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Assessment of Growth Performance of African Giant Land Snail (*Archachatina marginata, swaison*) using 25% Crude Protein on Different Particle Sizes

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Abstract
This work aimed at helping farmers with the best form of feed for their snails by assessing the live weight gain, length increase, width increase, average dry matter intake in relation to different particle sizes, effects of different particles sizes on consumption and total and average number of eggs laid, per snail as well as survival rate using 25% crude protein of powdered pellet, crushed pellet and pellet. The results of the work revealed that snails' live weights gained for the period of eight weeks that minimum values for weight gained for

*powdered is greater than, and pellet greater than crushed (206.7g>205.0g>198.9g). While the maximum values weights gain are 233.8g, 290.4g and 220.7g respectively (powdered< pellet>crushed). Weight gain was significant at 0.123** (0.01 levels). For width increase, the min. values were powdered 27.90cm, crushed 28.30cm and pellet 28.00cm. While maximum values is 29.50cm for powdered, 28.90cm for crushed and 30.30cm for pellet. Width increase is significant at 0.009** (0.01). Also for length increase of snails' shell, the minimum and maximum value was highest for pellet (13.20cm and 14.40 cm respectively). The length increase of snails' shell was significant at 0.171* (0.05 levels). Average number of eggs laid ranges between 0.663-2.400, where snails under powdered treatment has the highest and crushed-pellet least. There is a significant difference (.423*) in the number of eggs produced at p-(0.05) level. The study showed that all the particle sizes of these feed using 25% crude protein is all good for the feeding of snails in captivity. But this can be harnessed depending on what one desires (eggs, fast growth, etc). The use of compounded feed particles containing 25% crude protein can be used as supplement or main feed especially for snails farmer who has less time in gathering or selecting other natural feed. The compounded feed can be cheaply formulated or gotten from feed mill waste. Farmers who have snail farm at extensive level could embark on the use of compounded feed as a supplementary feed to supply the nutrients needed by the animal at right proportion and thereby improving their performances and also increase their population at the same time.*

Keywords: *Feed particles, Snails, Farmers, Crude Proteins, Weight Gain.*

INTRODUCTION

The increasing growth of human populations (Oyenuga, 1968) together with the rising standard of living has also placed great pressure on the existing sources of animal protein. Therefore, the need to intensify efforts in developing alternative animal protein sources is quite obvious. One of such is development of snails farms (Imevbore, 1990). In West Africa, African giant snail serves an increasing important role in the tropics by virtue of their survival under captive rearing, ability to accept and convert plant parts and artificial diet to flesh as well as being of high consumer

preference (Ejidike, 2004). Snails meat is a popular source of protein and non for the rural poor people but very expensive in their urban centers in here it's regarded as delicacy for the rich (Imevbore, 1990).

The most common breeds of edible snails found in Africa are: *Achachatina marginata, Achatina achatina, Limicolaria spp (FAO,* 1986). These snails belong to the largest groups of molluscs constituting the longest animal group after arthropods (Yoloye, 1984). Land snails habitat ranges from the dense tropical high forest in Southern Nigeria to the fringing riparian forests of the derived Guinea savanna (Ajayi *et. al.,* 1980). Edible land snails range in size, adaptability, environment, and growth rate (Amusan & Omidiji 1999). Snails are unequivocally of tremendous use as a source of food and income for man and by virtue of which its multiplication should receive urgent and adequate attention to prevent dependence of man on natural supply. Hence the need for better performance of Land snails, through intensive rearing systems over what is obtainable in their natural habitat where they are exposed to many environmental hazards like bush burning, drought etc. Few of the different rearing systems are: extensive system, intensive system and semi intensive (Imevbore 1990).

Snails are able to survive prolonged period without food or water losing much weight in the process. Compounded ration improves the performance of *A. marginata* as it provides for optimal snails growth (Ejidike 2004). Animals' growth depends greatly on the level of protein intake and utilization of other food nutrients (Ejidike 2004). Compounded feed is an alternative ration of feed which can be easily formulated using the appropriate formulae and generally contains protein, fat, minerals and vitamins for improved snails' growth (Akinnusi, 1998). Snails do well with scientific formulated feed which embraces all required nutrients for growth maintenance and reproduction. (Imevbore, 1990). Therefore, the investigation of diet protein level requirement of *A. marginata* is important using locally available ingredients (Ejidike, 2004).

Due to increasing human population and disequilibrium in food demand and supply, there is an urgent need to provide another source of animals' protein. African giant land snail *(Achachatina marginata)* is a non-conventional wildlife protein source in Nigeria and some parts of Africa. Snails are wild species known as one of the major forest products that requires conservation (Anadu, 1987). Therefore, there is a need to stop hunting wild snails to prevent extinction. Interest in snails farming needs to be encouraged among livestock farmers for sustainability. Experts have therefore provided sufficient information on types of housing, feed and feeding types and control measures of pest and diseases in the management. This study is therefore poised to assess the average live weight gain, length increase, width increase, average dry matter intake in relation to different particle sizes, effects of different particles sizes on consumption and total and average number of eggs laid per snail as well as survival rate using 25% crude protein of powdered pellet, crushed pellet and pellet.

BIOLOGY OF AFRICAN GIANT SNAIL (*Achachatina marginata, swaison*)

Taxonomic Classification of Snail

Snail belongs to the phylum *Mollusca.* It is the second largest group of invertebrate animals next to arthropods containing over 80,000 living species. The group is known with the possession of shell. The West African giant land snail is classified as follows:

Kingdom: Animalia
Phylum: Mollusca
Class: Gastropoda (Univalves)
Subclass: Pulmonata (Lung snail)
Superorder: Stylommatophora
Order: Sigmurethra
Suborder: Holopodopes
Superfamily: Achatinacae
Family: Achatinidae
Subfamily: Achatininae

Genus: Achachatina
Species: *Achachatina marginata*(Adapted from Akinnusi, 1998)

Physical Characteristics of Snails: Snail belongs to the class *gastropoda,* which is derived from the Greek word "gaster" meaning belly and "podos" foot. Hence, gastropoda are described as belly-footed or stomach-footed which refers to the broad tapered foot on which the animals glide (Akinnusi, 1998). The snail body is divided into three different regions: *head, larger ventral muscular feet* and *viscera mass.*

The Head: The fleshy head bears two pairs of tentacles that can be retracted. Each longer pair of tentacles has a tiny eye at the tip which distinguishes only light and darkness, while the shorter pair tentacles are organs of smell. The mouth is at the center of the head below the shorter pair of tentacles which opens directly into a muscular cavity equipped with horny jaw in a radula, a flexible file-like rasping organ with numerous rows of teeth for shedding food (Akinnusi 1998).

The Larger Ventral Muscular Feet: The pedal mucous gland secrets mucus which facilitates the snails movement, it also prevents snail and the delicate soles of the foot from dying (Segun, 1975). The broad flat foot is muscular and used for crawling and digging the soil. The speed of movement is very slow rarely exceeding 10-13cm per minute.

Visceral Mass: It is entirely contained within the shell, un-segmented and the digestive system is well developed. The visceral mass lies above the foot and carries the internal organs (Amusan and Omole, 2000). In most molluscs is a twisted alimentary treat; with a well developed digestive system with a mouth and anus.

Snail ranges greatly in size. The largest land snail is the giant African snail (*Achachatina marginata).* The African giant snail is native to the tropical rainforest extending from Guinea to Nigeria (Ayodele, 1993). The most common breeds of African land snails are: *Achachatina marginata,*

Achatina achatina, Achatina fulica and Limicolaria spp. (Akinnusi, 1998). *Achachatina marginata* has a bulbous shell with brown stripes and a wide apex. The foot is usually brown to black in colour (Akinnusi, 1998). When sexually matured, it lays eggs about 5-15 per clutch. It measures 11-19cm in length and 150-900g live weight while that of a newly hatched snailet is approximately 2.25g at day old. It is the largest snail which is found in many regions with most popular demand (Mariska, 2005).

Feeding in Snails

Snails have been described as nocturnal animals because they are more active at night. Hence the tendency has always been to restrict feeding and other maintenance activities till the evening and early hours of the night (Malcum, 1998). The snail food ranges from snails of all ages some can eat plants such as lettuce, cabbage, egg-plant, water-leaf, banana, pineapple, pawpaw etc. (Imevbore, 1990; FAO, 1986 and Akinnusi, 1998). All these have been found beneficial to growth and proper well being of the animals meeting energy requirement, mineral and salt needs among other body nutritional needs. Snails eat little quantity of food compared to other conventional livestock (Odukoya, 1998). It locates food with its shorter pair of tentacles, using many small hard teeth of the radula. The snail grasps at the food and swallows it (Imevbore, 1990).

Supplementary Feed

Snails do well with scientific formulated feed which embraces all required nutrients for growth, maintenance and production (Imevbore, 1990). Production of land snail species can be sustainable and economical only when both qualitative and quantitative feed requirements are met and established. These could be made possible by formulating and preparation of nutritionally balanced and less costly diets for snail at different stages of life (Ejidike, 2004).

Growth

Within the same snail population and under the same conditions, some snails will grow faster than the others. Some will take twice as long to

mature (Sheldon *et. al.,* 2008). Most of the differences in growth are probably due to environmental factors including steadying density. Mariska, 2005 reported that snails are untreatable to overpopulation which causes decrease in number of eggs produced and low weight gain which leads to death due to build up of slime on the ground. A snailet's shell depends on the egg size since the shell grows, the shell increases until it develops a flare up at its opening showing maturity (Thompson, 2008).

Habitat

Snails are the largest groups of molluscs constituting the largest animal group after arthropods (Yoloye, 1984). Land snail's habitat ranges from the dense tropical high forest in southern Nigeria to the fringing riparian forest of the derived Guinea savannah (Ajayi *et. al.,* 1980; Osaibo, 1997). From November to March each year, Nigerian snails aestivate because of hot and dry weather. During aestivation period, the aperture is temporarily closed and a calcified material known as epiphragm which is whitish, fragile material (Nisbet, 1974). During aestivation, the snails bury themselves in the soil or hide in order to avoid direct solar radiation (Schmidt-Nielsen *et. al.,* 1971). When it rains, the epiphragm breaks and very cold water stored before aestivation pours out of the aperture (Ajayi *et. al.,* 1980) then snail comes out to feed (Osaibo, 1997).

Reproduction

Snails have been known to be hermaphrodites. They possess both male and female organs. In spite of this, they hardly self-fertilize themselves, rather a common mating posture is usually undertaken when two animals come together and exchange sperms. This lasts between 6-24 hours. The complexity of the female organs ensures separation of the snails own sperm from that of the partner and makes it possible for various coating of the ovum. The slender vas deference, bound to the oviduct by connective tissues, passes forward from the anterior region of the albumen gland (Akinnusi, 1998). Most snails can mate when they are around 1 year old, the reproductive opening is on one side of the body near the front, through which the outer reproductive organs are excluded so that exchange of

sperm can take place for fertilization to occur (Free encyclopedia 2008). Egg laying snail needs soil at least 2 inches deep in which to lay egg (Thomson, 2008). Egg sizes differ among species. It is 3mm diameter in the giant African land snail. After 2-4 weeks of favourable weather, these eggs hatch and the young emerging snailets start new life (Free encyclopedia 2008). Snail needs sandy-loamy soil at least 2-5cm deep to lay their eggs. The eggs are laid within 7-14 days at mating in clusters or clumps. The snail pushes soil over the hole in which the eggs are laid and leaves the eggs with no further maternal care (Akinnusi, 1998).

Life Span and Predators

The life span of snail varies from species to species. Achatinidae snails live 5-7 years and helix snails live about 2-3 years. Most deaths are due to predators or parasites. In captivity, their lifespan is much longer, ranging from 10-15 years for most species. On occasions, snails have lived beyond this lifespan, up to 30 years (Free encyclopedia 2008).

Diseases and Pests

Basic common sense hygiene may prevent the spread of disease or otherwise improve the health and growth rate of snails (Thompson, 2008). Crowding snails are vulnerable to every population which causes decrease in number of eggs produced, low weight gains and deaths due to build up of slime on the ground. For African snails, density stocks of about 100 juveniles or 30 sub-adult snails per square meter is recommended (Mariska, 2005). Land snails have many natural predators including members of all major vertebrate groups decollate snails, ground beetles, leeches and even the predatory caterpillar, human also pose great danger to snails in the wild (Free encyclopedia 2008). Parasites, nematodes, trematodes, fungi, and micro arthropods may attack snails, predators like rats, mice, moles, skunks, weasels, birds, frogs, toads, lizards walking insects like beetles, some types of flies, centipedes and even cannibalistic snail varieties attack snails (Thompson, 2008).

MATERIALS AND METHODS

Study Area

This study was carried out in the domestication unit of the Department of Wildlife and Ecotourism Management, University of Ibadan, Ibadan. Ibadan coordinate is 7°23′47″N 3°55′00″E. it has a mean annual rainfall of about 1,350mm approximately in 80 days. This experiment was conducted during the raining season and with a maximum temperature of 30°C, in between middle of March and May 2009.

Materials used for the Study

- 3 doubled chambered raised wooden box 1.5m x 0.5m
- 90 adult snails (*Achachatina marginata*)
- 3 hand trowels and 3 watering cans
- Uniform percentage of 25% crude protein
- Feeding troughs
- Weighing balance
- Knife
- Tape rule
- Cutlass and
- Spent engine oil

Formula used in the Experiment for the Compounded Feed

Ingredients	Percentage Composition (%)
Maize	41.50
Wheat-offal	6.70
Corn-bran	6.70
Soya-bean meal	16.45
Oyster-shell	6.70
Bone-meal	6.70
Premix	6.70
Fish meal	8.55
Total	**100.00**

Methods

Ninety adult giant land snails *(Achachatina marginata)* with initial live weight measured were obtained for the study. The snails were randomly

allocated into 3 treatments of 30 each and each treatment is divided into a replicate of three containing 10 each. Each 10 were arranged in the double chambered wooden box which contained 5cm high loamy soil roasted on fire and sterilized from infectious diseases. Banana leaves were used to cover the wooden boxes to provide enough shade against sunshine and also reduce excess water loss. The environment was also kept clean using disinfectant to wade-off insects, pests and other forms of predations. The study spanned through eight weeks (8 weeks).

Feeding

The compounded feed with 25% crude protein (fish meal and Soya-bean meal) made in powdered form, semi-pellet form and pellet form were served to groups of two replicates treatment each.

Experimental Data collection

The weight gained was taken twice in a week. The size increase, egg production and mortality recorded. Size increase was obtained by taking away initial values from final values. Length and width was obtained by using a tape rule to measure from the apex of the shell to the base margin and circumference of the shell was determined between the outer lip and the opposite wall.

Statistical Analysis

The analysis for this work was done by using descriptive statistics, percentages, analysis of variance (ANOVA), and Correlation analysis.

RESULTS

Table 1a: Descriptive Statistics of Snails' Weight Gain

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Powdered	8	219.9750	8.96736	3.17044	206.70	233.80

Crushed	8	210.0375	7.93850	2.80668	198.90	220.70
Pellet	8	227.9000	26.20425	9.26460	205.00	290.40
Total	24	219.3042	17.56027	3.58447	198.90	290.40

Table 1b: Anova Values for Snails' Weight Gain

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1281.676	2	640.838	2.316	.123
Within Groups	5810.674	21	276.699		
Total	7092.350	23			

The snails' average live weights gained for the period of eight weeks is presented in table 1a and 1b above. The minimum average live weight gained for powdered, crushed and pellet were 206.7g, 198.9g and 205.0g while for maximum, the weights were 233.8g, 220.7g and 290.4g respectively. The anova result however showed that weight gain between groups was significant at 0.123.

Table 2a: Descriptive Statistics of Width Increase of Snails' Shell

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Powdered	8	28.7500	.53452	.18898	27.90	29.50
Crushed	8	28.5875	.21671	.07662	28.30	28.90
Pellet	8	29.5875	.90780	.32096	28.00	30.30
Total	24	28.9750	.74323	.15171	27.90	30.30

Table 2b: Anova Values for Width Increase of Snails' Shell

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4.607	2	2.304	5.975	.009
Within Groups	8.098	21	.386		
Total	12.705	23			

The snails' shell average width increase for the period of 8 weeks is shown in table 2a and 2b above. Minimum width increase for snails treated with powdered, crushed and pellet were 27.90cm, 28.30cm and 28.00cm respectively. Also, the maximum width increase for each treatment was 29.50cm for powdered, 28.90cm for crushed and 30.30cm for pellet. However, anova result revealed that the increase was significant between groups at 0.009.

Table 3a: Descriptive Statistics of Length Increase of Snails' Shell

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Powdered	8	13.6125	.34821	.12311	13.00	14.00
Crushed	8	13.6625	.45336	.16029	12.90	14.10
Pellet	8	14.0000	.47809	.16903	13.20	14.40
Total	24	13.7583	.44713	.09127	12.90	14.40

Table 3b: Anova Result Showing Length Increase of Snails' Shell

Table 4: Snails' Egg-laying Performance

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.711	2	.355	1.920	.171
Within Groups	3.888	21	.185		
Total	4.598	23			

It is shown in tables 3a and 3b above the length increase of snails' shell observed during the period of the study. The minimum values for each treatment of powdered, crushed and pellet were 13.00cm, 12.90cm and 13.20cm respectively. Also, the maximum length increase for each treatment was 14.00cm for powdered, 14.10cm for crushed and 14.40cm for pellet. The length increase of snails' shell was significant at 0.171 as shown by the anova result.

			Treatments			Total
			Powder	Crushed	Pellet	
Number of eggs	.00	Count	3	6	4	13
		% within number of egg	23.1%	46.2%	30.8%	100.0%
	1.30	Count	1	1	1	3
		% within number of egg	33.3%	33.3%	33.3%	100.0%
	2.00	Count	1	0	0	1
		% within number of egg	100.0%	0.0%	0.0%	100.0%
	2.30	Count	1	0	2	3
		% within number of egg	33.3%	0.0%	66.7%	100.0%
	4.00	Count	0	1	0	1
		% within number of egg	0.0%	100.0%	0.0%	100.0%
	4.60	Count	1	0	0	1
		% within number of egg	100.0%	0.0%	0.0%	100.0%
	6.00	Count	0	0	1	1
		% within number of egg	0.0%	0.0%	100.0%	100.0%
	9.00	Count	1	0	0	1
		% within number of egg	100.0%	0.0%	0.0%	100.0%
Total		Count	8	8	8	24
		% within number of egg	33.3%	33.3%	33.3%	100.0%

The average number of eggs laid within the period of 8 weeks under the three treatments is shown in table Di (see appendix). The table 4 shown above indicated the percentage count per week of eggs laid by the snails.

