depth Questionnaires were finalized to collected the field data. Observation techniques were also adopted to understand the farmer knowledge about the land type. Focus group discussions were conducted with the farmers to know about cropping patterns, land type and soil quality for cultivation. Firstly, the Upazila Nagarkanda, Faridpur were selected where maximum people are directly and indirectly involved in agriculture. A total of 100 farmers' were selected from 4 villages (4 villages

from). From each of a village 20-30 farmers' were sampled and data were collected for the study. Among the selected farmers, there were mixed groups of marginal, poor farmers and day laborers different age. The local knowledge about their agriculture is known from them through focus group discussions, in this regard key informants' were interviewed. Besides, local govt. (UP-Chairman & members) and officials (AEO) were also interviewed. Questionnaires were finalized after field test. Observation techniques were also adopted to understand the farmer's local knowledge about the land type. Focus group discussions were conducted with the farmers to know about cropping patterns, land type and soil quality for cultivation. Their thinking about the problems they face in cultivation and the way they are planning for solution of their problems were also addressed in this study. Data were collected from rice and non-rice crops growing farmers of the villages using questionnaire. There are many secondary data sources that are collected from various books, articles, thesis, reports and news article. The collected data was manually coded according to the objective of the study. All the collected data were summarized and scrutinized carefully. Data were analyzed by exploratory statistics. Graphs and graph tables were created by MS excel.

IV. RESULTS AND DISCUSSION

4.1 Land Type of Study Area

Nagarkanda Upazila (Faridpur district) lies in lower Ganges River Floodplain region which comprises the eastern half of the Ganges river floodplain. The land is low-lying and the area has a typical meander floodplain landscape of broad ridges and basins [19]. Whole area is a medium high land area which is most suitable for agriculture.

TABLE 1
LAND USE AND LAND CONTROL OF THE STUDY AREA

Cultivable land 92%	Percentage of land	Land control: Among the peasants	Percentage of peasants
Single crop	30%,	Landless	35%
Double crop	60%	Small	30%
Treble crop	10%;	Intermediate	25%
land under irrigation	80%.	rich	10%

Sources: BBS, District Statistics (2011).

4.2 Farmer's indigenous knowledge about land evaluation

Adequate knowledge of land elevation is required to make land use decisions. From interviews and group discussions, it appears that farmers of these villages possess considerable knowledge of the village land type, climate condition, cropping pattern. Though they have no scientific knowledge but they have much local and practical knowledge about land type, soil quality and crops suitability. They got this knowledge by living in this village environment for some period of time. This Local knowledge is very important for the agriculture of our country. All farmers recognized the occurrence, duration, and possible impacts of floods caused by high monsoon rainfall. The farmers of the study site consider the land elevation, floodibility, and land use pattern, to classify land categories. Farmers recognized four elevation levels; i).High Land (Vitta); ii).Medium Land (Taner Jomi); iii).Low Land (Nall/Dhop); iv).Very Low (Beel); in reference to Flood depth, elevation from river bank.

TABLE 2
FARMERS' CLASSIFICATION OF LAND BASED ON ELEVATION, FLOODIBILITY AND LAND USES

Local name	SRDI name	Amount of land	Floodibility by flood types	Flood depth	Land use
Vitta	High Land	1403 (9%)	Flood free	Flood free	Rural settlement, gardening, livestock farming, manmade forest
Taner Jomi	Medium Land	11938(77%)	inundated for 2/3 months	highest 180cm (6feet)	robi crop (Rice, onion,garlic Wheat) and kharip(jute).
Nall/Dhop	Low Land	1503(10%)	inundated 5/6 months	180cm to 275cm (6feet-9feet)	Ropa aman, mixed aush, fish pond
Beel	Very Low Land	600 (4%)	inundated 9/10 months	more than 275cm (9feet)	Bona aman, fish pond

Source: Field survey, 2015

The high land locally called Vitta, is relatively high land from the riverbanks and cannot hold waters during monsoon. It extends 1403 acres (9%) area of the study site. These land mainly used for rural settlement, livestock farming, gardening, and

manmade forest. The high land (vitta) is also used in agriculture purpose where three crops are cultivated in a year by irrigation. This land is most suitable for cultivating sugarcane, Banana, and different types of fruit. Next, elevation level is medium land which locally called Taner Jomi. Taner Jomi occupies 11938 acres (77%) area, are frequently flooded up to 180cm (6feet). This land mainly used as cropland (khet) and sometimes it remains fallow (patitha). This land is inundated for 2/3 months in the rainy season. So two crops are cultivated in a year in this land which is robi crop (Rice, onion Wheat) and kharip (jute).).The third level, dhop/nallis the low land covers 1503 acres (10%) area. And in the dhop land which is inundated 5/6 months in a year and flood depth extends180cm to 275cm (6feet-9feet) during the monsoon season. Only one crop (Ropa aman) is cultivated here in a year. Beel that occupies 600 acres or 4% of the study site is regularly flooded and this land is used to cultivate Bona aman, fish farming. Human-induced changes in land levels are prominent in that village. Over the years farmer migrate rice cultivation to fish farming. They dig so many (dighi) large ponds in the crop land for fish farming.

4.3 Soil of Nagarkanda Upazila

Soils of this region are silt loams and silty clay loams on the ridges and silty clay loam to heavy clays on lower sites. General soil types predominantly include calcareous dark grey and calcareous brown floodplain soils [19]. Organic matter content is low in ridges and moderate in the basins. General fertility level is medium. According to this sense Nagarkanda Upazila is a develop area by its Soil and land quality. According to SRDI Nagarkanda Upazila was divided into nine categories according to its land Type, soil quality and possibility of agriculture development. Broad soil classification of Nagarkanda Upazila in 2008 is shown in (table: 3) and figure (3).

TABLE 3
SOIL TYPES OF NAGARKANDA UPAZILA

Lower ganga Flood Plain-12				
S. No:	**Soil Name**	**Area**	**(%) of area**	**Soil Group**
1	Lower ganga Alluvium Soil-1	1702hec.	4.5%	Sara, Gopalpur,Ishirdi
2	Lower ganga Alluvium Soil-2	441hec.	1.2%	Sara,Gopalpur,Ganga polol.
3	Lower ganga Alluvium Soil-3	2279hec.	6.0%	Sara,Gopalpur,Ishirdi
4	Lower ganga Alluvium Soil-4	1495hec.	4%	Gopalpur, Ishirdi
5	Lower ganga Alluvium Soil-5	2634hec.	7%	Ishirdi, Ghieor.
6	Lower ganga Alluvium Soil-6	9709hec.	25.7%	Ishirdi, Ghieor.
7	Lower ganga Alluvium Soil-7	8006hec	21.2%	Ishirdi, Ghieor.
8	Lower ganga Alluvium Soil-8	4763hec.	12.6%	Ishirdi, Ghieor.
9	Lower ganga Flood Plain Soil-9	1545hec.	4%	Ghieor, Ramdia.

Sources: SRDI Report, 1999.

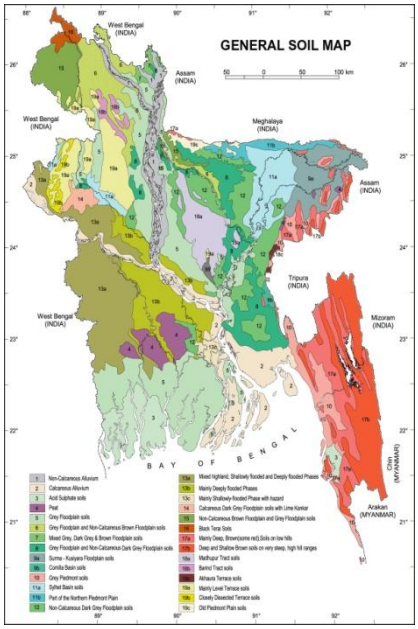

FIGURE 2: General soil map of Bangladesh
Sources: Banglapedia

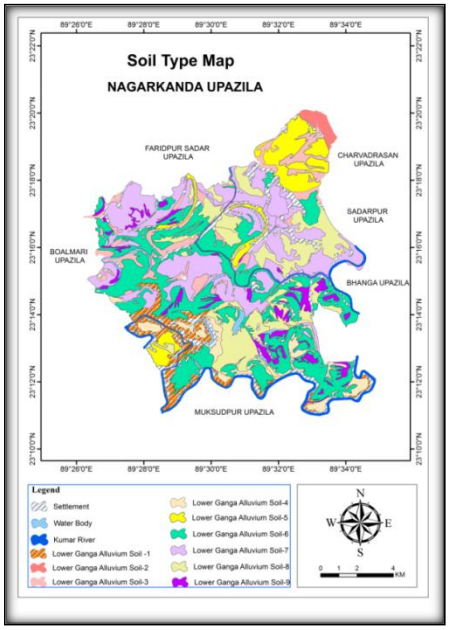

FIGURE 3: Soil map of Nagarkanda Upazila
Sources: SRDI Report, complied map by author

4.4 Farmers' indigenous knowledge about Soil Quality assessment

From the study it was explore that farmers of the study area possess considerable knowledge of the soils quality, moisture conditions of that area. Farmers' measurements of soil properties are rather qualitative than quantitative except for soil. The farmers of the study area were only concerned with the top soil as they use this part of the soil profile for agricultural purpose. They distinguish soil types primarily on the basis of color, rubbing, texture, vegetation, and fertility of soils. They use indigenous methods such as visual observation while tilling, tasting by tongue, feeling and rubbing with fingers to determine various soil properties. Then there they found different types of soil where sand, silt, clay and sandy loam are most. First, Farmers take handfuls of soil and feel the presence of sand, stones (kankar), silt, and clay to distinguish soil textures and classify soils into three broad types: Baila mati (sandy), Jharjara mati (silty), and Athaila mati (clayey). At the same time, they look for the presence of organic matter by color. In general dark soil is considered as fertile soil where light soil is less fertile based on their organic matter content. Black soil which is more fertile and contains relatively high levels of organic matter and light soil is less fertile and it contains less organic matter. They rub soil between two finger to assess whether it is sandy, clay, loamy and silt. They investigate how fast water penetrates into soil to determine soil drainage. Farmers taste soil by tongue to recognized acidity and salinity. They categorize on the basis of taste into salty for salinity, sour and irritating for acidity. Some farmer smell soil to determine whether it is good or bad soil. Finally, farmers use dark green vegetative growth of plants and high crop yields as the key indicators of soil fertility.

TABLE 4
SOIL CLASSIFICATION CRITERION

Criterion	Method of determination	Frequency by Percentage (%)
Color	Look the presence of organic matter	21
Rubbing	Rub soil between two finger	34
Vegetation cover	High crop yields indicates of fertile soil	27
Drainage	How fast water penetrates into soil	9
Salinity and acidity	Taste soil by tongue	5
smell	Bad smell indicates high organic matter	4

Source: Field survey, 2015.

TABLE 5
FARMER'S CLASSIFICATION OF SOIL BASED ON COLOR, DRAINAGE, AND VEGETATION COVER

Soil name	Local Name	SRDI Name	Total area (acres)	Frequency by Percentage (%)
Sany Loam	(Baila mati)	Bele Doash	0	0%
Silty Loam	(Jharjara mati)	Atel Doash	30127	90%
Clay Loam	(Athaila mati)	Poli Doash	3136	10%

Source: Field survey, 2015

Above table (5) shows the soil classification of study area. It represents that silty loam soil (Atel Doash mati) covering 30127 acres land of the study area is the dominant soil type of that area and local people called this soil as (jharjara mati). Clay loam soil (Poli Doash mati) locally called athaile mati remains 3136 acres land Occupying 33% land is another dominant soil type of this study area. Sandy loam (Bele Doash mati) is found very little amount in my study area, local people called this soil (Baile mati). Baile mati contains more sand and less silt and clay. This type of soil is light dark grey in color and contains less moisture. And found near the river bank area. Fertility of Soil varies from one land to another land. Normally Fertility of a land is decreasing by cultivating regularly. But now a days by using different fertility development strategies the fertility of maximum soil are increasing and few amount of soil fertility are decreasing for the lack of different fertility development strategies.

4.5 Cropping pattern of my study area

Crop suitability is a function of crop requirements for soil and land characteristics. Matching the land characteristics with the crop requirements gives the suitability. Eleven agro-edaphic factors (Soil: Soil Permeability, Effective Soil Depth, Available Soil Moisture, Nutrient Status, Soil Reaction (pH), Soil Salinity, Soil Consistency, Drainage; Inundation: Depth of inundation, Flood hazards; and Landform: Slope) were considered for land suitability analysis[20]. Highland may be suitable for kharif or perennial dry land crops if the soils are permeable. Impermeable soils may be suitable for transplanted Aus and/or Aman paddy. Medium Highland is suitable for crops which can tolerate shallow flooding, such as broadcast or transplanted Aus paddy, jute and transplanted Aman paddy. Lowland is flooded too deeply for broadcast Aus or transplanted Aman to be grown. Dry land rabi crops can only be grown if floodwater recedes before December. Very Lowland generally

is too deeply flooded for even deep water Aman to be grown .Where cultivated, very Lowland is generally used for irrigated Boro paddy, either HYV or local varieties.

In this region main crop is rich, jute, wheat, onion, garlic and different types of pulse and oil seeds. My study area is a part of lower ganga flood plain region. Its land is very fertile. According to local agro climatic zone the most suitable and medium suitable crops list are given (table 6) below.

TABLE 6
SUITABLE CROPS OF THE STUDY AREA

Most suitable crops:	Rice, Pulses, Potatoes, Jute, Onion, Sugarcane, vegetable, Lemon, Nut, Mustard.
Medium suitable crops:	Wheat, Jute, maize, Oat, Barley, Chena, Soabin, Ginger, Turmeric, Papaya, Banana.

4.6 Farmers' indigenous knowledge about Crop suitability assessment

The farmers of the study area had a better understanding of the effect of land and soil type for different crops. They know the relief and environmental conditions in which various crops thrive well, and the soil, water, and nutritional needs of those crops. They consider drainage status, soil depth, land elevation, fertility to choose crop. First, they consider the elevation of the land then the presence of sand, silt, and clay. Second, they look for the presence of organic matters (doash meaning loam) and further classify each textural class into two subtypes: soils with low or no organic matter and those with high organic matter content. Farmers know that the aus rice, a kharif crop, grows well on flood-free danga land containing bele maati (sandy) and bele–doash maati (sandy loam soils). It can neither thrive in severe drought or high flood, nor can it tolerate high compactness, salinity, and acidity that characterize most of the village soils. It is not a common crop in the village. Jute is also a kharif crop that grows well with floodwater.

TABLE 7
CROP SUITABILITY BASED ON LAND AND SOIL CHARACTERISTICS

Name of crop	Land	Soil
Aush	Taner Jomi	Sand, Silty loam, Sandy Loam
aman	Taner Jomi, Nall	Silt, clay
Boro	Taner Jomi, , Nall	Silt, Silty Loam, clay
Wheat	Vetta, Taner Jomi	Silt, Loam clay
Jute	Taner Jomi,, Nall	Silt, clay
Onion	Vetta, Taner Jomi	Silt, Silty Loam, clay
Oil seeds	Vetta, Taner Jomi	Silt, SiltyLoam
Pulse	Vetta, Taner Jomi	Silt,Loam, clay
Nut	High land	Loam
Potato	Vetta, Taner Jomi	Loam, Clay Loam

Source: Field survey, 2015.

The suitability of some main crop in respect to land type and soil quality is identified. Here according to land type and soil characteristics the crop suitability is classified into three categories (Table 8) Suitability of Different crops are shown in (Table: 9) .They are:

TABLE 8
CROP SUITABILITY CODE

Crop Suitability	Code
Suitable	1
Medium suitable	2
Not Suitable	3

TABLE 9
CROP SUITABILITY CODE ACCORDING TO LAND TYPE, SOIL TEXTURE, SOIL COLOR, SOIL MOISTURE AND IRRIGATION TYPE

Crop name	Land type			Soil texture			Soil color			Soil moisture			Irrigation type		
	High land	Medium land	Low land	Sand	Silt	clay	dark grey	moderate grey	light grey	High	medium	low	good	medium	low
Aush	1	1	3	3	1	1	1	2	3	1	2	3	3	2	1
aman	2	1	1	3	1	1	1	2	3	1	3	3	3	2	1
Boro	3	1	1	3	1	1	1	2	3	1	3	3	3	2	1
Wheat	1	1	3	3	2	1	1	2	3	1	2	3	1	2	3
Jute	1	1	3	3	1	1	1	2	3	1	3	3	1	2	3
Onion	1	1	3	3	1	1	1	2	3	1	3	3	1	2	3
Oil seeds	1	1	2	3	1	1	1	2	3	1	2	3	1	2	3
Pulse	1	1	2	3	1	1	1	2	3	1	2	3	1	2	3
Nut	2	2	3	1	2	3	1	2	2	2	2	2	1	2	3
Potato	2	2	3	1	2	3	1	2	2	2	2	2	1	3	3

V. CONCLUSION

Farmers' knowledge of land is inherited, acquired through generation-long in situ practical experience and is reflective of their close interaction with the physical environment. Despite their lack of scientific knowledge about topology, physiography and land characteristics of the study area, the farmers are highly knowledgeable in various land type of the study area. Thus, the farmers' knowledge of land has greater utility toward the sustainability of agriculture in the village. Farmer assessment about the soil quality, soil fertility is very much important in agriculture spatially cropping pattern of my study area. Though their local knowledge about soil is much different from scientific research, Farmers' interest in soils is to sustain higher yield of crops of their choice; hence they classify soils on the basis of topsoil conditions. They have traditional local knowledge about the crop suitability of that area. Depending on their local knowledge they cultivate different types of food and cash crops. Though their local knowledge about crop suitability is not wrong but if we can add scientific knowledge with their local knowledge then this knowledge will be better than the local knowledge. So from the above discussion it can be said that combined knowledge (local and scientific) is more suitable and useful than local knowledge.

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Impact Assessment of Agroforestry Practices on Community Socio-Economic Livelihoods in Rwanda

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Abstract— Agroforestry is the source of energy for cooking, materials for construction, domestic utensils and other products and services including fruits, medicine, livestock, feeding and fencing. This study aimed to assess the impact of agroforestry practices on community's socio-economic livelihoods in Karongi district, western Rwanda. The authors interviewed 45 Agroforestry Practioners (AFP) and 45 Non-Agroforestry Practioners (NAFP) from 8 cells randomly selected between July and September 2019.The data were analyzed by using the Statistical Package for Social Sciences (SPSS), version 20. The result, as asserted by 100 % of AFP, the Grevillea robustae was the frequently planted specie on contours and terraces due to its contribution on improving soil fertility and protecting the soil against erosion. The inheritance of land is the main mode of getting lands as mentioned by 69% and 62% of AFP and NAFP, respectively. In addition, it was noted that the number of reared goat, cattle and poultry is higher for the AFP than that of NAFP. Furthermore, the AFP' mean yearly income and its uses (food security, agriculture and household building) is significantly higher ($p<0.05$) compared to that of NAFP. Thus, in Karongi District, the agroforestry significantly enhances its practioner's livelihoods. This study can serve as guide to other similar areas in adopting the agroforestry.

Keywords— Agroforestry; Local Community; Livelihood; Karongi district; Rwanda.

I. INTRODUCTION

Cropland agroforestry system provides enough food, timber, fodder, fruit, fuel wood, construction materials, raw materials and other products for forest-based small-scale enterprises and other cottage industries. Trees in crop fields work as insurance in case of sudden crop failure or to support crops against environmental hazards and also to provide extra income from trees. Moreover, if there is a failure in one crop, the other crops would supplement the deficit. Therefore, cropland agroforestry is largely evolved with sustainability concerns, resiliency and diversity (Maduka 2007; Chakraborty et al. 2015; Islam et al. 2012). There is a range of practices that can be used for agroforestry, some of which have been employed for thousands of years. Such methods include alley cropping (planting single rows of trees and growing crops in the alley ways in between), silvopasture (combining trees with pasture or livestock grazing areas), forest farming (the cultivation of shade-tolerant crops under the protection of a managed forest), and others (TURGUT 2019; Enete and Amusa 2010).

Integrating trees in agricultural systems can certainly be complex and might be difficult to implement in various situations, and there is no one model that works for every region, but the benefits are significant. Overall, incorporating trees introduces more species in usually one or few species systems. And this in turn, has been shown to increase the crop productivity, improve nutrient cycling, create and change microclimate (Ospina 2017; TURGUT 2019). Some countries have heeded the call and are employing agroforestry technology as a strategy to rehabilitate degraded forestlands, avoiding "slash and-burn" farming, reducing soil erosion, improving soil quality, enhancing vegetation cover, and improving the living standards of forest-dependent communities (Bugayong 2003; Glover et al. 2013). Agroforestry can help to improve the livelihoods of the rural poor by producing food (e.g. fruit, nuts, edible leaves, sap and honey), fodder, timber, wood fuel, fibers and medicines. The adoption of agroforestry can save time in the harvesting of fodder and wood fuel, a particularly important benefit for women (Hillbrand 2017). According to the study conducted in Orlando, Florida, USA, trees also provide farmers with supplementary socio-economic benefits (fruit for food, firewood, medicines, forages, etc.) (El-Lakany 2004b; El-Lakany 2004a).