Table 5: Snails' Survival Rate (in percentage)

Treatment	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Mean Surv. Rate
Powdered	100	96.7	96.7	96.7	96.7	93.3	90.0	90.0	95.013
Crushed	100	100	96.7	96.7	96.7	96.7	83.3	83.3	94.175
Pellet	100	100	100	100	90.0	90.0	86.7	76.7	92.925

The survival rate of the snails (in percentage) under each treatment is presented in table 5 above. The survival percentage of the snails treated with powdered form of the pellet is the highest with 95.0 % and the one treated with pellet has the least, 92.9 %.

Table 6: Correlation Results on General Characteristics of Snails' Performances

		Weight gain	Width	Length	Number of Eggs
Weight gain	Pearson Correlation	1	.414*	.404	.142
	Sig. (2-tailed)		.044	.050	.508
	N	24	24	24	24
Width	Pearson Correlation	.414*	1	.837**	.393
	Sig. (2-tailed)	.044		.000	.057
	N	24	24	24	24
Length	Pearson Correlation	.404	.837**	1	.423*
	Sig. (2-tailed)	.050	.000		.039
	N	24	24	24	24
Number of Eggs	Pearson Correlation	.142	.393	.423*	1
	Sig. (2-tailed)	.508	.057	.039	
	N	24	24	24	24

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The general characteristics of snails' performances with different particles size of feed formation which include powdered form, crushed form and pellet is shown in table 6 above. The characteristics shown on table 6 are weight gain, width increase, length increase and number of eggs laid.

DISCUSSION

Snails' Weight Gain

The pellet treatment had the highest record while the crushed-pellet had the least. Correlation analysis conducted revealed that the difference in

feed particles did have a significant difference at 0.05 (.414*). This finding revealed that 25% crude protein compounded feed is good for the growth performance of giant land snail which is close to as being observed by (Bright, 1999 and Ejidike, 2004). The study also showed that mean growth was highest when snails were fed with pelleted form of the feed and higher when powdered form of the feed was used. It is therefore advisable to use pellet form of compounded feed due to its suitability to the growth and weight-gain of the snails.

Snails' Shell Width Increase

There was no significant difference at 0.05 among mean width increase. This is in consonance with the mean weight gain as shown in table 1 above. The size, width and length of the snails are directly proportional. When there is increase in any of these parameters, there tend to be increase in the other two. So, mean width increase was most pronounced in the snails treated with pelleted feed and more pronounced in snails with powdered feed. The powdered form of feed is also okay, and can be used in place of pelleted form should the need arise.

Snails' Shell Length Increase

Snails' length under the pelleted feed increased. But this is not the case with the powdered form as observed under weight gain and width increase. Instead, there was noticeable increase in mean length when snails were treated with crushed form of the feed than when treated with powdered feed (see appendix).

Snails' Egg-laying Performance

Average number of eggs laid ranges between 0.663-2.400 (table 4a in appendix), where snails under powdered treatment has the highest and crushed-pellet with least. There is a significant difference (.423*) in the number of eggs produced at p-(0.05) level. From the information on table 4a in appendix, it is shown that snails treated with powdered feed performed best in egg laying, followed by snails treated with pellet. It is therefore asserted that snails at point of lay should be treated with powdered feed

containing 25% crude protein. This may be due to the near total absorption of the feed, due to its very fine size.

Snails' Survival Rate (in %)

There is no significant difference at 0.05-level in the survival rate. It is again observed that the percentage survival in snails treated with powdered form was highest. There was total utilization of powdered feed by snails, which brought about complete supplies of nutrients to the snails and thus leading to high survival rate.

General Characteristics of Snails' Performance

Snails treated with crushed feed showed the highest (17.5 g see appendix) body weight gain throughout the period of the study. However, powdered feed also have a closer value (17.0 g see appendix) to that of the crushed feed. But the overall weight gain is significant (.414* at 0.05 level). It is therefore asserted that when crushed form of the feed is fed to snails *ad libitum,* there would be appreciable weight gain.

The powdered form of the same feed may also have the similar effect when treated on snails. However with pelleted form of the feed, the width increase was highest (2.3 cm see appendix). Powdered feed also performed above the crushed feed (1.4cm against 0.6 cm see appendix). There was similar performance when crushed and pellet form of the feed (1.2 cm and 1.2 cm see appendix) was used among the snails. The performance of the snails under the three treatments (powdered, crushed and pellet) was all right with no significant difference at 0.05 level but width increase was significant (.837** at 0.01 level). However, the length increase within treatment was significant (.837** and .423*) at both 0.01 and 0.05 levels respectively. The feed intake was almost the same and later dropped as the population reduced as utility set in. This was as well observed by (Rebecca and Shelden 2008) that the size of snail may increase significantly when powdered feed is used to feed snails. Generally, in only a couple of time, it was as well observed from this experiment that the snail under the pelleted treatment performs a little better than the remaining ones. This is as well

closer to the observation of Thompson *et al.,* 2008, that pelleted feed is fine for layer snails, powdered feed better for snailets and crushed feed for young snails and sub adult.

CONCLUSION

The study showed that all the particle sizes of these feed using 25% crude protein is all good for the feeding of snails in captivity. But this can be harnessed depending on what one desires (eggs, fast growth, etc). As shown in the study, each particles size of the feed (powdered, crushed and pellet) should be used with specificity as desired by the people (farmers, researchers, consumers etc.) concerned.

RECOMMENDATIONS

- The use of compounded feed can be used as supplement or main feed especially for snails farmers who has less time in gathering or selecting other natural feed.
- The compounded feed can be cheaply formulated or gotten from feed mill waste.
- Farmers who have snail farm at extensive level could embark on the use of compounded feed as a supplementary feed to supply the nutrients needed by the animal at right proportion and thereby improving their performances and also increase their population at the same time.

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APPENDIX

Table A: Snails Live Weight Gain (in gramme)

Treatment	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Mean-weight gain
Powdered	209.6	206.7	218.8	218.4	219.6	233.8	226.3	226.6	219.975
Crushed	198.9	200.8	205.8	207.4	214.7	220.7	215.6	216.4	210.038
Pellet	215.6	217.2	218.2	290.4	205.0	225.4	225.4	226.0	227.900

Table Bi: Width Increase of Snails Shell (in centimeters)

Treatment	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Mean Increase
Powdered	28.1	27.9	28.7	28.9	28.7	29.0	29.2	29.5	28.75
Crushed	28.3	28.6	28.4	28.5	28.5	28.6	28.9	28.9	28.59
Pellet	28.0	28.4	29.4	30.0	30.2	30.2	30.2	30.3	29.59

Table Bii: Duncan Post Hoc Tests on Width Increase

Treatment	N	Subset for alpha = 0.05	
		1	2
Crushed	8	28.5875	
Powder	8	28.7500	
Pellet	8		29.5875
Sig.		.606	1.000

Means for groups in homogeneous subsets are displayed using Harmonic Mean Sample Size = 8.000

Table C: Length Increase of Snails Shell (in centimeters)

Treatment	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Length Increase
Powdered	13.2	13.0	13.6	13.6	13.8	13.9	13.8	14.0	13.61
Crushed	12.9	13.0	13.8	13.8	13.8	13.9	14.0	14.1	13.66
Pellet	13.2	13.3	14.0	14.2	14.3	14.3	14.3	14.4	14.00

Table Di: Egg Laying Performance within the Treatments

Treatment	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Av. Performance
Powdered	0	0	0	2.3	2.0	9.0	4.6	1.3	2.400
Crushed	0	0	0	0	0	1.3	0	4	0.663
Pellet	0	0	0	0	2.3	2.3	1.3	6	1.488

Table Dii: Chi-Square Test of Snails Showing Egg-laying Performance

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.077[a]	14	.520
Likelihood Ratio	14.817	14	.391
Linear-by-Linear Association	.618	1	.432
N of Valid Cases	24		

24 cells (100.0%) have expected count less than 5. The minimum expected count is .33

Table E: Snails' General Performance

Performance Characteristics	Powdered Form	Crushed Form	Pellet
Initial body weight (g)	209.6	198.9	215.6
Final body weight (g)	226.6	216.4	226.0
Body weight gained (g)	17.0	17.5	10.4
Initial width (cm)	28.1	28.3	28.0
Final width (cm)	29.5	28.9	30.3
Width gain (cm)	1.4	0.6	2.3
Initial length (cm)	13.2	12.9	13.2
Final length (cm)	14.0	14.1	14.4
Length gain (cm)	0.8	1.2	1.2
Mean Survival rate (%)	95.0	94.2	93.0
Mean of eggs produced	2.4	0.7	1.5

Proximate Analysis of African Giant Land Snail *(Achachatina marginata)*

Contents	Percentage
Crude Protein	25.00
Crude Fibre	31.80
Fat	4.16
Ash	4.05
Calcium	1.08
Phosphorous	1.48
Energy (Kcal/kg)	3097

Assessment of Valuable Flora Composition in Homegardens of Rural Households in Ikono Local Government Area, Akwa Ibom State, Nigeria

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Abstract

This study aimed at assessing the flora composition of homegardens in Ikono Local Government Area, Akwa Ibom State. The research also focused on the identification and classification of plant species raised in homegardens as well as determining their various uses. The socio-economic characteristics of rural dwellers in the study area was also determined. Ikono LGA is made up of four clans namely, Ikono 1 clan, Ndiya clan, Ediene clan and Itak clan. Five Villages were randomly selected from each clans making a total of twenty Villages for enumeration which was equivalent to twenty households. A total of 120 questionnaires were administered to respondents and the data generated were assembled and analyzed using descriptive statistics which included the mean, frequency and percentage. Simpson's Diversity Index was used to analyze the diversity of plant species in homegardens. The results showed that the diversity index (DI) in Ediene, Itak, Ndiya and Ikono 1clans were 0.060, 0.660, 0.010 and 0.064 respectively. The result also revealed various species of plants in homegardens and their various uses such as food, medicine, wood, firewood, chewing stick and environmental protection. The result showed that 45% of respondents under the age range of 21-40 are actively involved in the business, about 50% of respondents do not attain formal education, 50% of respondents and 44% of respondents have income level at the range of ₦1000 to ₦10,000.00 per month.

Keywords: *Flora, Uses, Composition, Diversity and Homegarden*

INTRODUCTION

In recent years, traditional agroforestry systems have constantly undergone series of transformations. Among all the agroforestry systems practiced in Akwa Ibom State, homegardens represent multiple land use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual's houses which are the central points of biodiversity (Udofia, 2011). The practice of agroforestry in tropical areas have focused on homegarden management and reports from these have been described as prototype for sustainable ecological systems (Padoch and DeJong, 1991; Lamont *et al.,* 1991; Albuquerque *et al,.* 2005).

Homegardens in tropical rainforest have high degree of species diversity of various plant life forms ranging from trees, shrubs, herbs, climbers and grasses which attain different height and canopy structures according to different ecological successions (Etuk *et al.,* 2015). Most of the valuable plant species found in homegardens are planted by man, only very few are naturally inherited from the homegarden which also signifies that people had lived there years ago. The different plant species found in homegardens either cultivated or existing naturally have various uses in which some are multipurpose in nature such food (spicy, protein, vitamins, minerals, oils, soup thickener, fruit, etc,), medicine, fuelwood, income generation, live fences, fibre, forage, chewing stick, timber, nutrient cycling, raw materials and environmental services (Etuk and Attah, 2016). It is therefore imperative to take into consideration the ethnobotanical information and importance of these valuable bioresources especially towards the development of proper conservation strategies for sustainable management and utilization. Conservation of these resources is very paramount because some of these species are facing the danger of extinction due to high demand which to over exploitation for various uses.

Homegarden can therefore, be described as a mixed farming system that encompasses vegetables, fruit, plantations, crops, and ornamental plants

as well as livestock that can serve as a supplementary source of food and income to rural dwellers (Galhena *et al.,* 2013). Homegardens are found in many humid and sub-humid regions of the world and they are sometimes called backyard or kitchen gardens. The gardens have an established tradition and offer great potential for improving household food security and alleviating macro and micro-nutrient deficiencies for both man and livestock (Udoh *et al.,* 2016). The specific size of a home garden varies from household to household and normally, their average size is less than that of the arable land owned by the household (Udofia and Okeke, 2015). It may be delimited by physical demarcations such as live fences or hedges, ditches or boundaries established through mutual understanding. Also, the application of kitchen waste, animal manure and other organic residues has been practiced amongst homegardeners which helps in increasing the productivity and fertility of the gardens. It usually requires family labour including man, woman and children in management and utilization depending on the purpose of the individual species of plants (Landon-lane, 2011).

MATERIALS AND METHODS

The Study Area

Ikono Local Government Area is located at the northern part of Akwa Ibom State between longitudes 7° 50′ and 8° 00′ E and 5° 30′ and 7° 00′ N. Ikono is bounded on the North by Ini LGA and West by Ikot Ekpene LGA respectively. It has a land mass of 407.16 square kilometres. According to 2006 Nigerian census, the human population of Ikono LGA is estimated to be 120,340 people.

Ikono LGA experiences two distinct seasons i.e. wet season which begins in mid-March and last till October. The period is characterized by heavy rainfall (2400mm), high relative humidity of 75% and heavy cloud cover with temperatures of 27°C – 30° C. The dry season begins in November and last till early March (AKSMI, 2000). Ikono LGA has sandy loam soil with low land rainforest vegetation (AKS, 1989).

Methods of Data Collection

Ikono LGA is classified into four (4) clans namely Ikono 1, Ndiya, Ediene and Itak clans. Ikono 1 clan has one hundred and nineteen (119) Villages, Ndiya clan has twenty (20) Villages, Ediene clan has twenty five (25) Villages and Itak clan has seventeen (17) Villages, making a total of 181 Villages in entire Ikono LGA. Since the clans were large, 10% of Villages were randomly selected from each clan i.e. 12 Villages in Ikono 1, 2 Villages in Ndiya, 3 Villages in Ediene and 2 Villages in Itak clans, making a total of nineteen (19) Villages. In each of the 19 Villages, 120 households were randomly selected which were: 54 households for Ikono 1 with 12 Villages, 23 households for Ndiya with 2 Villages, 26 households for Ediene with 3 Villages and 16 households for Itak clans with 2 Villages respectively. Also, a total of 120 structured questionnaires were randomly distributed to the respondents, which is equivalent to the number of households selected in the study area for enumeration. Information relevant to this study were also obtained through oral interviews, text books, magazines, newspapers, journals and internet.

Data Analysis

The data collected from the study area were analyzed using suitable statistical designs such as descriptive statistics which included the mean, frequency and percentages. Simpson's Diversity Index model was also used to analyze the data in order to determine the diversity of plant species identified in the home gardens in the study area (Simpson, 1949). Simpson's Diversity Index can be expressed mathematically as:

$$DI = \sum_{i=1}^{q} \frac{n_i (n_i - 1)}{N (N - 1)}$$

Where,

DI = Simpson's Diversity Index
N = total number of individual plants enumerated
n_i = number of individuals of the species enumerated

q = number of different species enumerated (Ogbeibu, 2005).

RESULTS AND DISCUSSION

Results

Table1 showed that plant species with high population in Ikono 1 clan were *Colocasia esculenta, Dioscorea cayenensis,* and *Vernonia amygdalina* with 6591, 2951 and 2792. Others were, *Piper guinensis, Dioscorea alata, Lasianthera africana, Gnetum africanum,* and *Musa sapientum* with 2391, 2231, 2193, 1398 and 1389 as well as *Ananas cosmosus, Citrus limon, Dioscorea bulbifera* and *Gongronema latifolium* with 1229, 1731, 1523 and 1231. The least population of the species were obtained from *Abelmoscus esculentum* and *Cymbopogon citratus* with 57 respectively.

Table 1: Plant Species Identified in Homegardens of Ikono 1 Clan

Scientific name	Population of plant species	Common name	Ethnic name	Uses	Forms	Parts used
Abelmoschus esculentus	57	Okroa	Etikke	Food, medicine	Herb	Fruit/leaf
Ananas cosmosus	1229	Pinapple	Eyop mbakara	Food, medicine	Herb	Fruit
Capsicum fruitescens	549	Pepper	Ntokon/ntuen	Spice, medicine	Herb	Fruit/leaf
Carica papaya	651	Pawpaw	Popo	Food, medicine	Tree	Fruit, leaf, bark
Chrysophyllum albidum	87	African star apple	Udara	Food, timber, firewood	Tree	Fruit, stem
Sitrus sinensis	120	Orange	Sokoro	Food, medicine, firewood, ornamental	Tree	Fruit, stem, leaf
Cocos nucifera	391	Coconut	Isip mbakara/ isip eyop	Food, medicine, timber, firewood	Tree	Fruit, stem, juice
Cola accuminata	459	Kula nut	Ibong	Food, firewood, dye, medicine	Tree	Fruit, stem, bark, leaf
Cola argentea	641		Ndiya	Food, firewood, medicine	Shrub	Fruit, stem, root
Colocasia esculenta	6591	Cocoyam	Ikpong	Food, medicine	Herb	Corm
Colocynthis vulgaris	791	Melon	Ikon	Food, oil, medicine	Climber	Seed, leaf
Cymbopogon citrates	57	Lemon grass	Nyanyaha	Medicine, flavour	Grass	Leaf
Dacyodes edulis	981	Local peer	Eben	Food, firewood, timber	Tree	Fruit, stem
Dioscorea cayenensis	2951	Yellow yam	Akpanna	Food	Climber	Tuber
Dioscorea alata	2231	Water yam	Ebre	Food	Climber	Tuber
Dioscorea bulbifera	1523	Aerial yam	Edomo	Food	Climber	Bulbil
Dioscorea dumentorum	1329	Sweet yam	Enem	Food, medicine	Climber	Tuber, leaf
Elaeis guineensis	98	Oil palm tree	Eyop	Oil, medicine, broom, firewood, timber, palmwine	Tree	Fruit, stem, seed, frond
Heinsia crinata	232		Atama	Food, medicine, firewood	Shrub	Leaf, stem
Justicia schimperi	392	Hunter's weed	Meme	Food, medicine	Herb	Leaf, root
Lasianthera African	2193		Editan	Food, medicine, chewing stick	Shrub	Leaf, stem
Lycopersicum esculentum	983	Tomato	Tomato	Food	Herb	Fruit
Mangifera indica	891	Mango	Manko	Food, firewood, medicine	Tree	Fruit, stem, bark
Gnetum africanum	1398		Afang	Food, medicine	Climber	Leaf, root
Telfeiria occidentalis	991	Fluted pumpkin	Ikong ubong	Food, medicine	Climber	Leaf, seed
Piper guinensis	2391		Odusa	Food, medicine	Climber	Leaf, fruit
Solanum melongena	981	Garden egg	Nyia	Food, medicine	Shrub	Fruit
Citrus limon	1731	Lemon	Mkpri sokoro	Food, medicine	Shrub	Fruit
Vitis vinifera	998	Grape	Sokoro ntan	Food, medicine	Tree	Fruit
Zea mays	83	Maize	Akpakpa/ibok pot	Food, medicine, starch	Grass	Seed, leaf
Vernonia amygdalina	2792	Bitter leaf	Etidot	Food, medicine	Shrub	Leaf, root
Raffia hookeri	931	Wine palm	Ukot	Food, wine, alcohol, mat, fibre, climbing robe, medicine, staking	Tree	Leaf, juice, tie-tie, piassava,

				material, firewood		bamboo
Persea Americana	79	Avocado peer	Eben mbakara	Food, medicine, timber, firewood	Tree	Leaf, fruit, seed, bark, stem
Congronema latifolium	1231		Utasi	Food, medicine	Climber	Leaf
Ocimum gratisimum	928	Scent leaf	Ntong	Food, medicine	Shrub	Leaf
Musa sapientum	893	Banana	Mboro	Food, medicine, fibre	Tree	Fruit, leaf, stem
Musa paradisiacal	1389	Plantain	Ukom	Food, medicine, fibre	Tree	Fruit, leaf, stem
Manihot esculenta	768	Cassava	Iwa	Food, medicine, starch, beverage	Shrub	Root, leaf
Psidium quayava	93	Quava	Wopa	Food, medicine, firewood	Shrub	Fruit, leaf, stem

Table 2 results also revealed that plant species which have the highest number in Ndiya clan are *Dioscorea dumentorum* and *Colocasia esculentum* with 37879 and 6591. Others were 2951 from *Dioscorea cayenensis*, 1567 from *Lasianthera africana*, 1353 from *Gnetum africanum*, 1297 from *Justicia schimperi*, 1289 from *Vernonia amygdalina*, 5779 from *Colocasia esculentum* and 1209 was obtained from *Ananas cosmosus.* The least species population were obtained from *Cola acuminata* and *Cola argentea* with 10 and 13.

Table 2: Plant Species Identified in Homegardens of Ndiya Clan

Scientific name	Population of plant species	Common name	Ethnic name	Uses	Forms	Parts used
Abelmoschus esculentus	36	Okroa	Etikke	Food, medicine	Herb	Fruit/leaf
Ananas cosmosus	1209	Pinapple	Eyop mbakara	Food, medicine	Herb	Fruit
Capsicum fruitescens	491	Pepper	Ntokon/ntuen	Spice, medicine	Herb	Fruit/leaf
Carica papaya	158	Pawpaw	Popo	Food, medicine	Tree	Fruit, leaf, bark
Chrysophyllum albidum	32	African star apple	Udara	Food, timber, firewood	Tree	Fruit, stem
Sitrus sinensis	41	Orange	Sokoro	Food, medicine, firewood, ornamental	Tree	Fruit, stem, leaf
Cocos nucifera	50	Coconut	Isip mbakara/ isip eyop	Food, medicine, timber, firewood	Tree	Fruit, stem, juice
Cola accuminata	10	Kula nut	Ibong	Food, firewood, dye, medicine	Tree	Fruit, stem, bark, leaf
Cola argentea	13		Ndiya	Food, firewood, medicine	Shrub	Fruit, stem, root
Colocasia esculenta	5779	Cocoyam	Ikpong	Food, medicine	Herb	Corm
Colocynthis vulgaris	57	Melon	Ikon	Food, oil, medicine	Climber	Seed, leaf
Cymbopogon citrates	98	Lemon grass	Nyanyaha	Medicine, flavour	Grass	Leaf
Dacyodes edulis	36	Local peer	Eben	Food, firewood, timber	Tree	Fruit, stem
Dioscorea cayenensis	817	Yellow yam	Akpanna	Food	Climber	Tuber
Dioscorea alata	730	Water yam	Ebre	Food	Climber	Tuber
Dioscorea bulbifera	396	Aerial yam	Edomo	Food	Climber	Bulbil
Dioscorea dumentorum	37879	Sweet yam	Enem	Food, medicine	Climber	Tuber, leaf
Elaeis guineensis	93	Oil palm tree	Eyop	Leaf, root	Tree	Fruit, stem, seed, frond
Heinsia crinata	167		Atama	Leaf, stem	Shrub	Leaf, stem
Justicia schimperi	1297	Hunter's weed	Meme	Fruit	Herb	Leaf, root
Lasianthera African	1567		Editan	Fruit, stem, bark	Shrub	Leaf, stem
Lycopersicum esculentum	89	Tomato	Tomato	Leaf, root	Herb	Fruit
Mangifera indica	29	Mango	Manko	Leaf, seed	Tree	Fruit, stem, bark
Gnetum africanum	1353		Afang	Leaf, fruit	Climber	Leaf, root
Telfeiria occidentalis	996	Fluted pumpkin	Ikong ubong	Fruit	Climber	Leaf, seed
Piper guinensis	173		Odusa	Fruit	Climber	Leaf, fruit
Solanum melongena	78	Garden egg	Nyia	Fruit	Shrub	Fruit
Citrus limon	903	Lemon	Mkpri sokoro	Seed, leaf	Shrub	Fruit
Vitis vinifera	931	Grape	Sokoro ntan	Leaf, root	Tree	Fruit
Zea mays	71	Maize	Akpakpa/ibokpot	Leaf, juice, tie-tie, piassava, bamboo	Grass	Seed, leaf
Vernonia amygdalina	1289	Bitter leaf	Etidot	Leaf, fruit, seed,	Shrub	Leaf, root

				bark, stem		
Raffia hookeri	201	Wine palm	Ukot	Leaf	Tree	Leaf, juice, tie-tie, piassava, bamboo
Persea Americana	98	Avocado peer	Eben mbakara	Food, medicine, timber, firewood	Tree	Leaf, fruit, seed, bark, stem
Gongronema latifolium	129		Utasi	Food, medicine	Climber	Leaf
Ocimum gratisimum	98	Scent leaf	Ntong	Food, medicine	Shrub	Leaf
Musa sapientum	131	Banana	Mboro	Food, medicine, fibre	Tree	Fruit, leaf, stem
Musa paradisiacal	238	Plantain	Ukom	Food, medicine, fibre	Tree	Fruit, leaf, stem
Manihot esculenta	190	Cassava	Iwa	Food, medicine, starch, beverage	Shrub	Root, leaf
Psidium quayava	87	Quava	Wopa	Food, medicine, firewood	Shrub	Fruit, leaf, stem

Table 3 result showed that, plant species that have the highest population in Ediene clan were *Clolcasia esculenta* (7151), followed by *Lasianthera africana* (4940), *Piper guinensis* (1899), *Dioscorea cayenensis* (1842), *Manihot esculenta* (1817), *Gnetum africanum* (3062) and *Heinsia crinata* (1298), while the least in population were *Citrus limon* (11) followed by *Vitis vinifera* (11), *Cola acuminata* (14) and *Chrysophyllum albidum* (16) respectively.

Scientific name	Population of plant species	Common name	Ethnic name	Uses	Forms	Parts used
Abelmoschus esculentus	169	Okroa	Etikke	Food, medicine	Herb	Fruit/leaf
Ananas cosmosus	872	Pinapple	Eyop mbakara	Food, medicine	Herb	Fruit
Capsicum fruitescens	309	Pepper	Ntokon/ntuen	Spice, medicine	Herb	Fruit/leaf
Carica papaya	149	Pawpaw	Popo	Food, medicine	Tree	Fruit, leaf, bark
Chrysophyllum albidum	16	African star apple	Udara	Food, timber, firewood	Tree	Fruit, stem
Sitrus sinensis	76	Orange	Sokoro	Food, medicine, firewood, ornamental	Tree	Fruit, stem, leaf
Cocos nucifera	90	Coconut	Isip mbakara/ isip eyop	Food, medicine, timber, firewood	Tree	Fruit, stem, juice
Cola accuminata	14	Kula nut	Ibong	Food, firewood, dye, medicine	Tree	Fruit, stem, bark, leaf
Cola argentea	74		Ndiya	Food, firewood, medicine	Shrub	Fruit, stem, root
Colocasia esculenta	7151	Cocoyam	Ikpong	Food, medicine	Herb	Corm
Colocynthis vulgaris	81	Melon	Ikon	Food, oil, medicine	Climber	Seed, leaf
Cymbopogon citrates	53	Lemon grass	Nyanyaha	Medicine, flavour	Grass	Leaf
Dacyodes edulis	57	Local peer	Eben	Food, firewood, timber	Tree	Fruit, stem
Dioscorea cayenensis	1842	Yellow yam	Akpanna	Food	Climber	Tuber
Dioscorea alata	922	Water yam	Ebre	Food	Climber	Tuber
Dioscorea bulbifera	266	Aerial yam	Edomo	Food	Climber	Bulbil
Dioscorea dumentorum	585	Sweet yam	Enem	Food, medicine	Climber	Tuber, leaf
Elaeis guineensis	37	Oil palm tree	Eyop	Oil, medicine, broom, firewood, timber, palm wine	Tree	Fruit, stem, seed, frond
Heinsia crinata	1298		Atama	Food, medicine, firewood	Shrub	Leaf, stem
Justicia schimperi	57	Hunter's weed	Meme	Food, medicine	Herb	Leaf, root
Lasianthera African	4940		Editan	Food, medicine, chewing stick	Shrub	Leaf, stem
Lycopersicum esculentum	49	Tomato	Tomato	Food	Herb	Fruit
Mangifera indica	57	Mango	Manko	Food, firewood, medicine	Tree	Fruit, stem, bark
Gnetum africanum	3062		Afang	Food, medicine	Climber	Leaf, root
Telfeiria occidentalis	325	Fluted pumpkin	Ikong ubong	Food, medicine	Climber	Leaf, seed
Piper guinensis	1899		Odusa	Food, medicine	Climber	Leaf, fruit
Solanum melongena	142	Garden egg	Nyia	Food, medicine	Shrub	Fruit
Citrus limon	11	Lemon	Mkpri sokoro	Food, medicine	Shrub	Fruit
Vitis vinifera	11	Grape	Sokoro ntan	Food, medicine	Tree	Fruit
Zea mays	65	Maize	Akpakpa/ibokpot	Food, medicine, starch	Grass	Seed, leaf
Vernonia amygdalina	603	Bitter leaf	Etidot	Food, medicine	Shrub	Leaf, root
Raffia hookeri	58	Wine palm	Ukot	Food, wine, alcohol, mat, fibre,	Tree	Leaf, juice, tie-tie, piassava,

				climbing robe, medicine, staking material, firewood		bamboo
Persea Americana	30	Avocado peer	Eben mbakara	Food, medicine, timber, firewood	Tree	Leaf, fruit, seed, bark, stem
Gongronema latifolium	155		Utasi	Food, medicine	Climber	Leaf
Ocimum gratisimum	367	Scent leaf	Ntong	Food, medicine	Shrub	Leaf
Musa sapientum	352	Banana	Mboro	Food, medicine, fibre	Tree	Fruit, leaf, stem
Musa paradisiacal	820	Plantain	Ukom	Food, medicine, fibre	Tree	Fruit, leaf, stem
Manihot esculenta	1817	Cassava	Iwa	Food, medicine, starch, beverage	Shrub	Root, leaf
Psidium quayava	789	Quava	Wopa	Food, medicine, firewood	Shrub	Fruit, leaf, stem

Table 3: Plant Species Identified in Homegardens of Ediene Clan

Table 4 result showed that the plant species in Itak clan that have the highest number were *Colocasia esculenta* with 6610, followed by *Vernonia amygdalina* with 3805, *Lasianthera africana* with 3605 and 1186 from *Dioscorea cayenensis*. The least population of plant species in the area were obtained from *Cola acuminata* (15), followed by *Vitis vinifera* (7), *Citrus limon* with 9 species, *Persia americana* with 16 species and 12 stands of *Chrysophyllum albidum* respectively.

Table 4: Plant Species Identified in Homegardens of Itak Clan

Scientific name	Population of plant species	Common name	Ethnic name	Uses	Forms	Parts used
Abelmoschus esculentus	28	Okroa	Etikke	Food, medicine	Herb	Fruit/leaf
Ananas cosmosus	637	Pinapple	Eyop mbakara	Food, medicine	Herb	Fruit
Capsicum fruitescens	310	Pepper	Ntokon/ntuen	Spice, medicine	Herb	Fruit/leaf
Carica papaya	90	Pawpaw	Popo	Food, medicine	Tree	Fruit, leaf, bark
Chrysophyllum albidum	12	African star apple	Udara	Food, timber, firewood	Tree	Fruit, stem
Sitrus sinensis	31	Orange	Sokoro	Food, medicine, firewood, ornamental	Tree	Fruit, stem, leaf
Cocos nucifera	70	Coconut	Isip mbakara/ isip eyop	Food, medicine, timber, firewood	Tree	Fruit, stem, juice
Cola accuminata	5	Kula nut	Ibong	Food, firewood, dye, medicine	Tree	Fruit, stem, bark, leaf
Cola argentea	31		Ndiya	Food, firewood, medicine	Shrub	Fruit, stem, root
Colocasia esculenta	6610	Cocoyam	Ikpong	Food, medicine	Herb	Corm
Colocynthis vulgaris	89	Melon	Ikon	Food, oil, medicine	Climber	Seed, leaf
Cymbopogon citrates	48	Lemon grass	Nyanyaha	Medicine, flavour	Grass	Leaf
Dacyodes edulis	34	Local peer	Eben	Food, firewood, timber	Tree	Fruit, stem
Dioscorea cayenensis	1186	Yellow yam	Akpanna	Food	Climber	Tuber
Dioscorea alata	79	Water yam	Ebre	Food	Climber	Tuber
Dioscorea bulbifera	635	Aerial yam	Edomo	Food	Climber	Bulbil
Dioscorea dumentorum	92	Sweet yam	Enem	Food, medicine	Climber	Tuber, leaf
Elaeis guineensis	535	Oil palm tree	Eyop	Oil, medicine, broom, firewood, timber, palmwine	Tree	Fruit, stem, seed, frond
Heinsia crinata	57		Atama	Food, medicine, firewood	shrub	Leaf, stem
Justicia schimperi	3605	Hunter's weed	Meme	Food, medicine	Herb	Leaf, root
Lasianthera African	42		Editan	Food, medicine, chewing stick	Shrub	Leaf, stem
Lycopersicum esculentum	37	Tomato	Tomato	Food	Herb	Fruit
Mangifera indica	747	Mango	Manko	Food, firewood, medicine	Tree	Fruit, stem, bark
Gnetum africanum	103		Afang	Food, medicine	Climber	Leaf, root
Telfeiria occidentalis	657	Fluted pumpkin	Ikong ubong	Food, medicine	Climber	Leaf, seed
Piper guinensis	397		Odusa	Food, medicine	Climber	Leaf, fruit
Solanum melongena	41	Garden egg	Nyia	Food, medicine	Shrub	Fruit
Citrus limon	9	Lemon	Mkpri sokoro	Food, medicine	Shrub	Fruit
Vitis vinifera	7	Grape	Sokoro ntan	Food, medicine	Tree	Fruit
Zea mays	73	Maize	Akpakpa/ibokpot	Food, medicine, starch	Grass	Seed, leaf
Vernonia amygdalina	3805	Bitter leaf	Etidot	Food, medicine	Shrub	Leaf, root
Raffia hookeri	42	Wine palm	Ukot	Food, wine,	Tree	Leaf, juice, tie-

				alcohol, mat, fibre, climbing robe, medicine, staking material, firewood		tie, piassava, bamboo
Persea Americana	16	Avocado peer	Eben mbakara	Food, medicine, timber, firewood	Tree	Leaf, fruit, seed, bark, stem
Gongronema latifolium	154		Utasi	Food, medicine	Climber	Leaf
Ocimum gratisimum	371	Scent leaf	Ntong	Food, medicine	Shrub	Leaf
Musa sapientum	690	Banana	Mboro	Food, medicine, fibre	Tree	Fruit, leaf, stem
Musa paradisiacal	281	Plantain	Ukom	Food, medicine, fibre	Tree	Fruit, leaf, stem
Manihot esculenta	385	Cassava	Iwa	Food, medicine, starch, beverage	Shrub	Root, leaf
Psidium quayava	30	Quava	Wopa	Food, medicine, firewood	Shrub	Fruit, leaf, stem

Table 5 result showed that the diversity index of the species of plants obtained form homegardens of the four clans were Ikono 1 clan (0.064), Ndiya clan (0.010) and Ediene clan (0.060), while the total diversity index for the four clans were 0.200.