The Rwandan 3rd Integrated Household Living Conditions Survey (EICV3) reported that in Karongi district, 77.7% of households own less than 0.99 ha of land, among them 36.7% own less than 0.2 ha, and only 22.3% own more than 1 ha (Nahayo et al. 2016; Nabahungu and Visser 2011). A higher proportion of farmers cultivating larger areas would create an enabling environment for agriculture production increase. The proportion of households cultivating the smallest areas, i.e. below 0.3 ha land, represents 37.4% in Karongi District. This is slightly lower than the average national level (46%). The mean size of land cultivated per household in Karongi District is 0.5 ha, which is slightly higher than the national average (0.59ha) (Karongi 2018).Sometimes, it is argued that small farms in terms of land size are more productive than large farms and it is further recommended that agricultural development strategies need to be based on the backing of small rather than

large farms. In addition to this, the small farm biased agricultural development strategy simultaneously can help to overcome both growth and income distribution objectives (H.Freeman 2005; Ellis 2008).

The conversion of forestlands to agricultural lands in the region is rapidly increasing, which is reducing forest cover. However, in Rwanda, the adoption of agroforestry techniques to avoid rampant deforestation has not been simple in the country due to the existing challenges such as low literacy rate, insufficient credit facilities, absence of farm inputs, and other sociocultural issues (MINAGRI 2006). In such circumstances, traditional land use patterns should be converted into sustainable land use, which will permit maintenance of productivity combined with conservation of the resources. Agroforestry; a land based production system that is directly related to food security, employment, income opportunities and environmental issues plays a vital role in rural socio-economic development as well as poverty reduction (Maduka 2007; Chakraborty et al. 2015; Islam et al. 2012). Karongi District faces the problem of soil degradation, including soil infertility, soil erosion, deforestation, shortage of farmlands, land sliding. These are associated with other environmental concerns mainly in agriculture, urbanisation, infrastructure development and energy (Karongi 2018).Hence, agroforestry practices would be the best land-use system for sustainable livelihood in Karongi District to cope with the above challenges.

Therefore, it is good to analyze the extent to which agroforestry practices contribute to the advancement of social and economic livelihood of the local community. Hence, this study is conducted in Karongi Districtin order to assess the socio-economic impact of agroforestry practices on farmers' livelihood. The results derived from the current study will serve as guide to decision makers on how agroforestry practices contribute to rural community socio-economic livelihoods improvement.

II. MATERIALS AND METHODS

2.1 Description of the study area

This study was conducted in Karongi District, one of seven districts of the Western Province of Rwanda. For this study, the authors randomly considered eight cells namely: Kibilizi, Gitwa, Gisanze, Nyarugenge, Ruragwe, Gacaca, Bubazi and Mataba. The Karongi District stretches over an area of 993 Km^2 with an altitude varying between 1,470 to 2,200 meters. The District is mountainous and part of the Congo Nil Ridge (Watershed) which falls in both Kivu and Upper Nyabarongo Sub catchment(Karongi 2018).Due to its relief and topography, soil erosion and landslides are frequent in most areas of the district. The Karongi District has two dry seasons covering the period from December to January and from June to mid-September. The annual average temperature varies between 16^{o}C and 21^{o}C. The district is also characterized by two rainy seasons. The long rainy season starts from mid-September to late December, and the short rainy season begins from February to June with an annual rainfall ranging from 1,100 to 1,500 mm (DDP 2013).

According to the 4th Rwanda Population and Housing Census (EICV4), Karongi District has 331,808 inhabitants (156, 073 males, 175,735 females). The district counts 73,326 households; the population density is 334 inhabitants per square km (Nagel et al. 2015). The settlement in Karongi District is scattered at 53.6% compared to 50.8% at national level. The district counts only 2% of urban areas, not well developed while the remaining is rural and suffers from limited basic infrastructures(Nagel et al. 2015).

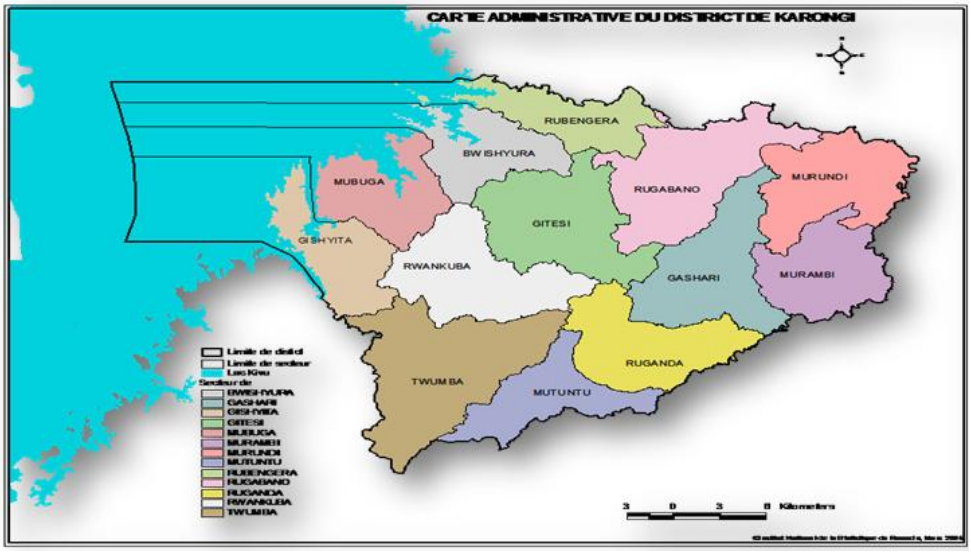

FIGURE 1: Administrative Map of Karongi district Source: Karongi, 2018

2.2 Methodology

For this study, a total of ninety (90) households were randomly selected from eight (8) villages in Karongi district. During the selection of 90 households, the authors made sure that half of the households (45) are Agroforestry Practioners (AFP) and the other half (45) is Non Agroforestry Practioners (NAFP).The authors considered that fact that it could not be possible to attain all the farmers, and then selected a representative sample among others. This study adopted purposive sampling procedure where a sample has been taken within a population of 8,802 households by using the formula of Dagnel, 2006.

$$n = \frac{Z^2 \times P \times q \times N}{d^n (N-1) + Z^2 \times P \times q \times N} \quad (1)$$

Where n is the sample size, Z is the coefficient of normal distribution, P is the probability of failure, d is the margin error and p is the probability of success and N is the total number of population (Universe size $<10^6$ individuals).

The margin error varies between 5 % and 10 %. By using the margin error of 10 %, the confidence level of 90 %, the probability of success (p = 0.5), failure probability (q = 0.5) and the coefficient of normal distribution (z = 1.65 in student table). Thus, the total households on these selected cells are 90 calculated by using the above formula.

$$n = \frac{(1.65)2*(0.5)*(0.5)*(8802)}{(0.1)2*(8802-1)+(1.65)2*(0.5)*(0.5)} = 89.8 = 90 \quad (2)$$

TABLE 1
NUMBER OF INTERVIEWED HOUSEHOLDS BY CELL

District	Cell	Total number of households	Selected sample of households
KARONGI	Kibilizi	1573	16
	Gacaca	1287	13
	Gitwa	1154	12
	Nyarugenge	1019	10
	Bubazi	939	10
	Ruragwe	1094	11
	Mataba	874	9
	Gisanze	862	9
Total		8802	90

Source: Karongi district Statistics, 2019

2.3 Data Collection and Analysis

This study targeted both the households in Karongi District that practice agroforestry practices (AFP) and those without agroforestry practices (NAFP) in their farmland. An intensive household survey was carried out by using the questionnaire between July and September 2019. The authors described the respondents by age, education level and sex. Thereafter, the study investigated on the types of trees used in agroforestry practices and the associated benefits to farmers practicing agroforestry compared to non-practioners of agroforestry. The Statistical Package for Social Sciences (SPSS) and Microsoft Excel were used to analyze primary data. Some data were checked randomly against original completed questionnaires to detect entry errors. Accordingly, the detected errors were corrected for analysis.

The Descriptive statistical analysis including frequency distribution, percentage, cross tabulation, mean and standard deviation (SD) were used for data analysis to summarize the farmers' socio-economic characteristics and farm specific characteristics. Furthermore, the Tables Pearson Chi-Square Test was used to analyze the relationship between dependent variables (Livestock asset, Physical asset, income and expenditure**,** use of generated income and health insurance) and independent variables (Agroforestry practices). In order to identify the variations, sample means were compared by performing independent t-test.

III. RESULTS AND DISCUSSION

3.1 Household characteristics

The following section described the respondents, both AFPA and NAFP by their age, sex and education level.

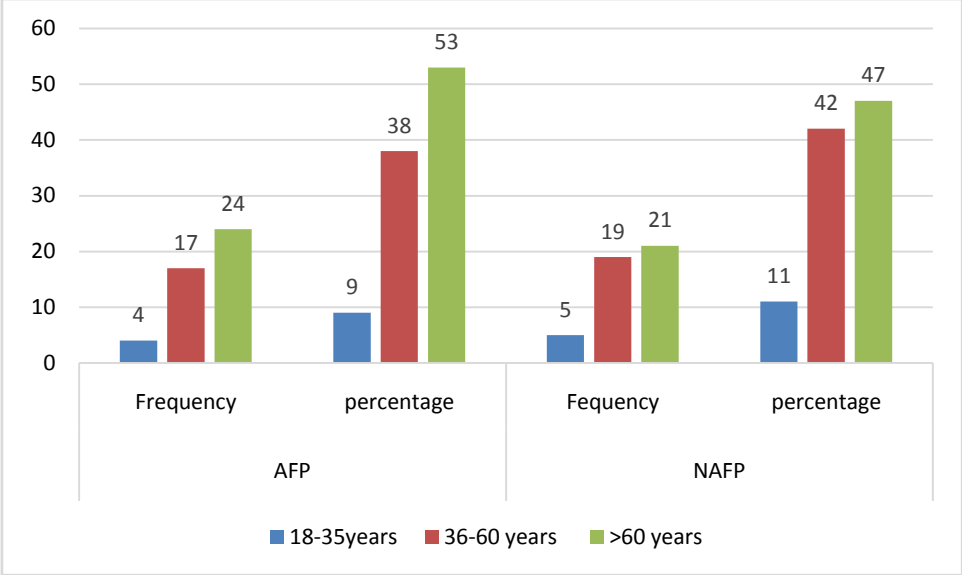

FIGURE 2: Age of respondents

From the results in the above Figure 2, it was noted that the majority of the surveyed farmers (53% of AFP and 47% of NAFP) are aged over 60 years old. A small proportion of respondents were composed by young people with4% and 11% of AFP and NAFP farmers, respectively. This indicates that the information on agroforestry practices and their social-economic benefits among the surveyed farmers was obtained from experienced people, as the majority of them (53 and 47 percent for the AFP and NAFP, respectively) are aged above 60 years. The study conducted in the Eastern Agro-Ecological Zone of Uganda, showed that farmers practicing agroforestry were above 42 years than non- agroforestry practioners and the difference was significant (Basamba et al. 2016).Also, the study conducted in China showed that the age of households implied a positive effect on farm yield (Ma and Abdulai 2016; Kumar et al. 2018). Likewise, the studies conducted in Ethiopia and Turkey, on the determinants of agricultural productivity and rural household income found out that farmers' age had a positive impact on their land productivity (Urgessa 2015; Gül and Ar 2019).

The findings of this study (Fig.2) showed the similarity with the study conducted in Busogo Sector of Musanze District of Rwanda which indicated that the high percentage (40.3 %) of the surveyed population was over 60 years old (Ndayambaje 2013). Accordingly, the study of Maduka (2007) reported that the high percentage (48%) of surveyed population was between 18-39 years old in Semi-Arid areas of Misungwi District, Mwanza, Tanzania. This indicates that age and experiences of an individual play an important role in application of indigenous knowledge and innovations(Makawia 2003; Akpınar et al. 2019).

TABLE 2
DESCRIPTION OF HOUSEHOLDS BY SEX

Sex	AFP		NAFP	
	Frequency	Percentage	Frequency	Percentage
Male	34	76	36	80
Female	11	24	9	20
Total	45	100	45	100

Source: Primary data, 2019.

From the results in Table 2, the number of NAFP (80%) and AFP (76%) male was higher than that of the female NAFP and NAFP which recorded 20 percent for both cases, respectively. This was likely due to the fact that the study surveyed the heads of households who are mainly male in Karongi district. These heads of families are decision makers that may affect the adoption of agroforestry practices (Ndayambaje 2013).Similarly, this was reported in Busia District, Uganda that there were more male than female farmers adopting (82.7%) compared to those who (79.1%) do not adopt agroforestry (Basamba et al. 2016).

In Karongi district, the level of education among AF farmers is generally high. About 73 percent of respondents of AFP and 67% of NAFP have formal education (primary level) while 6% of NAFP and 5% of AFP are illiterate (Table 3). The level of education is found to be significantly higher for AF farms than for NAF farms (Table 3).

TABLE 3
RESPONDENTS CLASSIFICATION BASED ON THEIR EDUCATION LEVEL

Level	AFP		NAFP	
	Frequency	Percentage	Frequency	Percentage
Primary	33	73	30	67
Secondary	5	11	3	7
Artisan School	4	9	9	20
Illiterate	2	5	3	6
University	1	2	0	0
Total	45	100	45	100

Source: Primary data, 2019.

The results of this study (Table 3) showed that Illiteracy is estimated at 5% among the AFP and 6% of NAFP. The results indicated that 20 percent of AFP and 9 percent of NAFP have studied in artisan school. This percentage is the results of the Craft production centers established across the district to provide the working facilities which most craftsmen and women cannot afford on their own. As the main part of farmers (73% of AFP and 67% of NAFP) interviewed has achieved primary school, this basic education can facilitate the delivery training to farmers and adoption of agroforestry practices which enhance their land use system and household welfare. The findings of this study (Table 3) are in congruency with report of Ndayambaje (2013) which revealed that the majority of agroforestry practitioners reached primary level of education (40.3%) in Busogo Sector of Musanze District of Rwanda. According to Basamba et al (2016), education was largely limited to primary level for both categories of agroforestry farmers. Similarly, such statement was reported (Sood and Mitchell 2009), that educated farmers are considered to be innovative or opinion leaders and willing to take more risks than illiterate farmers.

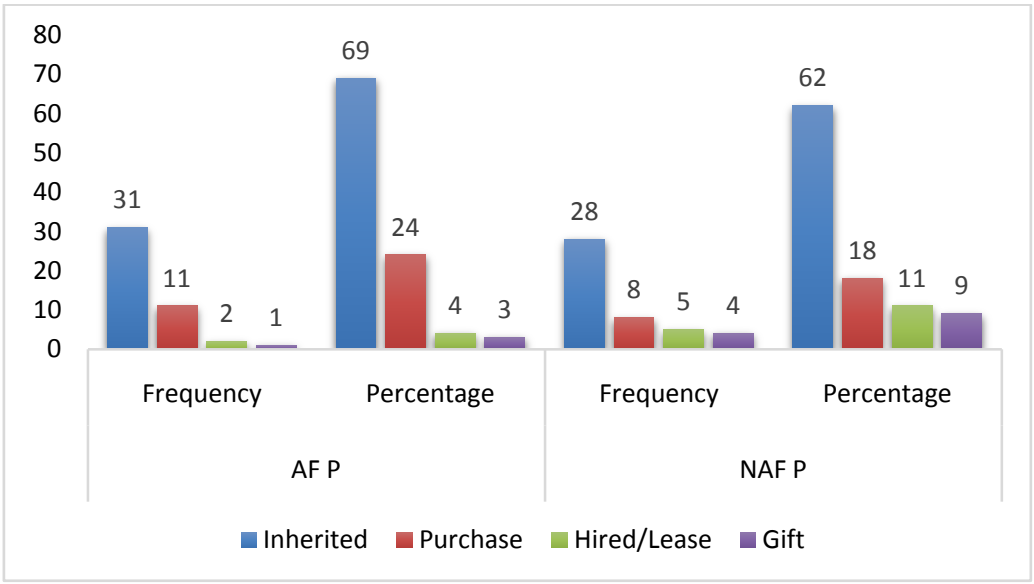

FIGURE 3: Respondent's classification according to land tenure.

The results in Figure 3 showed that in Karongi district, the land inheritance is the main mode used to get lands among farmers, as asserted by 69 % of AFP and 62% of NAFP. This is followed by land purchasing highlighted by 24% of AFP and 18%of NAFP, whereas the gift is the least mode of gaining land among people in Karongi district as mentioned by 9 % of NAFP and 3% of AFP. The findings of this study (Fig.3) agree with the results of Ndayambaje (2013) where land inheritance was ranked as the main mode (59.7%) in Musanze District of Rwanda. In addition, the study of Maduka (2007) reported that the major mode of land acquisition was mostly through inheritance (96.0%)in Semi-Arid areas of Misungwi District, in Mwanza, Tanzania. This kind of land acquisition motivates more farmers to extend agroforestry practice to their own lands.

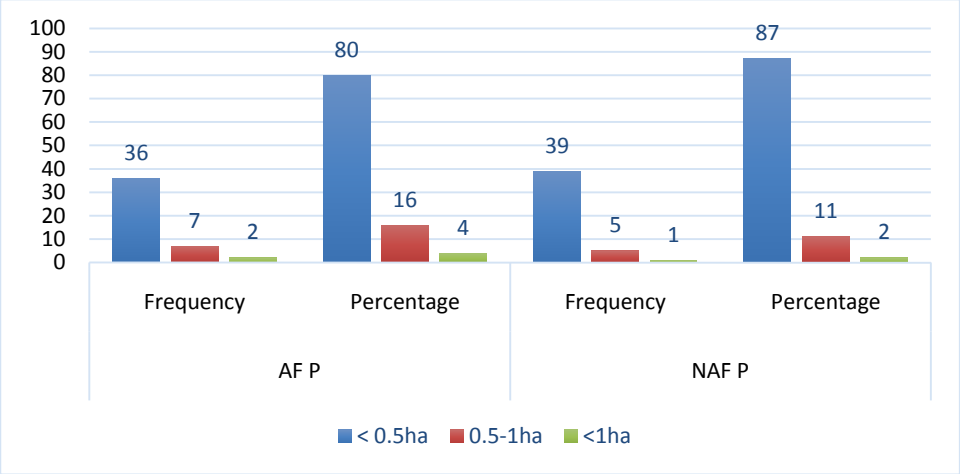

FIGURE 4: Farm size of respondents.

This study found that 80% of AFP farmers and 87% of NAFP have land size inferior than 0.5ha while 16% of AFP and 11% of NAFP have land ranging between 0.5 to 1ha (Fig. 4). According to the report of the Karongi District Development Plan (DDP, 2013), the mean size of land cultivated per household is 0.5 ha, which is slightly higher than the national average (0.59ha). The EICV3 reported that in Karongi district, 77.7% of households own less than 0.99 ha of land, among them 36.7% own less than 0.2 ha, and only 22.3% own more than 1 ha. Similar results were reported in Legho Mulo, in Kilimanjaro region where the landholding is 0.58 ha (Maduka 2007; Kessy 1992). However, due to these land shortages, farmers have adopted contour and terrace practices which have been providing better results due to favorable climatic condition.

3.2 Agroforestry Practices

TABLE 4
TYPES OF TREES GROWN BY FARMERS

Species	Frequency	%	Mean Rank
Callianda Calothyrsus	33	73	6.37
Persea Americana	44	98	4.62
Dracaena Afromantana	42	93	4.69
Euphorbia Tirucarri	40	89	5.75
Cajanus Cajan	17	38	7.06
Psidium Guajava	38	84	4.85
Persea Americana	44	98	4.62
Ricinus Comminus	36	80	5.05
Mangifera Indica	36	80	5.35
Leucana Diversifolia	33	73	5.70
Grevillea Robusta	45	100	4.60
Alnus Acuminata	35	78	5.35
Morus Alba	23	51	7.02
Ficus Thonningii	32	71	6.87
Markhamia Luthea	31	69	6.45
Eurthryna Abssynica	30	67	6.98
Carica Papaya	15	33	7.10
Test Statistics[a]			
N			**45**
Chi-Square			**111.335**
Df			**8**
Asymp. Sig.			**0.002**

a. Friedman Test; **b.** Ranks are in ascending order; **c.** 2 groups are generated; **d.** Consecutive ranks with ties sharing the same value

The Table 4 above indicated the trees planted by households in Karongi district as agroforestry practices. The results showed that the *Grevillea Robusta* (100%) is planted by all surveyed farmers in Karongi district with the Chi-squared value p-value = 0.002. In addition, the results in Table 4 indicated that the Grevilea Robusta was the agroforestry specie adopted by many farmers with high ranking of 4.60 while the lowest observed specie with lower ranking of 7.10 was the *Carica Papaya* (Table 4).