Table 5: Diversity Index of Plant Species in the Four Clans of Ikono LGA

Clans	Diversity Index
Ikono 1	0.063
Ndiya	0.009
Ediene	0.059
Itak	0.065
Total	**0.200**

Table 6 result showed that 45% of respondents are within the age range of between 21-40, 36% are within the age range between 41-60, while 19% of respondents are within the age range of 61-80. The result also showed that 70.83% of respondents are businessmen in the study area, while only 29.17% are civil servants in the area. Table 6 result revealed that 25% of respondents attends primary education, 13% attends secondary education, 12% attends tertiary education, while 50% of the respondents attends informal education. The result also showed that 44% of the people in the study area earn income between N1000.00-N10000.00, 25% earns between 11000.00-20000.00, 18% earns between 21000.00-30000.00 and 13% of the

respondents earn income between 31000.0-40000.00 from the sale of the products in the study area.

Table 6: Socio-Economic Characteristics of the People in the Study Area

Age of respondents		
Age range	**Frequency**	**Percentage (%)**
21 – 40	54	45
41 – 60	43	36
61 – 80	23	19
Total	**120**	**100**
Occupation of respondents		
Occupation	**Frequency**	**Percentage (%)**
Business	85	70.83
Civil service	35	29.17
Total	**120**	**100**
Educational qualification		
Qualification	**Frequency**	**Percentage (%)**
Primary	30	25
Secondary	16	13
Tertiary	14	12
Informal education	60	50
Total	**120**	**100**
Income level of respondents per month		
Income level per month (N)	**Frequency**	**Percentage (%)**
1,000.00 – 10,000.00	53	44
11,000.00 – 20,000.00	30	25
21,000.00 – 30,000.00	21	18
31,000.00 – 40,000.00	16	13
Total	**120**	**100**

DISCUSSION

The results from the tables identified and classified the plant species in all the clans in Ikono LGA into scientific names, common names, ethnic names, life forms as well as the uses and number of species planted in the homegardens. The research identified 39 different plant species of high economic importance to the people in the study area. The research revealed that the species of plants are distributed in varying populations across all the clans in Ikono LGA. For example, the population of *Colocasia esculentum* in Ediene clan was 7151, that of Itak clan was 6610, while Ndiya and Ikono 1 clans have 3789 and 6591 number of *Colocasia esculenta* in the homegardens in the study area (Tables 1 to 4).

The diversity of the species found in the homegardens of Ikono LGA may be attributed to favourable climatic and edaphic conditions. Also, the acceptability and utilization of the species may also be attributed to the culture and traditions of people in a particular area socio-economic value, which may influence the abundance or scarcity of the species in the study area (Table 6). This also determines the level of demand for each of the species available in the study area by the people in which the species may either be over or under exploited. Findings showed that some of the species can only be found in the homegardens, therefore, appropriate conservation strategies should be adopted to ensure a sustainable management and utilization of these valuable bioresources to avoid extinction. It is observed in the study area that homegardens are of various sizes which determines the population of individual species and diversity available in each of the homegardens in the study area.

The diversity index formulated by Simpson is probabilistic in nature, which helps to ensure the probability of occurrence of individual plant species in ecosystem and it holds that the higher the DI, the closer the probability level to one and vice versa. Based on the assertion above, Ikono 1clan has DI (0.064), Ndiya clan has DI (0.010), Ediene clan has DI (0.060) while Itak clan has the DI (0.065). This suggest that the DI is generally high in all the clans in the study area, but is higher in Ndiya clan

with (0.010) DI than other clans in the study area because the rule of Simpson's Diversity Index according to (Ogbeibu, 2005) states that the higher the DI value, the lower the species diversity and vice versa. The high DI also suggests that a lot of people are involve in the cultivation and management of the resources for their livelihood (Table 5). The results in the (Tables 1 to 4) also revealed that some species population are very low which may be due to over utilization, this means that people place high demand on the species than others which suggest that more effort should be intensified on the management of the species through in-situ and ex-situ conservation strategies to ensure continuous utilization of the resources on sustainable basis.

CONCLUSION

The diverse uses of plant species revealed in the study area points out to the fact that homegardens have been used to cultivate not only vegetables, but also other plant species of high economic values, ranging from trees, shrubs, herbs, climbers and grasses for various uses. Apart from this, homegardens serve as a reservoir for biodiversity conservation, since some of the species are no more found in the wild state due to high rate of deforestation and other anthropogenic activities. The species population and diversity varies with sizes of homegardens as well as general acceptability of the species by the people in the study area. Therefore, since the demand for the species are high appropriate conservation strategies should be put in place to ensure sustainable management and utilization of the valuable species on sustainable basis especially this era of climate change.

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Identifying Sustainable and Efficient Broiler Farms In The Light of Energy Use Efficiency and GHG Emission Reduction: Data Envelopment Analysis Approach

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Abstract
This study applied a non-parametric method in determining efficiency of farmers, discriminate efficient farmers from inefficient ones, identify wasteful uses of energy in order to optimize the energy inputs for broiler production, investigate the effect of energy optimization on greenhouse gas (GHG) emission and the total amount of GHG emission in actual quantity was compared with optimum quantity. A total sample size of 55 broiler farmers were selected from Kaduna State *viz.* multi-stage sampling technique. Total energy used in various operations during broiler production was 77916.14 MJ $(500bird)^{-1}$. Results revealed that 63percent of producers were technically efficient, while 43 producers under PTE were identified efficient (79.6%). Mean values of TE, PTE and SE of farmers were observed to be 0.976; 0.993 and 0.983, respectively. Also, it was discovered that 1.38 percent [1071.54 MJ $(500birds)^{-1}$] of overall input energies can be saved if the performance of inefficient farms rose to a high level. Finally it was concluded that, by energy optimization the total GHG emission can be reduced to the value of 981.08 Kg CO_2eq.
Keywords: GHG emission; Efficient; Sustainable; Energy; Broiler; DEA

INTRODUCTION

The Brundtland Commission visualizes that, 'sustainable agriculture should involve the successful management of resources to satisfy the

changing human needs while maintaining or enhancing the quality of environment and conserving natural resources. Sustainable agriculture management endeavours to tackle many serious problems affecting world food production, high energy costs, loss of productivity, depletion of fossil resources, low farm incomes and risk to human health and wildlife habitats. However, it is a systematic approach to understand the complex interaction within agricultural ecologies.

Gasses that cause greenhouse effects are for the most part natural compounds- water vapour, CO_2, methane and nitrous oxide that keeps the earth habitable. But human activity is increasing the concentration of these and other gasses. The trend, if continues, is expected by atmospheric scientists to lead to global climate change with uncertain but potentially grave long-term effects. The level of sophistication in socio-economic assessments of climate change impacts is still rather modest. Most available damage estimates are concerned with the impact of an equilibrium climate change associated with doubling of the pre-industrial CO_2 concentration of all greenhouse gasses. This means that if CO_2 occurred now, it would impose much damage on the world economy, particularly on vulnerable sectors including agriculture, human mortality and natural ecosystems. Efficient use of agricultural product energies helps to achieve increased production, productivity and contributes to the profitability and competitiveness of agriculture sustainability in rural areas (Heidari, 2011).

According to literature, the only study conducted on energy optimization in broiler production using DEA was by Heidari (2011); with no effort of investigating effect of energy optimization on GHG emission in broiler production, thus, making this present study first of its kind. However, literature revealed recent studies which used DEA to estimate GHG emissions in crops production *viz.* Pishgar-Komleh *et al.*(2012); Pishgar-Komleh *et al.*(2013); Mohammadi *et al.*(2013); Khoshnevisan (2013a); Khoshnevisan (2013b); Qasemi-Kordkheili and Nabavi-Pelesaraei (2014); Nabavi-Pelesaraei et al.(2014); Sadiq *et al.*(2015) and Sadiq *et al.*(2016). In

this study, the same methodology was adopted for broiler farms in Kaduna State, with the objectives to specify energy use for broiler production, segregate efficient farmers from inefficient ones, identify wasteful uses of energy inputs and investigate the effect of energy optimization on GHG emission in broiler production.

RESEARCH METHODOLOGY

Kaduna State is located between latitudes 9° 08′ and 11° 07′N and longitudes 6° 10′ and 8° 48′E, with a land mass of about 45,567 square kilometres; estimated population of 6,066,562. Agriculture constitutes the largest occupation of the people with many citizens participating in small scale farming. The State is a major region of animal husbandry. Multi-stage sampling technique was used for the study. Firstly, five LGAs *viz.* Kaduna North, Kaduna South, Kachia, Zaria and Makarfi were purposively selected due to high intensity of poultry production; followed by stratification of poultry producers into broilers and layers in each selected LGAs, and then random selection of 11 respondents from boiler strata in each selected LGAs, thus, given a total sample size of 55 broiler farmers. However, only 54 valid questionnaires were retrieved and subsequently treated. Data were elicited *viz.* pre-tested questionnaire coupled with interview schedule, and subsequently subjected to DEA analytical technique.

Table 1: Equivalents for various sources of energy

Items	Unit	Equivalent MJ
Human Labour	Man-hour	1.96
Chick	Kg	4.56
Broiler	Kg	4.56
Manure	Kg	18.0
Maize	Kg	7.9
Soyabean meal	Kg	12.06
Fish meal (FA)	Kg	9
Di calcium phosphate	Kg	10
H_2o	m^3	1.02
Petrol	L	48.23
Kerosene	L	36.7
Electric motor	Kg	64.8
Electricity	kWh	11.93

EMPIRICAL MODEL

Data Envelopment Analysis

DEA technique builds a linear piece-wise function from empirical observations of inputs and outputs. DEA is a nonparametric approach for estimating productive efficiency based on mathematical linear programming techniques. Unlike parametric methods, DEA does not require a function to relate inputs and outputs. The DEA envelops the data in such a way that all observed data points lie on or below the efficient frontier (Coelli, 1996). The efficient frontier is established by efficient units from a group of observed units. Efficient units are those with the highest level of productive efficiency. In DEA an inefficient DMU can be made efficient either by minimizing the input levels while maintaining the same level of outputs (input oriented), or, symmetrically, by maximizing the output levels while holding the inputs constant (output oriented).

Technical Efficiency (TE)

TE can be defined as the ability of a DMU (e.g. a farm) to produce maximum output given a set of inputs and technology level. The TE score (θ) in the presence of multiple-input and output factor can be calculated by the ratio of sum of weighted outputs to the sum of weighted inputs or in a mathematical expression given below (Cooper *et al.,* 2004):

$$\theta = \frac{U_1Y_1j + U_2Y_2j + \ldots + UsYsj}{V_1X_1j + V_2X_2j + \ldots\ldots + VmXmj} = \frac{\sum_{r=1}^{s} UrYrj}{\sum_{i=1}^{m} ViXij} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Let the DMU*j* to be evaluated on any trial be designated as DMU*o* (*o* = 1, 2 . . . *n*). To measure the relative efficiency of a DMU*o* based on a series of *n* DMUs, the model is structured as a fractional programming problem, and specified as follows (Cooper *et al.* 2006):

$$\text{Max: } \theta = \frac{\sum_{r=1}^{s} UrYr0}{\sum_{i=1}^{m} ViXi0} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\text{Subject to: } \frac{\sum_{r=1}^{s} UrYrj}{\sum_{i=1}^{m} ViXij} \leq 1 \qquad j=1, 2 \ldots\ldots\ldots\ldots n$$

$$Ur \geq 0, \quad Vi \geq 0$$

where *n* is the number of DMUs in the comparison, *s* the number of outputs, *m* the number of inputs, *Ur* (*r* = 1, 2, …, *s*) the weighting of output *Yr* in the comparison, *Vi* (*i* = 1, 2, …, *m*) the weighting of input *Xi*, and *Yrj* and *Xij* represent the values of the outputs and inputs *Yj* and *Xi* for DMU*j*, respectively. Equation (2) can equivalently be written as a linear programming (LP) problem as follows:

$$\text{Max: } \theta = \sum_{r=1}^{s} UrYro \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{Subject to: } \sum_{r=1}^{s} UrYrj - \sum_{i=1}^{m} ViXij \leq 0 \quad J=1, 2\ldots\ldots\ldots n$$

$$\sum_{i=1}^{m} UiXio = 1$$

Ur ≥ 0, Vi ≥ 0

The dual linear programming (DLP) problem is simpler to solve than Equation (3) due to fewer constraints. Mathematically, the DLP problem is written in vector–matrix notation as follows:

Min: θ..... (4)

Subject to: $Y\lambda \geq yo$

$X\lambda - \theta Xo \leq 0$

$\lambda \geq 0$

Where Yo is the $s \times 1$ vector of the value of original outputs produced and Xo is the $m \times 1$vector of the value of original inputs used by the o^{th} DMU. Y is the $s \times n$ matrix of outputs and X is the $m \times n$ matrix of inputs of all n units included in the sample. λ is a $n \times 1$ vector of weights and Θ is a scalar with boundaries of one and zero which determines the technical efficiency score of each DMU. Model (4) is known as the input-oriented CCR DEA model. It assumes constant returns to scale (CRS), implying that a given increase in inputs would result in a proportionate increase in outputs.

Pure Technical Efficiency (PTE)

The TE derived from CCR model, comprehend both the technical and scale efficiencies. So, Banker *et al.* (1984) developed a model in DEA, which was called BCC model to calculate the PTE of DMUs. The BCC model is provided by adding a restriction on λ (λ =1) in the model (4), resulted to no condition on the allowable returns to scale. This model assumes variable returns to scale (VRS), indicating that a change in inputs is expected to result in a disproportionate change in outputs.

Scale Efficiency (SE)

SE relates to the most efficient scale of operations in the sense of maximizing the average productivity. A scale efficient farmer has the same level of technical and pure technical efficiency scores. It can be calculated as follow:

$$SE = \frac{TE}{PTE} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

SE gives the quantitative information of scale characteristics. It is the potential productivity gained from achieving optimum size of a DMU. However, scale inefficiency can be due to the existence of either IRS or DRS. A shortcoming of the SE score is that it does not indicate if a DMU is operating under IRS or DRS conditions. This problem is resolvable by solving a non-increasing returns of scale (NIRS) DEA model, which is obtained by substituting the VRS constraint of $\lambda = 1$ in the BCC model with $\lambda \leq 1$. IRS and DRS can be determined by comparing the efficiency scores obtained by the BCC and NIRS models; so that, if the two efficiency scores are equal, then DRS apply, else IRS prevail. The information on whether a farmer operates at IRS, CRS or DRS status is particularly helpful in indicating the potential redistribution of resources between the farmers, thus, enables them to achieve higher output.

The results of standard DEA models divide the DMUs into two sets of efficient and inefficient units. The inefficient units can be ranked according to their efficiency scores; while, DEA lacks the capacity to discriminate between efficient units; number of methods are in use to enhance the discriminating capacity of DEA. In this study, the benchmarking method was applied to overcome this problem. In this method, an efficient unit which was chosen as the useful target for many inefficient DMUs and so appears frequently in the referent sets is highly ranked.

In the analysis of efficient and inefficient DMUs, the energy saving target ratio (ESTR) was used to specify the inefficiency level of energy usage for the DMUs under consideration. Following Sadiq *et al.*(2015); Sadiq *et al.*(2016), the formula is given below:

$$ESTR\ (\%) = \frac{(\text{Energy saving target})}{(\text{Actual energy input})} \times 100$$

Where energy saving target is the total amount of energy inputs reduced, which could be saved without reducing the output level. A higher ESTR percentage implies higher energy use inefficiency, and thus, a higher energy saving amount.

GHG Emissions

CO_2 emission coefficients of inputs were used to quantifying GHG emissions in broiler production. GHG emission was calculated by multiplying the input application rate by its corresponding emission coefficient (Table 2).

Table 2: GHG Emission Coefficients of Inputs

Items	Unit	GHG coefficient (kg CO_2eq. unit^{-1})
Petrol	L	1.85
Kerosene	L	1.85
Electric motor	MJ	0.071
Electricity	kWh	0.608

RESULTS AND DISCUSSION

Energy Use Pattern in Broiler Production

Table 3 presents the amount of inputs, output and their energy equivalents for broiler production. The total energy consumption was 77916.14MJ (500birds)$^{-1}$. Feed with approximate share of 72.7% was the most energy consumed, followed by electricity. The main reason for high feeds energy consumption was that farmers did not have appropriate knowledge about the proper time and amount of feeds usage, and also the common belief that increased use of feeds energy resource will increase output. Contribution of human labour, machinery (electric motor) and H_2O in comparison with other inputs in the total input energy is negligible. However, total output energy observed in the studied area was 142458.26 MJ (500birds)$^{-1}$; average output of broiler and manure were 816.86Kg and 7707.41 Kg, respectively, per 500 birds.