Also by using the Friedman Test, the study (Table 4) showed the p-value of 0.002 which means that there is no statistically significant difference in the number of farmers who adopted agroforestry species. The agroforestry practices used by farmers influence the choice of agroforestry species and their adoption. The Table5 below showed the agroforestry practices which are planted within the selected households in Karongi district.

TABLE 5
TYPES OF AGROFORESTRY PRACTICES IN KARONGI DISTRICT

Agroforestry practice	Frequency	%	Mean Rank
Alley Cropping	42	93	3.13
Live fences	19	42	5.91
Trees on farm boundary	41	91	3.09
On contours and Terraces	44	98	2.82
Around road and pathways	29	64	3.34
Homegarden	25	56	3.86
Test statistics[a]			
N			45
Chi-Square			62.5756***
Df			5
Asymp. Sig.			**0.025**

a. Friedman Test
b. *** imply statistical significance at 0.001

As indicated in Table 5, the most important agroforestry practice adopted by the farmers in Karongi district is trees planted on contours and terraces (98%) with the Chi-squared value p-value = 0.025. The findings of this study are similar to the study conducted in Musebeya sector, Nyamagabe District in the southern province of Rwanda. The study reported that the predominant agroforestry practices included alley cropping, woodlots, and boundary planting (Kiyani et al. 2017). In the above Table 5, the ranking highlighted the contours and terraces as the largely adopted agroforestry practice (rank of 2.82) compared to the live fences which ranked 5.91. Also by using the Friedman Test, the p-value of 0.025 was obtained, which means that the current agroforestry practices in Karongi district have a significant difference among farmers.

3.3 Agroforestry socio-economic benefits among household

3.3.1 Livestock ownership

Although the sale of crops and non-farm income are considered as main source of income for most households, farmers also get income from the sale of livestock. Most households rear different kinds of livestock including chicken, cattle, goat, sheep and pig. The livestock rearing is mainly practiced for two major reasons: income and food.

TABLE 6
TYPES OF REARED LIVESTOCK IN KARONGI DISTRICT

Livestock Assets	AFP			NAFP			Significance P value
	Mean	SD	%	Mean	SD	%	
Cattle	1.18	1.09	73	0.49	0.87	27	0.001**
Goat	1.31	1.04	78	0.69	0.79	51	0.001**
Poultry	1.64	1.46	80	0.76	1.21	33	0.002**
Pigs	0.29	0.51	27	0.20	0.40	20	0.359
Rabbit	0.64	1.19	31	0.33	0.65	20	0.144
Sheep	0.38	0.75	24	0.13	0.40	11	0.056*

Source: Primary data, 2019.

The results of this study in Table 6 indicated an average poultry of 2 for AFP and 1 for NAFP. For the goat, cattle and poultry rearing, it was found that the number of livestock is significantly higher for AFP than for NAFP (Table 6). Thus, there is statistically significant difference between livestock numbers among the two categories of households. This was confirmed by the study of Chakraborty et al (2013) where cropland agroforestry (CAF) farmers have 3 cattle per household, whereas non-cropland agroforestry (NCAF) farmers have 2 cattle per household on an average.

3.3.2 Physical assets ownership

Physical asset is a source of coping with shocks in the rural livelihoods. It is also a good indicator of life standard. People having more physical assets likely enjoy more social status than others (Chakraborty et. al.2013).

TABLE 7
PHYSICAL ASSETS OWNERSHIP

Physical asset	AFP			NAFP			Significance P value
	Mean	SD	Percentage	Mean	SD	Percentage	
Radio	0.69	0.47	69	0.73	0.50	53	0.646
Mobile Phone	0.80	0.40	80	0.62	0.49	62	0.063*
Bi-cycle	0.64	0.48	64	0.47	0.50	47	0.091*
Motor cycle	0.36	0.48	36	0.31	0.47	31	0.659
Television	0.51	0.51	51	0.38	0.49	38	0.207

Source: Primary data, 2019.

The results of this study in table 7 revealed that80 percent AFP have mobile phone compared to 62 percent of NAFP, and the possession of television is high for the agroforestry Practioners (51%) compared to the non-agroforestry Practioners (38%). The results indicated that the possession of the considered physical assets among the AFP is higher than that of NAFP. There are significant differences ($p<0.10$) in cases of bi-cycle and mobile phone ownership at 10 percent level of significance between the two categories of households (Table 7). The results of this study are similar to the study of Chakraborty et al. (2013) on the possession of television among CAF and NCAF, which indicated 55 and against 38 percent, for AFP and NAFP, respectively.

3.3.3 Main income sources

TABLE 8
INCOME SOURCES AMONG HEADS OF HOUSEHOLDS

Principal occupation	AFP		NAFP	
	Frequency	Percentage	Frequency	Percentage
Farmers	36	80	34	76
Handcrafts	4	9	7	16
Traders	3	7	2	4
Other groups	2	4	2	4
Total	45	100	45	100

According to the results in Table 8, the majority of AFP respondents (80 %) and 76% of NAFP grow crops, followed by handcrafts (16 % for NAFP) and 9% for AFP, along with trading occupied by 7 %and 4% of AFP and NAFP, respectively.

3.3.4 Health insurance

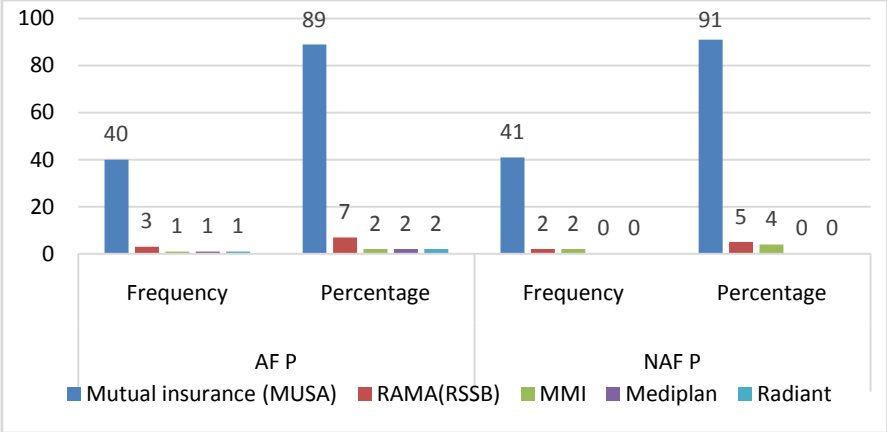

FIGURE 5: Possession of health insurance among respondents

The results in Fig.5 showed that 89 percent of AFP and 91% of NAFP use the Community Health Insurance, known as Mutuelle de Sante (MUSA) for health care whereas 7 percent of the AFP and 5% of NAFP employ the RAMA (Figure 5).

3.3.5 Income and expenditure among farmers

TABLE 9
AGROFORESTRY PRODUCTS HARVESTED

Product	Frequency	Percentage
Fruits	45	100
Stakes	34	80
Firewood	7	16
Building (poles &timber)	23	51
Biomass (green manure)	23	51
Fodder	3	7
Charcoal	2	4

Source: Primary data, 2019.

According to the results in Table 9, the agroforestry trees planted by respondents in Karongi district are mainly for fruits (100%), stakes (80%), building and green manure (51%).

TABLE 10
CASH INCOME (in million Rwfs) AND EXPENDITURE BY AFP AND NAFP

Indicators	AFP				NAFP				Significance P Value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
Annual Income	0.49	0.25	0.08	1.1	0.37	0.20	0.07	1	0.016**
Annual Expenditure	0.40	0.20	0.06	0.83	0.35	0.18	0.07	0.87	0.362

AFP: Agroforestry Practioners and NAFP: No-Agroforestry Practioners
Source: Primary data, 2019

The result in Table 10 showed that the mean income of AF households is 0.49 million and 0.40 million for NAF households in Karongi district. This expresses that the AF households' mean yearly income is higher than that of NAF households. The results in Table 10 indicated that the difference between mean income between the AF and NAF farmers is significantly different at 5 percent level of significance whereas the average expenditure values are not significantly different (P0.362) between The AF and NAF groups. The results of this study (Table10) are similar to the report of Chakraborty et al.,(2015)which indicated that the mean income of cropland agroforestry farmers (CAF) was Tk. 0.19 million and Tk. 0.13 million for cropland agroforestry farmers (NCAF) in Jessore District of Bangladesh. According to the study conducted in Nyamagabe District of Rwanda on the adoption of agroforestry, the practice has contributed to the increase of famers' income where the mean annual income of AFP was higher than that of NAFP at 278,000 Rwfs (about US$331) and 249,000 Rwfs (about US$297), respectively (Kiyani et al. 2017).

In addition, the report from the survey in Mwanga district of Tanzania indicated that AF participants in average had extra income than non-AF participants of almost US$ 617.5 annually (Charles et al. 2013). This expresses that agroforestry is one way to attain higher income and expenditure that leads to improving the socio-economic conditions and livelihood of farmers. Additionally, for this study (Table 9), the interviewed farmers reported increasing incomes through sales of local fuel wood and testified that that agroforestry helps to improve their social economic livelihoods in general. In Karongi district, the difference in incomes between AFP and NAFP can be attributed to factors like type of agroforestry practices adopted, number and type of trees species established and sold, and land ownership. Furthermore, the extra income obtained by AFP compared to NAFP can result from the levels and readiness of farmers in testing different interventions when delivered to them, like purchase of physical assets, keeping livestock, health insurance and improving well-being status of household as compared to non-AF practitioners.

TABLE 11
USE OF GENERATED INCOME BY HOUSEHOLDS

Indicators	AFP				NAFP				Significance P Value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
Energy	0.014	0.011	0	0.04	0.020	0.018	0	0.01	0.083*
Buying Food	0.163	0.12	0.01	0.46	0.109	0.09	0.009	0.419	0.023**
Paying School fees	0.115	0.079	0.02	0.32	0.113	0.085	0.007	0.3	0.895
Clothing	0.05	0.021	0.01	0.12	0.054	0.03	0.01	0.12	0.462
Medical insurance	0.025	0.006	0.015	0.04	0.024	0.118	0.015	0.65	0.460
Further investment	0.034	0.029	0	0.17	0.029	0.022	0	0.1	0.304
Agricultural inputs	0.154	0.112	0.015	0.409	0.109	0.094	0.015	0.419	0.047**
Building	0.201	0.15	0.015	0.07	0.108	0.095	0.008	0.419	0.001**

Source: Primary data, 2019.

From the independent t-test of the weighted mean of AF and NAF households, it is found that there is a clear difference between two categories of farmers. The use of income for the AF farmers for the food security, agricultural inputs and buildings is significantly higher ($p<0.05$) than that of NAF farmers (Table 11). The results of this study as shown in Table 11, agreed with previous report of Maduka (2013) that the income from agroforestry maintains the basic household needs, provides food security and fuel wood, and contributes to healthcare, housing and sanitation conditions, and meeting educational expenses.

It is reported by Ospina (2017) that in some place without agroforestry practices, some women and child would walk over 5 kilometers to collect firewood from state forests. Very often women who must travel so far for basic resources are at risk of assault during their journeys and have less time to devote to other household activities. The findings of this study in Fig. 6showed that the adoption of agroforestry in Karongi District significantly reduced the amount (2000 Rwfs) of fuel wood purchased and the time that households used to spend while collecting wood.

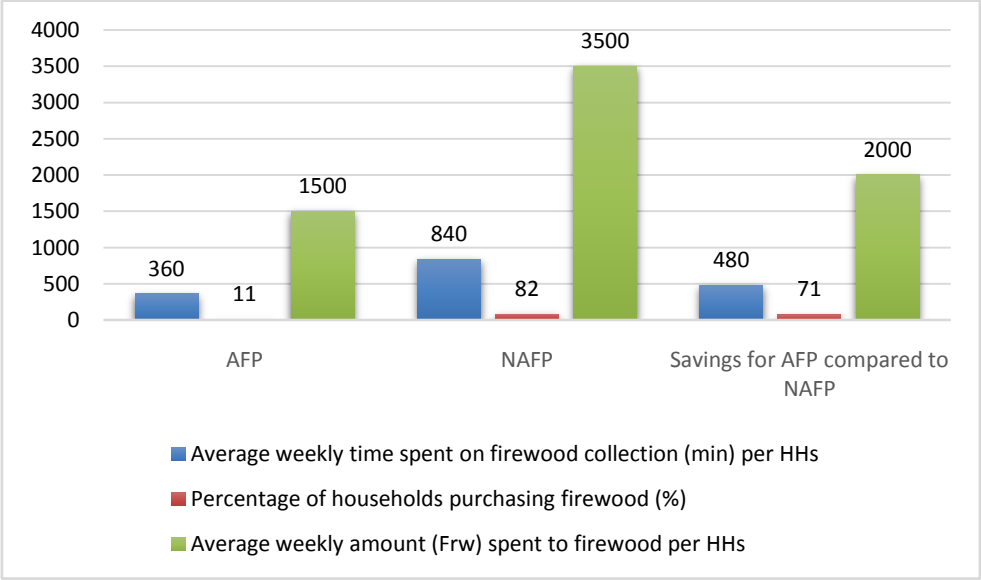

FIGURE 6: Amount and time spent by households on purchasing and collection of fuel wood

According to the results of this study (Fig.6),the respondents asserted that practicing the agroforestry has reduced the time spent on collecting firewood. This enabled AFP to save an average weekly time of 480min.In addition, the results in Fig. 6showed that households spend the average weekly amount of 1,500Rwf for AF and 3,500Rwf for NAF for purchasing fuelwood. This expresses that the agroforestry practices decreased the weekly amount spent up to 2,000Rwf for AFP compared to NAFP.

IV. CONCLUSION

Agroforestry has great potential to improve social and economic conditions in developing countries. Its ability to improve soil quality and mitigate climate change through carbon sequestration should also make it an appealing agricultural method in countries with more significant economic resources or large farm systems. This study surveyed 90 heads of households in Karongi district and compared the agroforestry socioeconomic benefits between agroforestry practioners (AFP) and non-agroforestry practioners (NAFP). The authors used a questionnaire to collect data from the selected respondents. The results indicated that agroforestry practice has a significant impact on farmers' livelihoods. It was noted that the AFP can save an average weekly time of 480min on fuel wood collection and a weekly amount of 2,000 Frw compared to the NAFP. Moreover, the findings indicated that the income of farmers who have adopted agroforestry practices is increasing since its introduction in the district. The findings of this study can serve as guidance to policy makers to design the necessary support measures to expand agroforestry practices toward increasing farmers 'livelihoods. This will ultimately improve rural communities' living standards, forest cover, and mitigate climate change as well.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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Agroforestry Practices in Ballia District of Eastern Plain Region of Uttar Pradesh, India

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Abstract— *Agroforestry is an efficient land-use system where trees or shrubs are grown with arable crops, seeking positive interactions in enhancing productivity on the sustainable basis. Agroforestry combines agriculture and forestry technologies to create more integrated, diverse, productive, profitable, healthy and sustainable land-use systems. The study was conducted in selected villages (1%) of Ballia District of Eastern plain region of Uttar Pradesh in India during the year 2018 to record the crop combinations with tree species and their stratified arrangement to identify agroforestry practices. The socio-economic studies based on general village profile, land holding, land use pattern and tree species planting pattern were performed in 1 % villages to collect the data with structured questionnaire and Participatory Rural Appraisal (PRA) tools. The results demonstrated that a total of six different agroforestry practices, agri-silviculture, silvi-horticulture, agri-horticulture, agri-silvi-horticulture, silvi-pastoral, and homestead existed in different villages. Out of different categories, timber, fruits, medicinal, agriculture, flower and other plant species were recorded. It was recorded that out of existing agroforestry practices, scattered near farms and around homestead was found most common (about 37.7 %) followed by agri-silviculture (20.20 %), silvi-horticulture (19.1 %) and agri-horticulture (12.3 %). The pattern of plantation on bunds and blocks was 17.94 % and 16.82 % respectively. The benefits from agro forestry practices in the villages was also assessed and ranked in their order of preferences in respective blocks of district. The different benefits as fruits/vegetables, timber, shade, medicinal, fodder, firewood, protection, and soil erosion were scored from 1 to 8. It was concluded from the results that status of agroforestry in the studied zonal area of the region is in developing stage and needs to be improved by imparting technical knowledge about planting material, methods and sale of end produces of trees to the farmers and tree growers.*

Keywords— Socio-economic studies, agroforestry practices, homestead system, trees benefit scoring.

I. INTRODUCTION

Agroforestry has traditionally been a way of life and livelihood in India for centuries. It is a land use system which involves trees with agricultural crop/grass or animals simultaneously. Agroforestry has attracted the interest of scientists and development planners because it provides variety of products for meeting varied requirements of the people, insurance against risks caused by weather aberrations, controlling erosion hazards and ensuring sustainable production of the intercrops (Nair, 2007). Agroforestry systems in India include trees in farms, community forestry and a variety of local forest management and ethno-forestry practices. In UP, agroforestry practices vary according to different agro-climatic zones, land capability and socio-economic status of farmers. The variation is reflected in terms of diversity in agroforestry practices, and comparative advantage prompted a renewed interest to harness the vivid potential (Verma *et al.* 2017). The survey revealed the wide spectral potential of agroforestry practices in sustenance of agriculture as they provide food, fodder, fruit, vegetables, fuel wood, timber, medicines, fiber etc. from the same piece of land at a time which not only fulfils the demand of people but also elevate their socioeconomic status and standard of life (Pathak et al., 2000).Today, Indian agriculture faces diverse challenges and constraint due to growing demographic pressure, increasing food, feed and fodder needs, natural resource degradation and climate change (Dhyani *et al*., 2013). Therefore, a management system needs to be devised that is capable of producing food from marginal agricultural land and is also capable of maintaining and improving quality of producing environment (Dobriyal, 2014).

Agroforestry system is one of the best known traditional practices and has an important role in reducing vulnerability, increasing resilience of farming systems and buffering households against climate related risks (CAFRI, 2015), but there are

several challenges that reap the benefits of agroforestry in India. There is shortage of superior planting material and improved seed varieties (Verma *et al*. 2017). In India, just as there is a great diversity in climate similarly there exists a large number of agroforestry systems of various forms and types (Dagar *et al*., 2014) .The current area under agroforestry in India is estimated as 25.31 million hectares or 8.2 percent of the total reporting geographical area of the country by Dhyani *et al*. (2013); Dagar *et al*. (2014) and CAFRI (2015). As the population of India is increasing at a very fast rate; the land-holding size of farmers shrink at a very fast rate and agroforestry is the only way to optimize the farm productivity (National Agroforestry Policy, 2014).It is generally well known that status of agroforestry in districts of Eastern plain region of Uttar Pradesh is in developing stage. From Forest survey of India report (2017), it was recorded that forest cover including tree cover is only 0.74 per cent in the district of Ballia. Therefore, a study has been conducted in selected villages (1%) of Ballia district of Eastern plain region of Uttar Pradesh in India during the year 2018 to assess the socio-economic profile of villages for land use pattern, general information about villages, status of tree plantations, crop combinations with tree species and their stratified arrangement to identify agroforestry practices with a view to study existing tree species in different agro forestry systems in the villages and their benefits in day- to- day life of rural livelihood. The choice of species in agroforestry models were also recorded on the basis of their preferences in plantations.

II. EXPERIMENTAL METHODS

2.1 Study area: Ballia district

Ballia is the eastern most part of the Uttar Pradesh state and borders on Bihar State. It comprises an irregularly shaped tract extending westward from the confluence of the Ganga and the Ghaghra, the former separating it from Bihar in the south and the latter from Deoria and Bihar in the north and east respectively. The boundary between Ballia and Bihar is determined by the deep streams of these two rivers. It is bounded on the west by Mau, on the north by Deoria, on the north-east and south-east by Bihar and on the south-west by Ghazipur. The district lies between the parallels of 25º33' and 26º11' North latitudes and 83º38' and 84º39' East longitudes. It has 17 blocks with 2372 number of villages.