Table 3: Amounts of inputs, output and their energy equivalents for broiler production

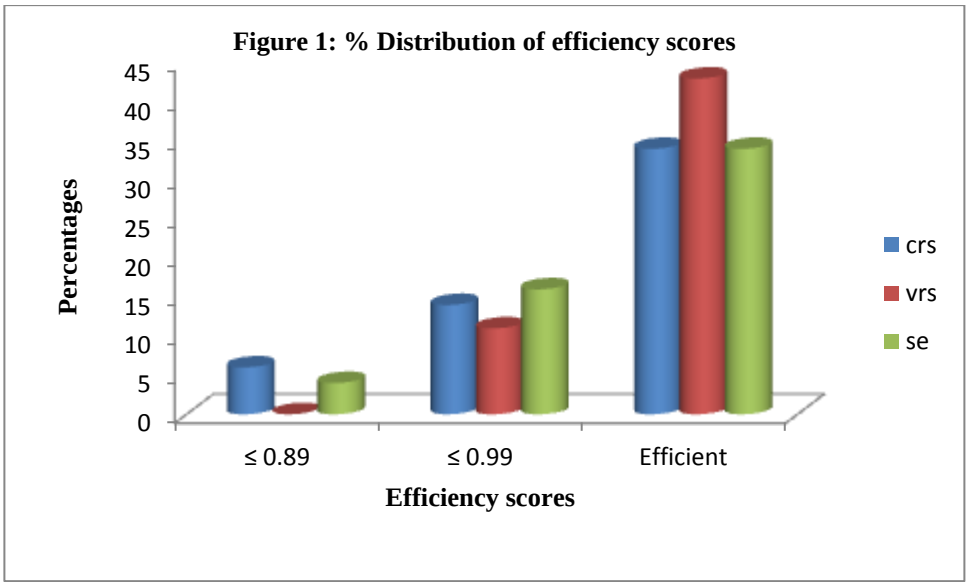
Inputs	Quantity(500birds)$^{-1}$	Total energy equivalent [MJ(500birds)$^{-1}$]	(%)
Chicks (kg)	222.33	1013.84	1.3
Human labour (mhr)	78.83	154.5	0.2
Feeds (kg)			
a. Maize	1434.076	11329.20	14.5
b. Soyabean meal	1878.806	22658.40	29.1
c. Fatty meal (FA)	2014.079	18126.71	23.3
d. Di-calcium phosphate	453.168	4531.68	5.8
H_2O (m^3)	0.1028	0.1049	0
Petrol (L)	44.63	2152.49	2.8
Kerosene (L)	13.704	502.93	0.7
Electric motor (kg)	3.045	197.32	0.2
Electricity (kWh)	1445.847	17248.96	22.1
Total energy input		**77916.14**	**100**
Output			
a. Broiler (kg)	816.86	3724.88	
b. Manure (kg)	7707.41	138733.38	
Total energy output		**142458.26**	

Source: Field survey, 2015

Efficiency Measurement of Broiler Farmers

Results of farmers' distribution based on the efficiency score obtained by the application of CCR and BCC DEA models are shown in Figure 1. Evidently, 63 percent (34farmers) and 79.6 percent (43 farmers) from total farmers were identified as efficient farmers under constant and variable returns to scale assumptions, respectively; implying these farms could shift on CCR and BCC frontier. Furthermore, approximately 25.9 percent and

20.4 percent of TE and PTE respectively, had efficiency scores between 0.99 and 1.00. However, if the BCC model is assumed, only 11.1 percent had efficiency scores of less than 0.89; whereas, if the CCR model is considered, none had efficiency score of less than 0.89. The results of returns to scale estimation indicated that all of the technically efficient farmers (based on the CCR model) were operating at CRS, indicating optimum scale of their practices.



Summarized statistics for the three estimated measures of efficiency are given in Table 4. Results revealed that the average values of technical and pure technical efficiency scores were 0.976 and 0.0.993, respectively. The technical efficiency scores varied from 0.814 – 1.00; while pure technical efficiency scores ranged from 0.904-1.00. The small variation in the technical efficiency implies that all the farmers were fully aware of the right production techniques but did not apply them properly; while mild variation in pure technical efficiency indicates that the farmers were almost rational in allocation of resources at their disposal. Average PTE provides information about the potential resource savings that could be achieved while maintaining the same output level.

Table 4: Deciles frequency distributions of efficiency scores

Efficiency level	TE	PTE	SE
≤ 0.89	6 (11.1)	0	4 (7.4)
≤ 0.99	14 (25.9)	11 (20.4)	16 (29.6)
1.00	34 (63)	43 (79.6)	34 (63)
Total	54	54	54
Minimum	0.814	0.904	0.814
Maximum	1.00	1.00	1.00
Mode	1.00	1.00	1.00
Mean	0.976	0.993	0.983
SD	0.047	0.021	0.040

Source: Computed from DEAP 2.1 computer print-out
Figures in parenthesis are percentages

In the case of TE, farmers with efficiency scores of less than one, are technologically inefficient in energy use, while for PTE, farmers with less than one efficiency scores are wasting energy resources than required, indicating ample scope for target farmers to improve their operational practices in enhancing their energy use efficiency for adjustment strategy. If technical efficiency is assumed, average farmers need to increase their efficiency scores by 2.4 percent; worst inefficient farmers require TE adjustment scores of approximately 18.6 percent, and best inefficient farmers require approximately 0.7 percent adjustment, respectively, to be on the frontier surface.

However, if an adjustment for pure technical efficiency scores is assumed, average farmers need to reduce their energy inputs by 0.7 percent; worst inefficient farmers' needs approximately 9.6 percent input reduction, and best inefficient farmers require 0.2 percent input reduction, respectively, to be on the frontier surface. Based on pure technical efficiency, 34 farmers were globally efficient and operating at the most productive scale sizes of production, while 9 farmers were locally efficient entities operating at an inferior scale sizes. The average scale efficiency score was relatively low (0.983), showing the disadvantageous conditions of scale size. This

indicates that if all of the inefficient farmers operated at the most productive scale size, about 1.7 percent savings in energy use from different sources would be possible without affecting the output level.

Returns to Scale Properties in Broiler Production

The BCC model includes both IRS and DRS, while NIRS model gives DRS. To determine whether a DMU has IRS or DRS, an additional test is required. The values of TE for both BCC and NIRS were calculated and their values were compared. The same values of TE for NIRS and BCC models show that the DMU has DRS, while different values imply that the farm has IRS. Results of RTS for some selected DMUs revealed that 34 DMUs had CRS; 12 DMUs had DRS, while 8 DMUs were found to be operating at IRS (Table 5). Therefore, a proportionate increase in all inputs leads to more proportionate increase in outputs; and for considerable changes in yield, technological changes in practices are required. The information on whether a farmer operates at IRS, CRS or DRS is particularly helpful in indicating the potential redistribution of resources between the farmers, thus, enables them to achieve higher output.

Table 5: Characteristics of farms with respect to return to scale

Scale	No. of farms	Mean energy output	
		Broiler	Manure
Sub-optimal	8	3438.38	128025
Optimal	34	3753.48	144158.82
Super-optimal	12	3834.87	130500

Source: Computed from DEAP 2.1 computer print-out

Ranking Analysis of Broiler Production

Identifying efficient operating practices and their dissemination will help to improve efficiency not only in the case of inefficient farmers but also for relatively efficient ones, because efficient farmers obviously follow good operational practices. However, among the efficient farmers, some show better operational practices than others, therefore, discrimination need to be made among the efficient farmers while seeking the best operational

practices. In order to have the efficient farmers ranked, the number of times an efficient DMU appears in a referent set was counted (Table 6). Only efficient farms serve as peers for the inefficient farms and in this instance farms 1-2, 15-16, 17-20, 21-24, 25-26, 28-29, 31-33, 37-39, 40-41, 44-45, 47-48, 49-50, 51 and 52 are the peers. Farm 24, for example, was a peer for 7 farms making it the most comparator used farm. These efficient farms can be selected by inefficient DMUs as best practice DMUs, making them a composite DMU instead of using a single DMU as a benchmark. While the referent set is composed of the efficient units which are similar to the input and output levels of inefficient units, efficient DMUs with more appearance in referent set are known as superior unit/spark plug in the ranking.

Results of such analysis would be beneficial to inefficient farmers to manage their energy sources usage in order to attain the best performance of energy use efficiency. However, these superior units/spark plugs can be use as reference means of dissemination of farm improvement by extension delivery services.

Table 6: Benchmarking of efficient DMUs

DMUs	Frequency in referent set	Ranking	DMU(farm)	Frequency in referent set	Ranking
F24	7	1	F51	2	5
F01	5	2	F02	1	6
F39	5	2	F16	1	6
F44	5	2	F31	1	6
F26	4	3	F33	1	6
F40	4	3	F37	1	6
F20	3	4	F45	1	6
F41	3	4	F47	1	6
F15	2	5	F48	1	6
F17	2	5	F49	1	6

F21	2	5	F50	1	6
F25	2	5	F52	1	6
F28	2	5			
F29	2	5			

Source: Computed from DEAP 2.1 computer print-out

Performance Assessment of Broiler Farms

Table 7 shows the peers for each farm and the weights that these peers account for. For each inefficient farm there are peers which serve as comparators against which the farm is measured. Efficient farms do not have any peers other than themselves as they are on the efficient frontier, thus defining the efficiency. It stands to reason that the weight will be unity in the case of efficient farms. The higher the weight the more important that particular farm is as a peer for the inefficient farm in question. This means that the inefficient farm is better off comparing itself to the peer with the highest weight in order to improve its efficiency by emulating its peers. The identification of peers is important in that the peers' production technology, in this case pollution minimizing technology, can be studied and implemented by the inefficient farms. Result shows the worst inefficient DMU (DMU22) and the best inefficient DMU (DMU12). For instance, in the case of DMU22 the composite DMU that represents the best practice or reference composite benchmark DMU is formed by combination of DMU40, DMU51, DMU17, DMU1 and DMU5.

This means DMU22 is close to the efficient frontier segment formed by these efficient DMUs, represented in the composite DMU. The selection of these efficient DMUs is made on the basis of their comparable level of inputs and output to DMU22. The benchmark DMU for DMU22 is expressed as 40(0.484); 51(0.127); 17(0.099); 1(0.267) and 5(0.024), where 40, 51, 17, 1 and 5 are the DMU numbers while the values in the brackets are the intensity vector λ for the respective DMUs. The higher value of the intensity vector λ for DMU40 (0.484) indicates that its level of inputs and output is closer to DMU22 compared to the other DMUs.

Table 7: Performance assessment of broiler farms

DMUs	PTE score (%)	Benchmarks
F22	90.4	40(0.484) 51(0.127) 17(0.099) 1(0.267) 5(0.024)
F11	91.6	28(0.212) 24(0.276) 40(0.194) 26(0.068) 39(0.250)
F13	99.5	24(0.143) 48(0.004) 1(0.190) 41(0.459) 49(0.034) 29(0.059) 20(0.111)
F35	99.5	24(0.011) 20(0.094) 29(0.122) 44(0.205) 39(0.469) 1(0.099)
F12	99.8	20(0.041) 1(0.507) 44(0.392) 24(0.060)

Source: Computed from DEAP 2.1 computer print-out

Setting Realistic Input Levels for Inefficient Broiler Farmers

A pure technical efficiency score of less than unity for a farmer indicates that, at present conditions, he is using energy values more than required. Therefore, it is desirable to suggest realistic levels of energy to be used from each source for every inefficient farmer in order to avert energy wastage. Results in Table 8 presents the average energy usage in actual and optimum conditions [MJ (500 birds)$^{-1}$], possible energy savings and ESTR percentage for different energy sources. It is evident that, total energy input could be reduced to 76844.60 MJ (500 birds)$^{-1}$; while, maintaining the current production levels and also assuming no other constraining factors. Required energies for petrol, kerosene, machinery (electric motor) and electricity were 2086, 495.55, 192.43and 16922.59 MJ (500 birds)$^{-1}$, respectively; while chicks, human labour, feeds and H_2o energies required were 1003.28, 151.72, 55992.3 and 0.1046MJ (500 birds)$^{-1}$, respectively.

Furthermore, ESTR results showed that if all farmers operated efficiently, reduction in petrol and machinery energy inputs, with respect, by 3.06 percent and 2.48 percent would be possible without affecting the output level. These energy inputs had the highest inefficiency which owed mainly to lightening of poultry huts. Artificial lighting is important in raising the production of chickens; if the housing is lit in the cooler hours before

sunrise or after sunset, the chickens are able to eat more and grow well. However, day length must not be increased during the growing period of the young chicks until just before four weeks. In order to improve the farms environment as well as reduction in consumption of petrol fuel, it is strongly suggested that the heating system efficiency be raise or replace with alternative sources of energy such as biogas, solar energy, wind etc. Moreover, the ESTR percentage for total energy input was 1.38 percent, indicating that by adopting the recommendations obtained from this study, on average, about 1.3 percent [1071.54MJ(500 birds)$^{-1}$] from total input energy in broiler production could be saved without affecting the output level.

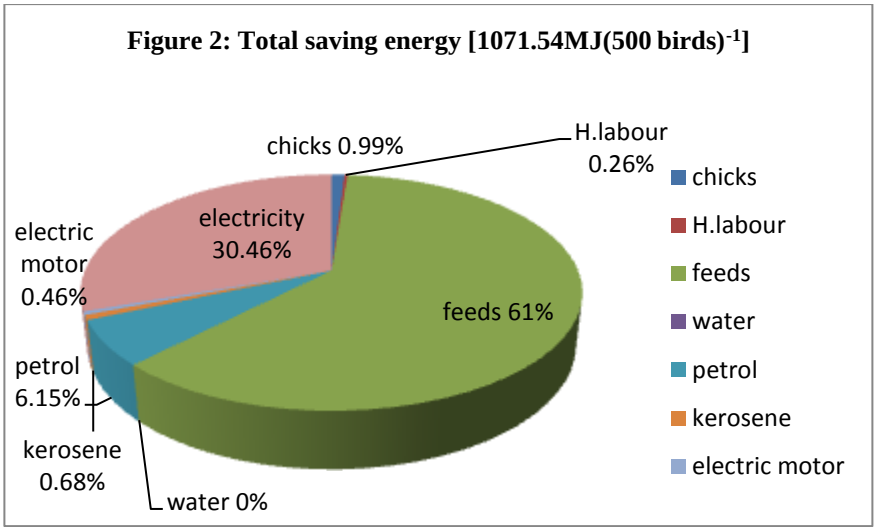
Table 8: Energy saving [MJ (500birds)$^{-1}$] from different sources if recommendations of study are followed

Input	Actual energy used [MJ(500birds)$^{-1}$]	Optimum energy requirement [MJ(500birds)$^{-1}$]	Energy saving	ESTR (%)
Chicks	1013.84	1003.28	10.56(0.99)	1.04
Human labour	154.5	151.72	2.78(0.26)	1.8
Feeds	56645.99	55992.3	653.69(61)	1.15
H_2O	0.1049	0.1046	0.0003(0)	0.29
Petrol	2152.49	2086.62	65.87(6.15)	3.06
Kerosene	502.93	495.55	7.38(0.68)	1.47
Electric motor	197.32	192.43	4.89(0.46)	2.48
Electricity	17248.96	16922.59	326.37(30.46)	1.89
Total energy input	77916.14	76844.60	1071.54	1.38

Source: Computation from DEAP 2.1 computer print-out
Figures in parenthesis are percentages

Figure 2 shows distribution of saving energy from different sources for broiler production. It is evident that the maximum contribution to total saving energy is 61 percent from human labour. However, human labour and electricity energy inputs contributed to the total saving energy by about 91.46 percent. From these results it is strongly suggested that improving the usage pattern of these inputs be considered as priorities providing significant improvement in energy productivity for broiler production in the study area. Improving energy use efficiency of human labour *viz.* channeling of its excess to other sectors is suggested to prevent wastage by inefficient farmers. Applying alternatives sources of energy such as biogas, solar energy, wind etc is suggested to prevent electrical energy wastage by inefficient farmers.

Figure 2: Total saving energy [1071.54MJ(500 birds)$^{-1}$]



Improvement of Energy Indices for Broiler Farms

Comparison between energy indices in the actual and optimum energy use showed improvements of these indices (Table 8). Obviously, by optimization of energy use, both energy ratio and energy productivity indicators can improve by 1.09 percent and 1.84 percent, respectively. Also, in optimum consumption of energy inputs, the net energy indicator by improvement of 1.66 percent would increase to 65613.66MJ (500birds)$^{-1}$. In otherwords, energy ratio, energy productivity, specific energy and net

energy were 1.83; 0.109 Kg MJ(500birds)$^{-1}$; 9.14MJ(500birds)$^{-1}$ and 64542.12MJ(500birds)$^{-1}$, respectively, and they can be improved to 1.85; 0.111 Kg MJ(500bird)$^{-1}$; 9.02 MJ(500birds)$^{-1}$ and 65613.66MJ(500birds)$^{-1}$.Therefore, it is obvious that broiler production had relatively high requirements for nonrenewable energy resources and to certain extent feeds energy (renewable energy); its electrical energy requirement is high and need high amount of petrol fuel consumption in situation of power outage.

In the case of feeds, farmers mainly don't have enough knowledge on more efficient input use and there is a common belief that increased use of feed energy resource will increase output. These situations occur simply because the farmers mainly don't have enough knowledge on more efficient input use. Methods presented in this study demonstrate how energy use efficiency in broiler production may improve by applying the operational management tools to assess the performance of farmers. On an average, considerable savings in energy inputs may be obtained by adopting the best practices of benchmarking/ high-performing DMUs in broiler production process.

Adoption of more energy-efficient poultry systems would help in energy conservation and better resource allocation. Strategies such as providing better extension and training programs for farmers and use of advanced technologies should be developed in order to increase the energy efficiency of broiler productions in the studied area. The farmers should be trained with regard to the optimal use of inputs, especially, electricity, petrol and feeds as well as employing the new production technologies. Therefore, agricultural institutes in the state have an important role in this case to establish the more energy efficient and environmentally healthy broiler production systems in the studied area.

Table 8: Improvement of energy indices for broiler farms

Items	Unit	Qty in Actual use	Qty in optimum use	Change (%)
Energy ratio	-	1.83	1.85	1.09
Energy productivity	$KgMJ^{-1}$	0.109	0.111	1.84
Specific energy	$MJKg^{-1}$	9.14	9.02	-1.3
Net energy	$MJ(500birds)^{-1}$	64542.12	65613.66	1.66
Total input energy	**$MJ(500birds)^{-1}$**	**77916.14**	**76844.60**	**-1.38**

Source: Authors computation, 2015

GHG Emissions in Broiler Production

GHG emission of efficient and inefficient DMUs was investigated to determine the role of energy optimization in environmental condition of broiler production in the studied area (Table 9). The total GHG emission of broiler production was 1001.03KgCO_{2eq}; most amount of CO_2 emission was related to electricity with an estimated amount of 879.1Kg CO_{2eq} and followed by petrol. Therefore, energy consumption can be reduced by improving some management practices and technological changes in inefficient DMUs, subsequently; the emission of GHG can be decreased in the studied area. Furthermore, findings indicate that optimum GHG emission by decreasing of 2 percent can be reduced to the value of 981.08 Kg CO_{2eq}. However, most reduction was observed in electricity (83.71%) and followed by petrol (12.68%). Using alternative renewable sources of energy for electricity generation such as wind, solar and biogas energy sources can lead to broiler production with less GHG.

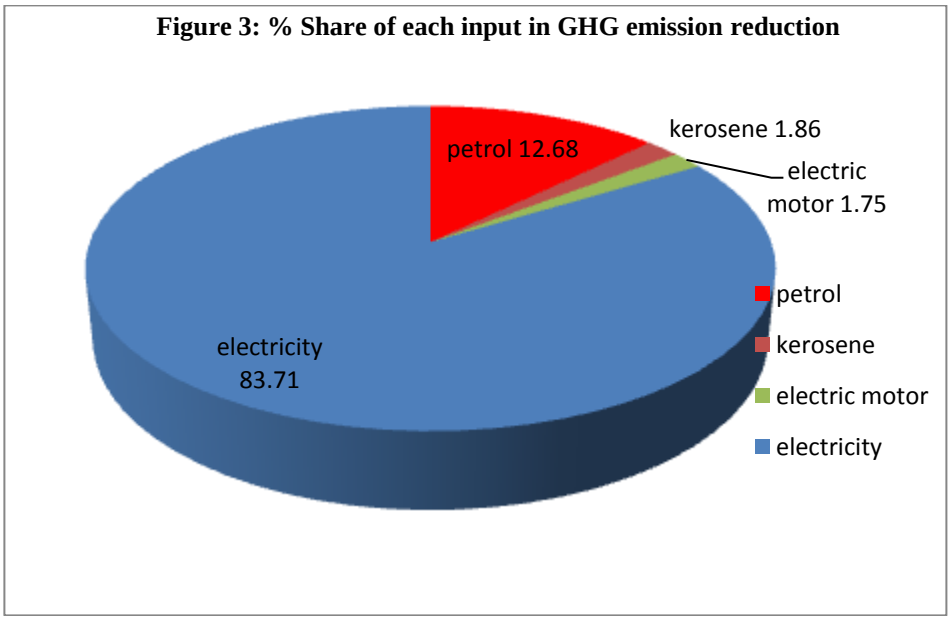
Table 9: Amounts of GHG emission for actual and optimum

Inputs	Actual [$KgCO_2(500birds)^{-1}$]	Optimum [$KgCO_2(500birds)^{-1}$]	GHG reduction [$KgCO_2(500birds)^{-1}$]
Petrol	82.57	80.04	2.53(12.68)
Kerosene	25.35	24.98	0.37(1.86)
Electric motor	14.01	13.66	0.35(1.75)
Electricity	879.1	862.4	16.7(83.71)
Total GHG emission	1001.03	981.08	19.95

Source: Computed from DEAP 2.1 computer print-out
Figures in parenthesis are percentages

Percentage share of each potential input in total GHG reduction in broiler production indicated electricity to have the highest share in GHG emissions reduction (83.71%) (Figure3). Therefore, using environmental friendly renewable sources of energy can lead to broiler production with less GHG emission.

Figure 3: % Share of each input in GHG emission reduction



CONCLUSION

This study determines the possibilities of energy use improvement in broiler production using DEA approach. This method helped to identify the impact of energy use from different inputs on output, measure efficiency scores of farmers, segregate efficient farmers from inefficient farmers, ranking efficient farmers, identifying wasteful energy uses by inefficient farmers, GHG emission of actual and optimum quantity was investigated to determine the role of energy optimization in environmental condition of broiler production in the studied area.

Results indicated that there were substantial production inefficiencies by farmers; such that, potential of 1.38 percent reduction in total energy input use may be achieved if all farmers operated efficiently and assuming no other constraints on this adjustment. In other words, the total energy input could be reduced by 1.38 percent without reducing the present output level by adopting study based recommendations. It was observed that the actual and optimum total GHG emission were 1001.03$KgCO_2eq$ and 981.95$KgCO_2eq$, i.e possibility of potential total GHG emission reduction by 19.95 $KgCO_2eq$ if farmers comply with recommendations from this findings; most reduction was observed in electricity (83.71%). Moreover, results revealed that broiler production in the studied area showed a high sensitivity to non-renewable energy sources which may result in both the environmental deterioration and rapid rate of depletion of these energetic resources. Therefore, policies should emphasize on development of new technologies to substitute fossil fuels with renewable energy sources aiming efficient use of energy and lowering the environmental footprints; limited fossil fuels sources implies that policy makers need to come up with best management in productivity improvement of broiler production in the studied area.

Development of renewable energy usage technologies such as lightening systems using biogas, wind or solar power, using better management techniques, utilization of alternative sources of energy such as biogas, wind and solar energy are suggested to reduce the environmental footprints of

energy inputs and to obtain sustainable broiler production systems. However, modern and well established scientific practices should be use to obtain higher technical efficiency in broiler production *viz.* having good knowledge of broiler feeds consumption; specifically the quantity of required feeds per meat Kg (feed conversion ratio); capacity training of poultry farmers and processors to enable them cope with the present challenges of modern poultry farming and commercialization of the poultry sub-sector in the state in particular and the country in generally. Also, losses at the farmers' level can be minimized through opening and strengthening of Agricultural Technology Information Centre (ATIC) in agricultural institution. Further, local level extension systems needs to be strengthened for effective transfer of technology.

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Appendix: Efficiency scores

DMUs	CRSTE	VRSTE	SE	Return to Scale	DMUs	CRSTE	VRSTE	SE	Return to Scale
F01	1.000	1.000	1.000	CRS	F31	1.000	1.000	1.000	CRS
F02	1.000	1.000	1.000	CRS	F32	1.000	1.000	1.000	CRS
F03	1.000	1.000	1.000	CRS	F33	1.000	1.000	1.000	CRS
F04	0.888	1.000	0.888	IRS	F34	0.991	1.000	0.991	IRS
F05	1.000	1.000	1.000	CRS	F35	0.992	0.995	0.997	IRS
F06	0.960	0.988	0.972	IRS	F36	1.000	1.000	1.000	CRS
F07	0.920	1.000	0.920	IRS	F37	0.987	1.000	0.987	DRS
F08	0.968	0.971	0.997	DRS	F38	0.977	1.000	0.977	DRS
F09	0.854	1.000	0.854	IRS	F39	1.000	1.000	1.000	CRS
F10	0.814	1.000	0.814	IRS	F40	1.000	1.000	1.000	CRS
F11	0.886	0.916	0.968	DRS	F41	1.000	1.000	1.000	CRS
F12	0.990	0.998	0.992	DRS	F42	1.000	1.000	1.000	CRS
F13	0.993	0.995	0.998	IRS	F43	0.962	0.980	0.982	DRS
F14	0.836	0.922	0.907	DRS	F44	1.000	1.000	1.000	CRS
F15	1.000	1.000	1.00	CRS	F45	1.000	1.000	1.00	CRS

			0					0	
F16	1.000	1.000	1.000	CRS	F46	0.951	0.965	0.986	DRS
F17	1.000	1.000	1.000	CRS	F47	1.000	1.000	1.000	CRS
F18	0.891	1.000	0.891	DRS	F48	1.000	1.000	1.000	CRS
F19	1.000	1.000	1.000	CRS	F49	1.000	1.000	1.000	CRS
F20	1.000	1.000	1.000	CRS	F50	1.000	1.000	1.000	CRS
F21	1.000	1.000	1.000	CRS	F51	1.000	1.000	1.000	CRS
F22	0.900	0.904	0.995	DRS	F52	1.000	1.000	1.000	CRS
F23	0.977	0.979	0.998	DRS	F53	1.000	1.000	1.000	CRS
F24	1.000	1.000	1.000	CRS	F54	1.000	1.000	1.000	CRS
F25	0.982	1.000	0.982	DRS					
F26	1.000	1.000	1.000	CRS					
F27	1.000	1.000	1.000	CRS					
F28	1.000	1.000	1.000	CRS					
F29	1.000	1.000	1.000	CRS					
F30	1.000	1.000	1.000	CRS					

A Study of Physical and Chemical Properties of an Earthen Fish Pond Water

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Abstract

The study of physical and chemical parameters in earthen pond in AK Farm in Kwara State, Nigeria was conducted to determine the quality of water for pond fish culture from January to May, 2015. Eleven Water samples were collected from the ponds and analyzed using standard laboratory methods and procedures. The results showed variation in the observed parameters at upstream and downstream. The samples were analyzed at Chemistry Department laboratory, University of Ilorin, Ilorin, Nigeria. Temperature ranged from 25-28°C, pH 7.4 -7.8, Dissolved oxygen 100.8 - 128.0 mg/l, Biological oxygen demand 22.6 - 44.3 mg/l, Alkalinity 1.10-5.14 mg/l, Calcium 1.6- 6.5 mg/l, Hardness 2.0 - 13.72 mg/l, Turbidity 15.5 – 57.1 cm and Water colour ranged from pale to greenish brown. The results are between the acceptable and required limits, there were little differences at the upstream and downstream of the pond. The increase in the pond Turbidity at upstream was as a result of feed decomposition in this point because is used as the feeding point. Also in March the increase in the turbidity was as a result of excessive rainfall which washed sand into the pond.

Keywords: *Water, Water Samples, Water Quality, Turbidity, Fish, Earthen Pond*

INTRODUCTION

A pond refers to as an inland body of standing water, either natural or man-made smaller than a lake. Water quality generally means the

component of water which must be present for optimum growth of aquatic organisms (Ehiagbonare and Ogunrinde, 2010). Earthen pond is the oldest form of fish culture system in Nigeria, the system involves the development of ponds in land with close proximity to a water body or along the course of gentle flowing stream or spring or excavation of a marked portion of land where water is close to the ground surface.

Fish culture involves controlled cultivation and harvesting of fish for either family consumption or salesin the market. Although, fish culture is over fifty years old in Nigeria, it is yet to develop fully when compared with arable agriculture and to some extent livestock production (Bolorunduro and Abba 2000).

In aquaculture, water is the most important resource and can also be the source of contamination. The contamination level increases due to human activities and lack of environmental regulations (Mishra, 1999).The optimum production of fish is totally dependent on the physical, chemical and biological qualities of water. Successful pond management requires the understanding of water quality. Aquaculture is a major fast growing sector of universal food production; a source of protein of the globe. Fish is important component of human foods and animal feeds. Hence, the need for rapid development and proper management of fishery is becoming a necessity in view of the high demand for fish by people as a relatively cheap source of protein (Torimiro, 2014). According to Boyd (2000), the mortality of fish due to disease and water pollution constitutes problems to aqua-cultural development in Nigeria.

According to Edwards, 1999 the qualities of water in which fish are contained is also important to their livelihood. Kolo (1996) observed that inadequate environmental condition is one of the major factors that limits fish production. The distribution and size of the fish population are largely determined by the interaction of the fish with

the immediate environment which directly has impact on the quality of pond water and on the ecosystem.

Water quality is very hard to define and to a great extent extremely subjective. It is not simply a case of the cleaner or pure the better, for example, distilled water is extremely pure chemically and so its quality can be considered as being high as it contains no toxicants or pollutants, yet it is unsuitable for portable use and it lacks the trace elements necessary for freshwater biota. Water quality can only be defined in relation to some potential use for which the limiting concentration of various parameters can be identified (Gray, 1994). There are a variety of uses for water, each requiring their own set of specific quality requirements (criteria). This classification system was originally proposed by the World Health Organization (WHO, 1978).

The quality suitability of different water sources depend largely on the status of its chemical composition. The parameter of concern in quality determination of water include: Electrical Conductivity (EC_W), Total Dissolved Salt (TDS), Cations and Anions (Na^+, Mg^{++}, Ca^{++}, Cl^-, Co_3-, HCo_3^-, So_4^-). Others include; Ammonium-Nitrogen (NH_4-N), Nitrate-Nitrogen (No_3- -N), Phosphate Phosphorus (Po_4- -P), Acidity and Basicity (pH), and Boron (B) (Loveday, 1997).

In most of the countries, fishes are cultivated in ponds but unfortunately such culturists are not so aware of importance of water quality management in fisheries and if they are properly guided, and make aware about the water quality management practices, they can get and have a maximum fish yield in their ponds to a greater extent through applying low input cost and getting high output of fish yield. The role of the various factors like temperature, turbidity, water colour, pH, alkalinity, hardness, ammonia, nitrite, nitrate, biochemical oxygen demand (BOD) etc. can't be overlooked for maintaining a healthy aquatic environment and for the production of sufficient fish food organisms in ponds for increasing fish production (Anita and Pooja, 2013).

It is in the light of the above that this study was carried out to study the effects of water quality on fish growth by determining some major physico-chemical properties of pond, compare the result with some acceptable standards, in order to as to ascertain the suitability of the pond for artificial fish culture.

STUDY APPROACH AND METHODOLOGY

Description of the Study Area

AK Earthen Fish Pond is located beside Apostolic Secondary School, Airport Road in Ilorin West Local Government Area of Kwara State, Nigeria. It is located at latitude 08° 20'N and longitude 04° 30'E of the Greenwich Meridian. Bore hole is used as water source to supplement rainfall, and monoculture fishing system is adopted. The area and volume of pond are 50×30m (1,500m^2) and 7,500m^3 (50×30×5 m), respectively. The pond's wall is made up of cement bags filled with salty soil to prevent water leakages. It consists of an inlet and outlet at upstream and in downstream, respectively. The pond was stocked with 1,200 pieces of juvenile catfishes produced from the farm hatchery on the 12th of January 2015.

Water Sampling Method

Four sampling points were considered; upstream stream, middle point, the downstream and the main source (borehole). Eleven water samples were collected each in 2 liters transparent plastic containers from 10th January to 9th of May, 2015 and tagged sample A_0, A_1, A_2, B_1, B_2,C_1, C_2, D_1, D_2, E_1, and E_2, respectively. These water samples were taken to the laboratory for analysis.Table 1 below shows the water sampling details.

Table 1: Water Sampling Details

S/N	Sample	Source of collection	Date of collection
1	A_0	Borehole	10th of January 2015
2	A_1	Upstream	10th of January 2015
3	A_2	Downstream	10th of January 2015
4	B_1	Upstream	7th of February 2015

5	B_2	Downstream	7th of February 2015
6	C_1	Upstream	7th of March 2015
7	C_2	Downstream	7th of March 2015
8	D_1	Upstream	4th of April 2015
9	D_2	Downstream	4th of April 2015
10	E_1	Upstream	9th of May 2015
11	E_2	Downstream	9th of May 2015

Water Analysis Methods

The following methods were employed for the analyses:

(i) The soil pH by using glass electrode pH meter in soil-water filtrate.

(ii) The exchangeable cations by flame analyser after extraction with neutral ammonium acetate.

(iii) Turbidity was measured using a spectrophotometer.

(iv)Dissolved oxygen (DO) was determined by a titration method.

(v)Total hardness was determined titrimetrically, where 20 ml of each sample was measured
into conical flask with 50 ml of water.

(vi)Biological Oxygen Demand - Water sample was aerated for five days at 20°C in incubator in a BOD bottle using a clean supply of compressed air, and then the dissolved oxygen was then taken after five days of incubation to determine the BOD.

(vii)Alkalinity was also determined by adding methyl orange to 50 ml of each sample, it is then titrated against 0.02 m of hydrochloric acid which produced an orange colour when it reached its end point.

(viii) Colour -Distilled water was put to Lovibond Compactor glass tubes and water sample added. When reading was taken, the Lovibond disc was placed over the end of the tube containing distilled water and rotated until a combination was found that appears to have a colour similar to that of the sample. The colour was recorded as the sample colour.

(ix) Temperature - Mercury in glass centigrade thermometer was immersed vertically in the pond, and allowed to stand till the temperature readings was steady. The reading was taken.

RESULTS AND DISCUSSION

Fish do not like any kind of changes in their environment. Any changes add stress to the fish and the larger and faster the changes, the greater the stress. So the maintenance of all the factors becomes very essential for getting maximum yield in a fish pond. Good water quality is characterised by adequate oxygen, proper temperature, transparency, limited levels of metabolites and other environmental factors affecting fish culture (Anita and Pooja, 2013). The results of analyses of the water samples from the earthen pond were shown in Tables 2.

Table 2: The Results of Analysis of Water from Earthen Pond

S/N	Parameter	January		February		March		April		May	
		US	DS	US	DS	US	DS	US	DS	US	DS
1	pH	7.69	7.74	7.37	7.74	7.5	7.4	7.80	7.70	7.59	7.61
2	DO (mg/l)	128	117	121.6	124.8	108.2	125.4	104.0	100.8	101.9	101.2
3	BOD (mg/l)	40.2	38.5	40.0	40.1	41.8	44.3	24.20	22.60	35.60	30.60
4	Alkalinity (mg/l)	1.50	1.30	1.30	1.28	5.14	4.32	1.10	1.20	2.30	2.80
5	Calcium (mg/l)	2.40	2.10	1.6	2.0	5.80	6.50	2.30	2.10	2.10	2.05
6	Hardness (mg/l)	4.20	4.5	3.8	4.1	12.6	13.72	2.10	2.00	5.00	4.91
7	Colour	Pale		Greenish		Greenish brown		Greenish brown		Greenish	
8	Turbidity (cm)	15.5	21.4	55.8	56.5	53.1	57.1	17.4	18.3	16.9	17.2
9	Temperature (°C)	25	25	24	25	25	25	28	28	25	25

The pH of water is a measure of how acid or basic it is, on a scale of 0 to 14 with 7 being neutral. P^H testing is useful to detect possible mineral acidity. The range of pH obtained from results of this study is 7.37 - 7.80. According to Boyd, 1998most fish species do well within the pH range of 6.5 to 9.0. Chronic pH levels below 6.5 may reduce fish reproduction and experiences slow growth, and are associated with fish die-off. A pH

reading below 4.5 indicates that there is strong mineral acidity, which is harmful to fish and difficult (expensive) to neutralize. Low pH between 4.5 and 6.5 can often be corrected by the addition of crushed limestone. At approximately pH 4.0 or below and pH 11 or above, most species die (Lawson, 1995). Thus, with this water, good productivity and fish health can be achieved.

Dissolved oxygen is considered as one of the most important aspect of aquaculture. It is needed by fish to respire and perform metabolic activities. Dissolved oxygen (DO) affects the growth, survival, distribution, behaviour and physiology of shrimps and other aquatic organisms (Solis, 1988). The principal source of oxygen in water is atmospheric air and photosynthetic planktons. Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth and more fish mortality, either directly or indirectly (Bhatnagar and Garg, 2000).The low levels of dissolved oxygen are often linked to fish kill incidents. On the other hand, optimum levels can result to good growth, thus result to high production yield. The DO (mg/l) obtained from this study is in the range of 100.8 - 128.0 mg/l which is acceptable for fish production. In general, a saturation level of at least 5 mg/L is required. Values lower than this can put undue stress on the fish, and levels reaching less than 2 mg/L may result to death (Lawson, 1995).