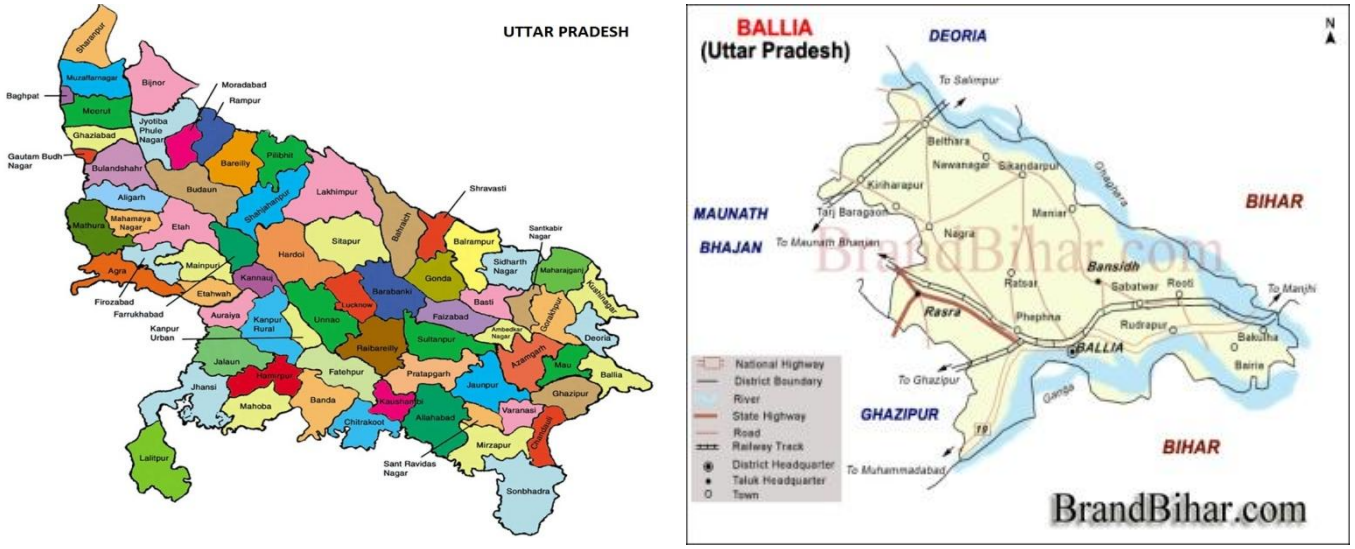

FIGURE 1: Map of Uttar Pradesh, and Ballia district

2.2 Socio-economic study:

The study was carried out in Ballia district of eastern plain region of UP. The socio-economic survey with structured questionnaire and Participatory Rural Appraisal (PRA) technique was used to study the general information of villages, land use pattern, existing status of agroforestry through appraisal of existing farming systems and agroforestry practices and farmers preference for management practices of agroforestry systems such as agri-silviculture, boundary plantation, silvi-pasture, silvi-horticulture, agri-silvi-horticulture, multi-storey, homestead etc. In the region, one representative village in each

developmental block was selected to cover the area. Out of 2372 villages existing in the Ballia, 1% villages were taken for study through stratified random sampling method. A total of 10 per cent households were involved in the survey including farmers of small, medium, large and marginal category, males and females covering age and caste of all groups in selected villages. In each selected village, a random sampling technique was used to select farmers. The primary and secondary data was collected from the selected study area. A semi–structured questionnaire was developed. The pre-test work of questionnaire was done by interviewing farmers in selected villages. Thus, the final questionnaire was prepared on the basis of valid suggestions. Before going to make interview, each respondent was given a brief introduction about the nature and purpose of the study. The collected data was verified through surveying the villages and personal interview with the sample respondents. Interviews were normally conducted in a common place of villages where people of all categories including women may sit collectively.

2.3 Data processing and analysis

After completion of collecting data from all the interview schedules were compiled, tabulated and analyzed in accordance with objectives of the study. The responses to the questions in the interview schedules were transferred to master sheet to facilitate tabulation for describing the different characteristics and their constraint facing, the respondents were classified into several categories. The MS Excel was used for data processing and analysis.

2.4 Experimental Results and Analysis

The results of socio-economic studies in villages of Ballia district revealed that land holding area (Table 1) for majority of farmers are under marginal category (86.88 %) with small, medium and large in 8.24, 3.00 and 1.88 % respectively. The land use pattern (Table 2) showed that agriculture was major land use (78.41 %) followed by agroforestry (11.24 %) and horticulture (4.59 %). The diversity of trees, crops and vegetables in the study area reflected different combination of trees and crops in the study area (Table 3). The results demonstrated that a total of 06 different agroforestry practices, agri-silviculture, silvi-horticulture, agri-horticulture, agri-silvi-horticulture, silvi-pastoral, and homestead existed in different villages. Out of different categories, timber, fruits, medicinal, agriculture, flower and other plant species were recorded. The different agroforestry combinations were recorded namely: eucalyptus-wheat, teak-maize, teak-marigold, teak-vegetables (potato & cabbage) in Dubhad block, teak-wheat / mustard, teak- maize, teak-mango, teak-vegetables (potato) in Belhari block, teak-maize/sorghum, teak- wheat/mustard, teak-marigold, teak/shisham-potato/chilli, Aquaculture in Bairia block, teak- maize, mango-wheat, eucalyptus-vegetable (tomato/chilli) in Murlichhapara block, teak-wheat, teak-chickpea, teak-pigeon pea in Beruarbari block, shisham-wheat, teak-mango/wheat/pigeon pea in Gadwar block, wheat-eucalyptus, teak-chickpea/potato, shisham-black/green gram in Chilkahar block, eucalyptus/shisham-wheat/arhar, teak-wheat/vegetables in Maniar block, eucalyptus/shisham-aquaculture, teak-pigeon pea, mango-mustard/wheat, teak-bajra/maize in Nawanagar block, teak-potato, shisham-onion/garlic, teak-maize/sorghum in Pandah block, shisham-potato/tomato, teak-marigold, mango/guava-wheat/mustard, teak-maize in Bansdih block, teak-wheat, teak/eucalyptus-garlic/onion in Revati block, teak-maize/sorghum, shisham/teak-chick pea, mango-mustard, teak-vegetables(potato/cabbage/chilli) in Sohaon block, teak-wheat/maize/sorghum, shisham-potato/chilli in Hanumangaj block, teak/mango-wheat, eucalyptus-wheat/mustard in Siar block, eucalyptus/shisham-wheat, shisham/mango-mustard/wheat, teak-maize/jowar in Nagra block, teak-wheat/mango, eucalyptus-maize crops in Rasra block of the district Ballia.

It was recorded that out of existing agroforestry practices, scattered near farms and around homestead was found most common (about 37.7 %). The existing agroforestry systems were also quantified in the district (Table 4 and Fig.2) followed by agri-silviculture (20.20 %), silvi-horticulture (19.1 %) and agri-horticulture (12.3 %). The teak, mango, eucalyptus and aonla were most preferred species in plantations (Table 5). The pattern of plantation in agroforestry was also studied and found that systematic tree planting on bunds and blocks was very less with 17.94 % and 16.82 % respectively (Table 6 and Fig.3). The benefits ranking from trees depicted that daily need (fruits and vegetables) was ranked most preferred followed by timber as second and shade was ranked as third benefit. The other benefits were nutrients, protection, soil erosion control and N-fixation (Table 1).

TABLE 1
LAND HOLDING PATTERN IN BALLIA DISTRICT

S. No.	Land holding area (ha)	Dubhar	Belhari	Bairia	Murli Chhapra	Beruarbari	Garwar	Chilkahar	Maniar	Navanagar	Pandah	Bansdih	Rewati	Sohanv	Hanumanga j	Siar	Nagra	Rasra	Average
1	Marginal (<1ha)	92	95	98	99	95	94	95	90	55	99	95	93	95	70	40	92	80	86.88
2	Small (1-2 ha)	5	3	2	1	3	3	4	5	40	1	2	4	3	20	30	4	10	8.24
3	Medium (2-3 ha)	2	1	0	0	1	2	1	3	3	0	2	2	1	6	20	2	5	3.00
4	Large (>3ha)	1	1	0	0	1	1	0	2	2	0	1	1	1	4	10	2	5	1.88

TABLE 2
LAND USE PATTERN IN BALLIA DISTRICT

S. No.	Land use Pattern	Dubhar	Belhari	Bairia	Murli Chhapra	Beruarbari	Garwar	Chilkahar	Maniar	Navanagar	Pandah	Bansdih	Rewati	Sohanv	Hanumangaj	Siar	Nagra	Rasra	Average
1	Agriculture	75	70	75	90	80	85	70	73	75	90	80	80	82	80	75	83	70	78.41
2	Agroforestry	10	18	15	5	12	3	20	18	10	2	10	9	8	10	20	11	10	11.24
3	Horticulture	8	5	7	1	2	2	3	5	2	1	5	5	7	5	2	3	15	4.59
4	Waste Land	2	3	1	1	2	3	1	2	3	2	2	3	1	2	1	2	2	1.94
5	Others	5	4	2	3	4	7	6	2	10	5	3	3	2	3	2	1	3	3.82

TABLE 3
EXISTING TREE CROP COMBINATIONS IN AGROFORESTRY SYSTEMS IN BALLIA

S. No.	Blocks	Existing Agroforesry System	Classes of Agroforestry System
1	Dubhad	Eucalyptus – Wheat Teak – Maize Teak – Marigold Teak – Potato / Cabbage	Agri – Silviculture Agri – Silviculture Silvi – Horticulture Silvi – Horticulture
2	Belhari	Teak – Maize Teak – Wheat / Mustard Teak – Mango Teak – Potato	Agri – Silviculture Agri – Silviculture Silvi – Horticulture Silvi – Horticulture
3	Bairia	Teak – Maize / Sorghum Teak – wheat / Mustard Teak – marigold Teak / Shisham – Potato / Chilli Mango/Mahua – Aquaculture	Silvi – Pastoral Agro – Silviculture Silvi – Horticulture Silvi – Horticulture Aqua – Horticulture
4	Murlichhapara	Teak – Maize Teak – Wheat Mango – Wheat / Mustard Eucalyptus – Tomato / Chilli	Agro – Silviculture Agro – Silviculture Agro – Horticulture Silvi – Horticulture
5	Beruarbari	Teak – Wheat Teak – Chickpea Teak – Pigeon Pea	Agro – Silviculture Agro – Silviculture Agro – Silviculture
6	Gadwar	Shisham – Wheat Teak - Mango Teak – Wheat Teak – pigeon Pea	Agro – Silviculture Silvi – Horticulture Agro – Silviculture Agro – Silviculture