Alkalinity is the water's ability to resist changes in pH and is a measure of the total concentration of bases in pond water including carbonates, bicarbonates, hydroxides, phosphates and borates, dissolved calcium, magnesium, and other compounds in the water (Cook *et al.,* 1986). According to Wurts and Durborow (1992) alkalinity between 75 to 200 mg/L, but not less than 20 mg/L is ideal in an aquaculture pond. Stone and Thomforde (2004) suggested 50-150 mg/L ($CaCO_3$) as desirable range; an acceptable range of above 20 mg/L and less than 400 mg/L for ponds. According to Santhosh and Singh (2007) the ideal value for fish culture is 50-300 mg/L. In the study, alkalinity ranged from 1.10 -5.14 mg/l which is low and less than the desirable range. The low alkalinity indicates that

even a small amount of acid can cause a large change in pond water pH. The low level of alkalinity in the study area can be increased by calcium carbonate, concrete blocks, oyster shells, limestone, or even egg shells depending upon soil pH and buffering capacity.

Calcium is generally present in soil as carbonate and most important environmental, divalent salt in fish culture water. Fish can absorb calcium either from the water or from food (Anita and Pooja, 2013).Wurts and Durborow (1992) recommended range for free calcium in culture waters is 25 to 100 mg/L (63 to 250 mg/L $CaCO_3$ hardness).Calcium range is 1.60 –6.50 mg/l from the results of this study and this range is less than the recommended range.Addition of bone meal, Oyster shell and lime stone can be used to improve the level of calcium in the pond water.

Hardness is the measure of alkaline earth elements such as calcium and magnesium in an aquatic body along with other ions such as aluminum, iron, manganese, strontium, zinc, and hydrogen ions (Anita and Pooja, 2013). Hardness values from the results of this study varied monthly; it ranged from 2.0– 13.72 mg/l. The values are lower than the recommended value of 25 -100 mg/l by Wurts and Durbow, 1992.

Turbidity - Ability of water to transmit the light that restricts light penetration and limit photosynthesis is termed as turbidity and is the resultant effect of several factors such as suspended clay particles, dispersion of plankton organisms, particulate organic matters and also the pigments caused by the decomposition of organic matter (Anita and Pooja, 2013). In this study, turbidity ranged from 15.5 - 56.5 cm which is desirable for fish production. According to Bhatnagar*et al.* (2004) turbidity range from 30-80 cm is good for fish health; 15-40 cm is good for intensive culture system and < 12 cm causes stress. According to Santhosh and Singh (2007) the transparency between 30 and 40 cm indicates optimum productivity of a pond for good fish culture.

Temperature is defined as the degree of hotness or coldness in the body of a living organism either in water or on land (Lucinda and Martin, 1999). As fish is a cold blooded animal, its body temperature changes according to that of environment affecting its metabolism and physiology and ultimately affecting the production (Anita and Pooja, 2013). According to Delince (1992), temperature of 30-35°C is tolerable to fish. Santhosh and Singh (2007) recommended that the suitable water temperature for fish culture is between 24 and 30°C. The temperature values range is 24 to 28 °Cfrom the results of this study which is desirable for fish production in accordance with the recommended range.

The colour of an object is defined by the wavelengths of visible light that the object reflects (Anita and Pooja, 2013).The results of this study for water colour ranged from pale to greenish brown, which is in line with the recommended range for fish production. According to NAER (1996) pale colour, light greenish or greenish waters are suitable for fish culture and Bhatnagar *et al.,*(2004)states that dark brown colour is lethal for fish culture, light green colour is good for fish culture, dark green colour is not ideal for fish culture and clear water is unproductive for fish culture.

Biochemical oxygen demand (BOD) is the measurement of total dissolved oxygen consumed by microorganisms for biodegradation of organic matter such as food particles or sewage etc. (Anita and Pooja, 2013). In this study, the BOD values ranged from 22.6 – 44.3 mg/L which is greater than the recommended optimum level. Santhosh and Singh (2007) recommended optimum BOD level for aquaculture should be less than 10 mg/L but the water with BOD less than 10-15 mg/L can be considered for fish culture. The increased level of BOD in this pond water can be corrected by adding lime, removal of non-biodegradable and floating organic matter from the pond surface, aeration, screening or skimming to reduce BOD level.

CONCLUSIONS

Generally, the parameters analyzed fell within the desirable and acceptable limits. Although, there were values higher than the acceptable

limit, the situation can be remedied by change of water in the ponds. However, significant pollution of the fish ponds was not indicated from the result of the parameters analyzed. The growth of the fish was also affected positively, the average weight was 1.5kg and low mortality was recorded.

There is a need to analyze the fish pond water at regular intervals. This is a quality assurance process to ensure that there are no toxic substances in the ponds leading to possible bio-accumulation and magnification. In this way, the good health of the aquatic ecosystem, humans and environment can be guaranteed.

RECOMMENDATIONS

The following recommendations were drawn from this study:

(i) Regular water quality assessment should be undertaken annually and Proper control of vegetation growth around the pond is essentially important.
(ii) Feeding of fish must be regulated.
(iii) Wild aquatic organisms should be controlled in and around the pond.

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Tree species diversity and structure of Illo-Kaoje Forest reserve, Kebbi State, Nigeria

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Abstract

This study was carried out to examine tree species diversity and structure of Illo-Kaoje Forest Reserve. Twenty sample plots (20m×25m) were laid at random within the forest reserve. In each plots, the number and type of tree species were identified and recorded. Diameter at breath height (dbh) and Tree height of each stand was also measured. A total of 568 tree species distributed in 13 families, 27 genera and 31 species were recorded. *Vitaleria paradoxa* had the highest number of trees (91) followed by *Daniellia oliveri* (76) while *Strichnos spinosa* and *Nauclea diderrichii* had 3 stand each. Shannon Wiener diversity index was 2.92; Species richness 1.30; Evenness 0.85 while Hmax and Density stood as 0.85 and 0.06 respectively. Illo-Kaoje Forest Reserve has a moderate diversity and therefore, the need to manage the existing forest resources for continual production of goods and services is hereby recommended.

Key words: Diversity, forest reserve, Dbh, tree height and density

INTRODUCTION

Forests provide significant economic and ecological benefits to man. They play important role in protecting soil and water resources and provide a vast array of products and services for the population (Thomas, 2006). The total number of plants, their types and appearances within the environment make up the vegetation of that area, thus vegetation means the plant cover of an area (Thomas, 2006). Forests are important source of fuel (firewood and charcoal). Timber from the trunk of woody plants is still

the most dominant structural material for building and construction purposes. Forests are also imperative in watershed management and amelioration of hostile environment e.g. sand dunes fixation, minimization of soil erosion and desertification control. They also provide food, raw materials for industries, fodder for animals, recreation opportunities, shelter for wild animals etc. Forests also serve as an effective sink for carbon dioxides (sequestration) and also release oxygen from its photosynthesis process which helps in stabilization of climate. Forests therefore constitute significant element in the national economies and ecological stabilization of many tropical countries. Forests are important in the maintenance of an attractive forest environment, provision of opportunity for relatively intense outdoor recreation, provision of habitat for wildlife, watershed management, general conservation including minimization of soil erosion and the production of wood for various uses (Aweto, 1990). Forest also serves as effective sink for carbon dioxide and releases oxygen from its photosynthetic activity.

In Nigeria, population growth coupled with urbanization and industrialization have put more pressures on the dwindling forest resources which increases demand on renewable natural resources and often resulted to over exploitation and clearance of forests. According to Oyebo (2006) about 350, 000 to 400,000 ha of forests are being lost per annum through over exploitation (mainly as food, fuel, fodder, illegal logging, overgrazing etc.) and non-replacement of the natural vegetation. Forest reserves were therefore created in order to harness the forest resources through protection and conservation for the use of present generation as well as generations yet to come. The overall objectives of forest reserves in Nigeria include; production of goods and services, conservation for future uses, protection of flora and fauna, gene pool conservation and research purposes. Other objectives are recreation, environmental protection and production of timber and non-timber products.

Pressures on forests, especially in the tropical world, to provide economic resources have been increasing rapidly as a result of geometric increase of

human population in the region (Salami, 2006). This has led to unabated deforestation, which has been recognized as one of the major drivers of biodiversity loss (Ojonigu *et al.*, 2010). According to FAO (2005), each year about 13 million hectares of world's forest are lost due to deforestation. Groombridge (1992) observed significant pressures on biodiversity of forest reserves through anthropogenic activities such as over exploitation of forest resources, grazing in forest reserves and conversion of forest areas to other forms of use such as residential, schools, industries, road constructions etc and unstable climate conditions. The overall impacts are reduction, fragmentation and impaired natural ecosystem functions. Forest reserves plays significant role in the socio-economic of (rural) dwellers around the reserve as well as ecological benefits derived there from.

The Illo-Kaoje Forest Reserve is the richest reserve in both flora and fauna in Kebbi State. Its location in guinea savannah ecological zone in the state provides the area with diversified plant species and a variety of wildlife habitats. This rich reserve has been seriously degraded and some part of the area has been converted to other land uses. This has resulted in the decline of land area and loss of biodiversity (both fauna and flora). The major objectives of this research were to determine the tree species composition, diversity as well as structure of tree species in Illo-Kaoje Forest Reserve of Kebbi State, Nigeria.

MATERIALS AND METHODS

Study Area

The research was carried out in Illo-Kaoje Forest Reserve No.7, as identified in the Gwandu Native Authority (N.A.) Forest Reserve No.7 (Illo-Kaoje Forest), under the Forestry Ordinance 1950 of the Northern Region of Nigeria. It was published as N.A Public Notice No.104 of 1950 at page 11 as a supplement to Gazette No.68 of 21st December 1950. It is now located in Bagudo Local Government Area of Kebbi State on longitude 3° 45' – 3° 58' E and latitude 11° 10' – 11° 26'N of the Equator (Singh and Babaji, 1989). The mean annual temperature varies from 28°C - 34°C while mean annual rainfall totals to more than 1000mm but the

rainfall distribution is erratic, often resulting in extended periods of drought (FORMECU, 1998).The reserve is bounded by Benin Republic to the Southwest and Republic of Niger to the Southeast. The Reserve covers a total land area of 590.5 km^2 of Illo and Kaoje Districtsof Kebbi State (Figure 2).

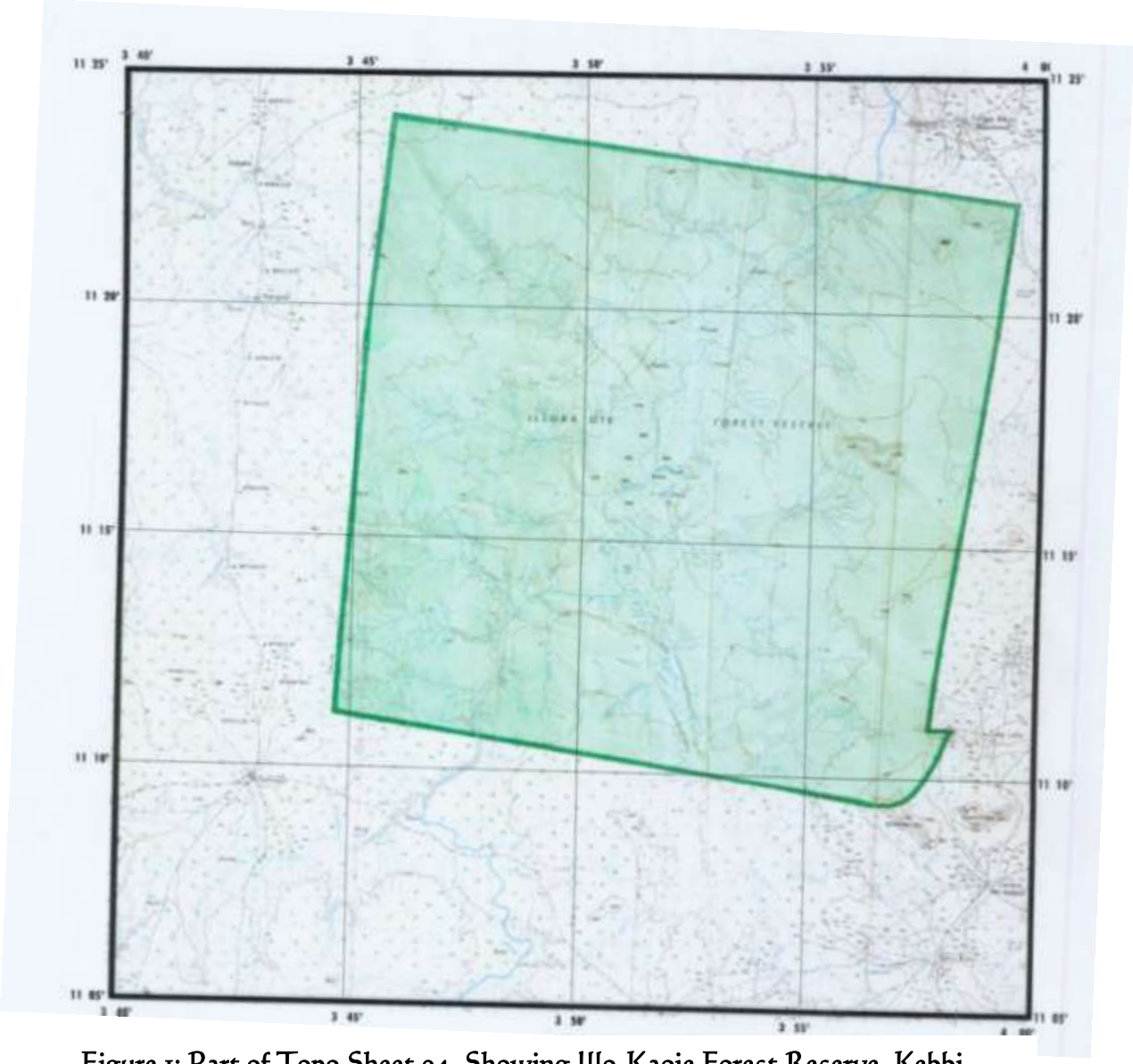

Figure 1: Part of Topo Sheet 94, Showing Illo-Kaoje Forest Reserve, Kebbi

Source: Ministry of Land and survey, Sokoto State (2013).

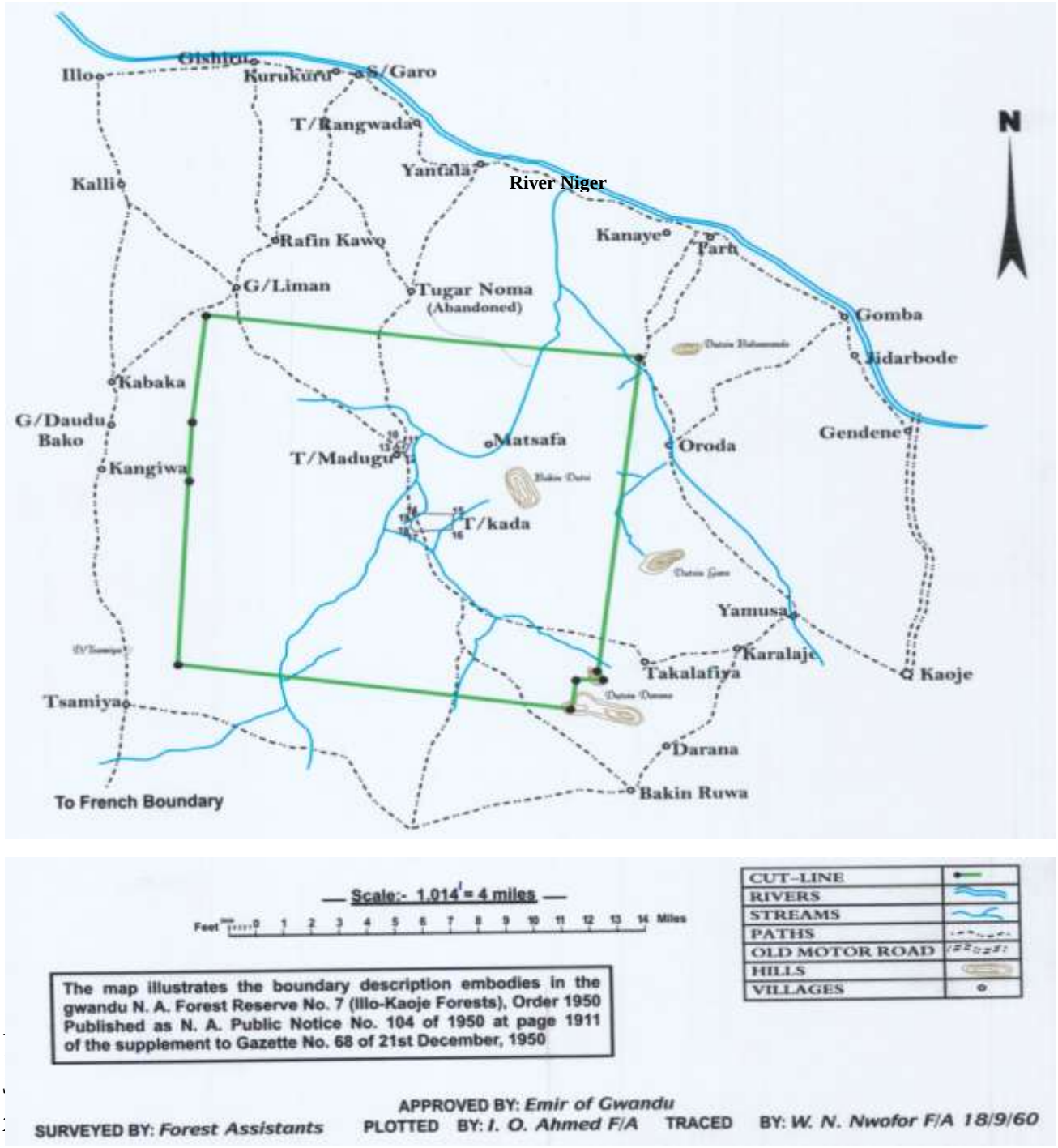

Figure 1: Map of Nigeria showing Kebbi State
Source: Dodo *et al.*, 2011

Data Collection

The entire forest reserve was divided into rectangular plots of 100 x 100 m (1 ha) in size and twenty sample plots measuring 20m x 25m were selected using the simple random sampling technique. Within each of the selected sample plots, measurement and identification were limited to all woody plants with diameter at breast height (dbh) of ≥ 10 cm. The tree data collected in each sample plot for further analysis were dbh and height of all tree species in each plot using Spiegel relaskop. The number and scientific names of all the tree species encountered in each plot were recorded. When it was difficult to identify the species in the field, the common/local name were recorded, and plant specimens such as leaves, fruits were collected for identification using Hopkins and Standfield (1966) and Ghazanfar (1989).