7	Chilkahar	Wheat – Eucalyptus Teak – Chick Pea Teak – Potato Shisham – Black / Green Gram	Agro – Silviculture Agro – Silviculture Silvi – Horticulture Agro – Silviculture
8	Maniar	Eucalyptus – Wheat / Arhar Teak – Wheat Shisham – Wheat / Arhar Teak – Potato / Brinjal Teak – Onion / Cauliflower	Agro – Silviculture Agro – Silviculture Agro – Silviculture Silvi – Horticulture Silvi – Horticulture
9	Nawanagar	Eucalyptus – Wheat Teak – Pigeon Pea Eucalyptus / Shisham – Aquaculture Mango – Mustard / Wheat Teak – Bajra / Maize	Agro – Silviculture Agro – Silviculture Aqua – Silviculture Agro – Horticulture Silvi – Pastoral
10	Pandah	Eucalptus – Wheat / Mustard Teak –Potato Shisham – Onion / Garlic Teak – Maize / Sorgham	Agro – Silviculture Silvi – Horticulture Silvi – Horticulture Silvi – Pastoral
11	Bansdih	Teak – Maize Shisham – Potato / tomato Teak – Marigold Mango / Guava – Wheat / Mustard	Agri – Silviculture Silvi – Horticulture Silvi – Horticulture Agro – Horticulture
12	Revati	Teak – Wheat Teak – Garlic / Onion Eucalyptus – Garlic / Onion	Agro – Silviculture Silvi – Horticulture Silvi – Horticulture
13	Sohaon	Teak – Maize / Sorghum Shisham / Teak – Chick Pea Mango – Mustard Teak – Potato / Cabbage / Chilli	Silvi –Pastoral Agro – Silviculture Agro – Horticulture Silvi – Horticulture
14	Hanumanganj	Teak – Wheat Shisham – Potato / Chilli Teak – Maize / Sorghum	Agro – Silviculture Silvi – Horticulture Silvi – Pastoral
15	Siar	Teak – Wheat Eucalyptus – Wheat / Mustard Mango – Wheat	Agro – Silviculture Agro – Silviculture Silvi – Horticulture
16	Nagra	Eucalyptus - Wheat Shisham – Wheat Shisham – Mustard Mango – Wheat / Mustard Teak – Maize / Jowar	Agro – Silviculture Agro – Silviculture Agro – Silviculture Agro – Horticulture Silvi – Pastoral
17	Rasra	Teak – Wheat Teak – Mango Eucalyptus - Maize	Agro – Silviculture Silvi –Horticulture Agro – Silviculture

TABLE 4
EXISTING AGROFORESTRY SYSTEMS IN BALLIA DISTRICT

S. No.	Classes of agroforestry systems	Status in Ballia district (%)
1	Agri-silvi	20.20
2	Silvi-horti	19.1
3	Agri-horti	12.3
4	Agri-silvi-horti	3.5
5	Silvi-pastoral	7.3
6	Homestead	37.7

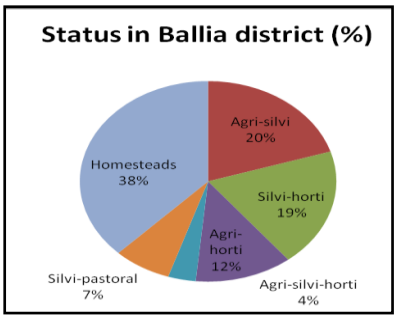

FIGURE 2: Status of Agroforestry systems were also quantified in the district

TABLE 5

PREFERENCE SCORE OF TREES IN BALLIA DISTRICT

S. No.	Tree species	Preference score of trees
1	Teak	1
2	Shisham	8
3	Mango	2
4	Neem	5
5	Babool	7
6	Bamboo	9
7	Mahua	6
8	Eucalyptus	3
9	Aonla	4
10	Others	10

TABLE 6

STATUS OF PATTERN IN AGROFORESTRY PLANTATION IN BALLIA DISTRICT

Pattern of agroforestry plantation	Status in developmental Blocks (%)																	Status in Ballia District (%)
	Dubhar	Belhari	Bairia	Murli Chhapra	Beruarbari	Garwar	Chilkahar	Maniar	Navanagar	Pandah	Bansdih	Rewati	Sohanv	Hanumangaj	Siar	Nagra	Rasra	
Scattered on farms	23	30	28	40	23	28	23	24	31	35	32	24	28	21	28	22	27	27.47
Bunds	17	12	16	8	18	16	22	26	18	12	17	16	16	19	22	30	20	17.94
Block	14	18	12	6	22	12	17	22	21	10	11	12	24	15	26	20	24	16.82
Others	46	40	44	46	37	44	38	28	30	43	40	48	32	45	24	28	29	37.76

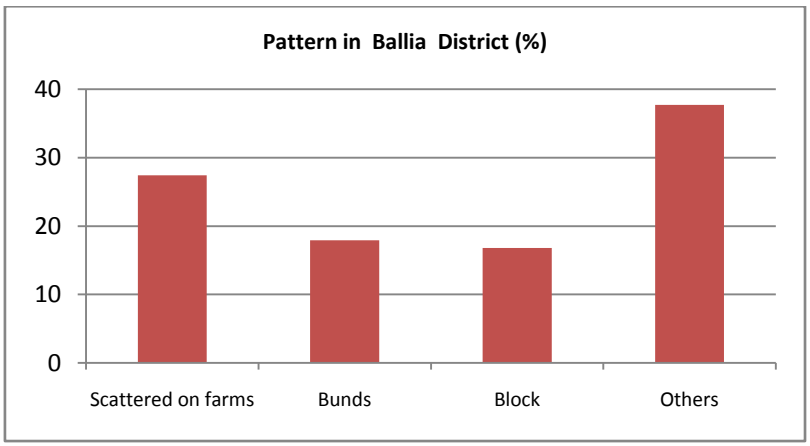

FIGURE 3: Systematic tree planting on bunds and blocks

TABLE 7

BENEFITS FROM AGROFORESTRY IN BALLIA

Benefits	Benefits in developmental Blocks																		Preference score
	Dubhar	Belhari	Bairia	Murli Chhapra	Beruarbari	Garwar	Chilkahar	Maniar	Navanagar	Pandah	Bansdih	Rewati	Sohanv	Hanumangaj	Siar	Nagra	Rasra	Average	
Shade	2	3	3	1	3	2	3	3	3	1	2	3	3	3	3	3	3	2.59	**3**
Fruit/Veg.	1	1	1	2	1	1	1	1	1	3	1	2	1	1	1	2	1	1.29	**1**
Timber	3	2	2	3	2	3	2	2	2	2	3	1	2	2	2	1	2	2.12	**2**
Fire wood	4	4	8	8	5	8	5	4	8	8	4	5	5	5	6	5	5	5.71	**6**
Medicinal	8	6	7	4	6	4	6	5	4	5	5	4	4	6	5	4	6	5.24	**4**
Soil erosion	6	7	5	5	8	6	8	6	7	7	8	8	7	8	8	8	8	7.06	**8**
Protection	7	5	6	7	7	7	7	7	6	6	7	7	8	7	7	7	7	6.76	**7**
Fodder	5	8	4	6	4	5	4	8	5	4	6	6	6	4	4	6	4	5.24	**5**

The farmers have little opportunities to select the tree species and therefore, they accept whatever is available on their land (Bhatt *et al.* 2010). Dadhwal *et al.* (1989) and Toky *et al.* (1989) have recognized three agroforestry systems with their multifarious benefits. The various problems and constraints of agroforestry can be overcome through policy and institutional reforms (Smith *et al.,* 1998). Moreover, there is deficiency in the understanding of biophysical concerns correlated with productivity, water-resource sharing, soil productivity and plant interactions in agroforestry systems, since most of the research is site-specific, observational in nature and not process-oriented (Puri and Nair, 2004). In almost all tropical and subtropical eco zones, agroforestry is represented by the homestead farming, essentially the mixed cropping of annual and perennial crops around the farmer's dwelling houses. Home gardens are recognized worldwide as an epitome of sustainable agroforestry systems (Torquebiau, 1992; Kumar & Nair, 2004). Thus, agroforestry practices can be an important tool to achieve the 4 per cent sustainable growth in agriculture (National Agroforestry Policy, 2014). The promotion of sustainable agroforestry practices on a large scale in future is only possible through amalgamation of proactive farmer policies of government, involvement of the industries, support services from NGOs and willingness of farmers (Verma *et al.* 2017). Extension services are important for smooth dissemination of research results on the different aspect of agroforestry but research results on agroforestry, available in the public and private domain do not regularly reach the farmers due to lack of a proper or dedicated extension system. The Farmers with major land holdings will get more benefit by the agroforestry related schemes than the small and marginal farmers. So, there is need to introduce special programmes on agroforestry models for marginal and small farmers (Verma *et al.* 2017) because 2/3rd farmers of Indian farmers are small and marginal farmers (Kumar *et al.* 2017; Singh & Pandey, 2011) . It is needed to strengthen the agroforestry practices by identifying successful models that can be adopted by the farmers on a wide scale. Advancement of contemporary agricultural technology would also be helpful in increasing the yield of sole crops as well as intercrops (Jain & Singh, 2000). In order to use agroforestry systems as an important option for livelihood improvement, climate change mitigation and sustainable development in India, research, policy and practice will have to progress towards: (i) effective communication with people in order to enhance agroforestry practices with primacy to multifunctional values; (ii) maintenance of the traditional agroforestry systems and strategic creation of new systems; (iii) enhancing the size and diversity of agroforestry systems by selectively growing trees more useful for livelihood improvement; (iv) designing context-specific silvicultural and farming systems to optimize food production, carbon sequestration, biodiversity conservation; (v) maintaining a continuous cycle of regeneration-harvest–regeneration as well as locking the wood in non-emitting uses such as woodcarving and durable furniture; (vi) participatory domestication of useful fruit tree species currently growing in wilderness to provide more options for livelihood improvement, and (vii) strengthening the markets for non-timber forest products. Prevalence of a variety of traditional agroforestry systems in India offers opportunity worth reconsidering for carbon sequestration, livelihood improvement, biodiversity conservation, soil fertility enhancement and poverty reduction (Pandey, 2007).

III. CONCLUSION

The different combinations of agroforestry systems were recorded in the studied areas which were of various benefits for rural livelihood. The systematic pattern in tree planting needs to be improved for the region. The extension and training programmes regarding selection of species, tree planting pattern, nursery raising, quality planting material, maintenance and management of plantations and most importantly, the marketing of trees as end produce. In marketing or sale of trees, transit and felling permit to be issued by forest department is very important. The unawareness of rules and fear of administration discourages farmers for adopting agroforestry widely at large level in this region. It is well known that western part of UP is more flourished than Eastern part for adoption of agroforestrty. It is now urgent need of time to adopt tree plantations in massive way in districts of Eastern Plain zone to achieve our national target of forest policy. Agroforestry is the only way for progress for farmers and rural people, leading to sustainable development, food and nutritional security. Agroforestry adoption with suitable species of economic value will improve country's forest and tree cover to the 33 per cent as desired in national forest policy. The foresters, researches, NGOs and tree growers and traders are needed to coordinate on a common platform for successful implementation of agroforestry programme on massive level. Further, to enhance the efforts of farmers, sale of end products should be strengthened with the involvement of project planners and wood based industries.

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