Data Analysis

Tree species diversity

The following indices were also employed following Kent and Coker (1992).

i. Shannon wiener diversity index

$$H' = \sum_{i=1}^{s} pi \ln (pi) \quad \text{(1)}$$

Where; H'= Shannon diversity index, S = number of species in the community, Pi = proportion of individuals found in the ith species. And Pi = ni/N where ni = number of individuals of species i in the sample, N = total number of individuals sampled.

ii. Pielou's species evenness index

$$E_H = H'/H \quad \text{(2)}$$

iii. Margale f's index of species richness (M)

$$M = \frac{S-1}{LnN} \quad \text{(3)}$$

Forest Structure Analysis

i. Basal area

The basal area of all trees in the sample plots were calculated using the formula:

$BA = (\prod D^2)/4$ …… (4)

Where, BA = Basal area (m2), D = Diameter at breast height (cm) and л = pie (3.142). The total BA for each plot was obtained by adding all trees BA in the plot.

ii. Volume

The volume of each tree was calculated in every plot using the Huber's formula, as described by Charles (1989).

$V = h\ (BA)$……..…….. (5)

Where, h = Height and BA = Basal area. Plot volumes were also obtained by adding the volumes of all the trees in the plot.

iii. Relative density (%) of each species was computed following the equation of Brashears *et al.* (2004)

iv.

$RD = (\frac{ni}{N}) \times 100$ ……..……. (6)

Where, RD is the relative density of the species; ni is the number of individuals of species *i* and N is the total number of all individual trees.

v. Relative dominance

Relative dominance (%) of each species was estimated using the following equation:

$RDo = \frac{\Sigma_{B_{ai}\ x\ 100}}{\Sigma_{B_{an}}}$ ……..…….. (7)

Where, RDo is the relative dominance of the species; Ba*i* is the basal area of all individual trees belonging to a particular species i; Ba*n* is the basal area of all species in the study area.

vi. Importance value index

The sum of the RD and RDo divided by 2 (RD x RDo/2) gave the importance value index for each species (Brashears *et al.* 2004; Yang *et al.,* 2008). This was used to express the share of each species in the tree community (Rajkumar and Partha- sarathy, 2008).

RESULTS

A Checklist of Plant Species in Illo-Kaoje Forest Reserve

A checklist of plant species (>10cm dbh) revealed a total number of 568 tree species distributed in 18 families, 27 genera and 31 species (Table 3). A species in *Saponaceae* with only 1 genus account for 16% of the total population followed by a species in *Caesalpinaceae* (*Daniellia oliveri* with 13.4%). Most of the families are represented by only 1 or 2 genera except *Caesalpinaceae* that has 5 genera, followed by *Combretaceae* 4, while *Mimosaceae* and *Moraceae* had 3 genera each.

Tree Species Diversity and Abundance in Illo-Kaoje Forest Reserve

Table 1 shows that *Vitaleria paradoxa* had highest number of species (91) followed by *Daniellia oliveri* (76) and *Anogeissus leiocarpus* (61). *Nauclea diderrichii, Annona senegalensis* and *Strichnos spinosa* had the least number of species (3 each). *Khaya senegalensis* has the highest dbh of 48.1cm, followed by *Anogeissus leiocarpus* with 44.6cm while the least dbh was recorded on *Combretum nigricans* (14cm); *C. glutinosum* (15.2cm) and *Terminalia avicennoides* (16.7cm). The highest (42m) and lowest (4.2m) height were recorded for *Isoberlinia doka* and *C.nigricans* respectively. The highest basal area (0.14m^2) and volume (4.6m^3) were attributed to *Anogeissus leiocarpus* and *Khaya senegalensis* respectively while the least basal area (0.013m^2) and volume (0.14m^3) were contributed to *Combretum nigricans*.

Daniellia oliveri had the highest IVI (16.8%) followed by *Anogeissus liocarpus(13.58%)* as well as *Vitaleria paradoxa* and *Piliostigma thonningii* had similar IVI of 13.3%. *Annona senegalensis* has the least IVI (0.3%)

followed by *Parinari microphylla, Lannea acida* and *Tamarindus indica* with same IVI of 0.76%. The total basal area and volumes of the reserve were 23.92m^2 and 688.02m^3 respectively. While Shannon wiener diversity index was 2.92; Species evenness was 0.85; Species richness was 1.30; Shannon's maximum diversity index (Hmax) was 3.34 and Density index stood at 0.06.

Table 1: Dbh distribution for Trees in Illo-Kaoje forest reserve

Dbh (cm)	No. of Plants	Percentage %
10-20	64	11.3
21-30	239	42.1
31-40	216	38.0
41-50	49	8.6
Total	568	100

Source: Field Survey, (2014)

Table 2: Height Distribution for Trees in Illo-Kaoje Forest Reserve

Height (m)	No. of Plants	Percentage %
<5	47	8.3
6-10	121	21.3
11-15	224	39.4
16-20	85	15.0
21-25	76	13.3
26-30	14	2.5
>30	1	0.2
Total	568	100

Source: Field Survey, 2014.

Table 3: Checklist of Plant Species in Illo-Kaoje Forest Reserve

Family	Scientific name	Frequency	V/N (Hausa)
Anarcadaceae	*Lannea acida*	6	Farun tudiya
	Lannea microcapa	15	Faru
Annonaceae	*Annona senegalenisis*	3	Gwadardaji
Amlidaceae	*Cissus populnea*	5	Dafara
Bombaceae	*Bombax costatum*	8	Kurya
Caesalpinaceae	*Daniellia oliveri*	76	Maje
	Detarium microcarpum	22	Taura
	Isoberlinia doka	34	Doka
	Piliostigma thonningii	10	Kalgo
	Tamaridus indca	5	Tsamiya
Combretaceae	*Anogeissus leiocarpus*	61	Marke
	Combretum glutinosum	10	Tsiriri
	Combretum nigircans	13	Tsiriri
	Terminalia avicennoides	38	Baushe
Ebanaceae	*Diospyros mespiliformis*	13	Kaiwa
Fabacceae	*Piptadeniastum africanum*	3	Dorawarbiri
Leguminoceae	*Pterocarpus erinaceus*	39	Madobiya

Table 3. Cont'd.

Logamaceae	*Strichnos spinosa*	3	Kokiya
Meliaceae	*Khaya senegalensis*	4	Madaci
	Parkia biglobosa	28	Dorawa
	Prosopis Africana	18	Kirya
Moraceae	*Ficus platyphylla*	6	Gamji
	F. polita	4	Durumi
	F. sycomorus	8	Baure
Palmae	*Borassus aethiopium*	8	Giginya
Rosaceae	*Parinari microphylla*	4	Gawasa
Rubiaceae	*Nauclea diderrichii*	3	Tafashiya
Saponaceae	*Vitaleria paradoxa*	91	Kadanya
Verbanaceae	*Vitex doniana*	13	Dinya
Total		568	

Source: Field Survey (2014)

Species	F	Ht	Dbh	BA(m^2)	Vol.(m^3)	pilnpi	RD	Rdo	IVI
Acacia sieberiana	12	7.6	28.2	0.034971	0.262284	-0.0817	2.112312	1.3854	1.74642
Annona senegalensis	3	7.2	21.1	0.028957	0.196905	-0.02777	0.535423	0.2132	0.37103
Anogeissus liocarpus	61	23.6	40.8	0.138562	3.276505	-0.24009	10.744534	16.4243	13.5823
Bombax costatum	8	19	38.2	0.109873	2.086754	-0.0602	1.408451	1.941338	1.674895
Combretum glutinosum	10	7.5	26.2	0.023238	0.169639	-0.07131	1.760563	0.93023	1.345397
C. nigricans	13	6.8	17.8	0.038713	0.270988	-0.08667	2.288732	0.766123	1.527428
Daniellia oliveri	76	26.2	37.8	0.102367	2.221367	-0.26961	13.38028	20.2428	16.81154
Detarium microcarpum	22	6	18.5	0.025734	0.156976	-0.12623	3.87239	1.429771	2.651081
Diospyros mespiliformis	13	7.5	26.4	0.066061	0.594545	-0.08667	2.288732	1.830048	2.05939
Ficus platyphylla	6	16.5	38.1	0.102367	1.822135	-0.0482	1.056338	1.414861	1.2356
F. polita	4	8.4	27.8	0.109873	2.086754	-0.0602	1.408451	1.941338	1.674895
F. sycomorus	8	6.6	24.2	0.023238	0.169639	-0.07131	1.760563	0.93023	1.345397
Isoberlinea doka	34	20.8	39.6	0.038713	0.270988	-0.08667	2.288732	0.766123	1.527428
Khaya senegalensis	4	22.2	41	0.181734	4.616045	-0.035	0.704225	1.379309	1.041767
Lannea acida	6	18.8	30.4	0.055475	0.454394	-0.04178	0.880282	0.6484	0.764341
L. microcarpa	15	17.9	35.1	0.020615	0.115442	-0.18134	6.690141	2.952631	4.821386

Nauclea diderrichii	3	9.6	30.5	0.076464	0.77993	-0.02777	0.528169	0.502244	0.515207
Parinari microphylla	4	5.5	23.4	0.055475	0.454394	-0.04178	0.880282	0.6484	0.764341
Parkia biglobosa	28	16.4	34.5	0.020615	0.115442	-0.18134	6.690141	2.952631	4.821386
Piliostigma thonnongi	10	6.5	25.4	0.039766	0.457308	-0.29386	16.02113	10.68383	13.35248
Piptadeniastrum africanum	3	9.4	24.5	0.045623	0.506411	-0.08667	2.288732	1.800613	2.044673
Prosopis africana	18	10.2	28.7	0.09O804	0.771832	-0.0602	1.408451	1.65143	1.529941
Pseudocedrela kotschyi	4	12.7	28.4	0.181734	4.616045	-0.035	0.704225	1.379309	1.041767

Table 4: Tree species Diversity and Abundance in Illo-Kaoje Forest Reserve

Table 4: Cont'd

Species	F	Ht	Dbh	BA(m^2)	Vol.(m^3)	pimpi	RD	Rdo	IVI
Pterocarpus erinaceus	39(2014)	19.6	34.8	0.114623	2.120531	-0.18432	6.866197	7.33233	7.099264
Cissus populnea	5	11.2	28.2	0.045623	0.506411	-0.08667	2.288732	1.800613	2.044673
Strichnos spinosa	3	10.2	25	0.09O804	0.771832	-0.0602	1.408451	1.65143	1.529941
Tamarindus indica	5	8.5	27.4	0.055475	0.454394	-0.04178	0.880282	0.6484	0.764341
Terminalia avicennoides	38	6.7	23.4	0.020615	0.115442	-0.18134	6.690141	2.952631	4.821386
Vitaleria paradoxa	91	9.8	28.6	0.039766	0.457308	-0.29386	16.02113	10.68383	13.35248
Vitex doniana	13	9.4	29.5	0.045623	0.506411	-0.08667	2.288732	1.800613	2.044673
Borassus aethiopium	8	9.6	38.3	0.09O804	0.771832	-0.0602	1.408451	1.65143	1.529941
Total	568					-2.92219	100	100	100

Index	Value
Shannon wiener diversity Index (H′)	2.92
Species Evenness	0.85
Species Richness	1.30
Shannon's maximum Diversity (Hmax)	3.34
Density	0.06

Key: F=Frequency, DBH=Diameter at breath height, BA=Basal Area Vol.=Volume, RD=Relative Density, RDo=Relative dominance, IVI=Important Value Index

Source: Field Survey

DISCUSSION

Forest contains high diversity in terms of species, genetic materials and ecological processes of ecosystems on terrestrial environment. Forest habitat plays a central role in the functioning of biosphere as they are the origin of many cultivated plants and animals (EU, 2008). A total number of 568 tree species were encounted which were distributed in 18 families, 27 genera and 31 species with families *Saponaceae,Caesalpinaceae* and *Mimosaceae* dominating. This is close to what Muazu (2010) found in Kuyambana Forest Reserve, Zamfara State, Nigeria. He reported the dorminance of *Caesalpinaceae, Mimosaceae* and *Combretaceae* families. In comparison to a similar research done in the Southern part of the country, where Ihenyen *et al.*(2009) reported 2062 tree stands (in just 3 compartments of the forest reserve) belonging to 99 different species distributed into 87 genera and 36 families in Ehor Forest Reserve, Edo State (Forest zone) of Southern Nigeria. These differences may be attributed to variability in terms of weather and climate between savanna and forest ecological zones of Nigeria.

The results obtained from the diameter and height classes of the trees in Illo-Kaoje forest reserve revealed that, the reserve is made up of 3 distinct types of vegetation; namely shrub land, savanna woodland and forest. Each class has a distinctive feature from one another in terms of species diversity. Atiku *et al.,* (2011) found a similar vegetation cover in Tangaza North Forest Reserve of Sokoto State, where they reported that some species were more established than others, some were taller, while others were higher in dominance and that the well established species were not necessarily the indigenous ones. The number of tree species encountered in the study area was adopted as an identifier for the actual species richness in this study (Magnusan *et al.,* 2010).

The diameter and height classes of the trees in Illo-Kaoje forest reserve revealed that, the reserve is made up of 3 distinct types of vegetation; namely shrub land, savanna woodland and forest. Each class has a distinctive feature from one another in terms of species diversity (Table 1 and 2).

Vitaleria paradoxa had the highest number of occurance (with 91 stands) and a relative density of 16.02 (Table 4). So, it could be regarded as the most abundant species in Illo-Kaoje forest reserve. The results further indicate that *Daniellia oliveri* had the highest RD and RDo of 13.38% and 20.24% followed by *Anogeissus leiocarpus* with 10.74% and 16.42% while the low RD and RDo were recorded by *Annona senegalensis* with 0.52% and 0.21% and *Nauclea diderrichii* with 0.53% and 0.56% respectively. Bello *et al.* (2013) reported similar results in Kogo Forest Reserve, where they reported *Anogeissus leiocarpus* with highest RD and RDo of 24.5% and 23.2% followed by *Isoberlinea doka* with 18% and 13.1% while tree species with low RD and RDo were *Annona senegalensis* and *Acacia sieberiana* accordingly.

Biodiversity indices are generated to bring the diversity and abundance of species in different habitats to similar scale for comparison and the higher the value, the greater the species richness (IIRS, 2002). The estimate of species diversity could come from different sources of which forest surveys, adopted in this present study, and biodiversity monitoring programmes have been reported as major sources (Baffetta *et al.,* 2007). But, Beck & Kitching (2007) reported that the observed richness can only be a good approximation of the true richness when it can be demonstrated that the survey is very unlikely to have missed any forest tree species. Therefore, the species richness (1.30) recorded in the reserve is the correct estimate since all the tree species within the sample plots has been counted. The Shannon wiener diversity index of tree species was computed as 2.92. This is similar to 2.63 reported by Bello *et al.* (2013) for Kogo forest reserve of North-Western Nigeria. This value of the diversity index for this study falls within the general limit of diversity index of 1.5-3.5 (Kent and Coker, 1992). The dominant woody tree species in the reserve was *Vitaleria paradoxa* which appeared in almost all the 20 sample plots (20m x 25m) with a total of 91 stands per hectare.

CONCLUSION AND RECOMMENDATIONS

The species diversity indices and abundance obtained in this research compared favorably with other similar forest ecosystems. The Shannon-

wiener diversity index (2.92) obtained from this research falls within the general limit of diversity index of 1.5 – 3.5 (Kent and Coker, 1992) which indicates that tree species are very diverse in the reserve. This shows the potentiality of the reserve in terms of biodiversity conservation and hence the need for effective management of the resources. A fair tariff should also be imposed on logging with specification of trees to harvest; this will discourage illegal logging which destroys habitat and threaten some important tree species.

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Role of School Farm in Social and Technological Development of Students IN Nigerian Secondary Schools

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Abstract

Agricultural Science is one of the core subjects taught in both junior and senior secondary schools in Nigeria. Beside, adequate and qualified agricultural science teachers, adequate classrooms, agricultural science laboratory and school farms are prerequisites to teaching and learning of agricultural science in schools especially in the areas of crop production, soil science and animal production. Schools in Nigeria vary in terms of availability of farming facilities and equipments based on school location and perception of the school administrators. Despite the prevalent nature and condition of school farms its relevance in the social and technological development of secondary school student forms the basis for this discourse. It was however recommended among other that the school management should exploit every avenue to raise funds for the procurement of farm facilities, equipment and material inputs in the school farm and as well seek and encourage other stakeholders in the investment and operation of school farm activities

INTRODUCTION

Agricultural Science programs are designed to instill in students the importance of the different agric-sciences, of marketing strategies, as well as safe food production coupled with the need for continuous research to improve agriculture. Agriculture is a highly technical and ever-changing industry upon which everyone is dependent. Strong, relevant, rigorous agric-science programs are necessary to make students career and college ready in the field of agriculture.

Agricultural Science is one of the core subjects taught in both junior as practical agriculture and as agricultural science in senior secondary schools in Nigeria (FRN, 2009). Because of its promising role in promoting self reliance through the provision of employment opportunities and production of staple foods for the populace together with raw material supply for the agro-allied industries, its teaching as a course offering in our schools and colleges has been made compulsory by the federal government. The Federal Republic of Nigeria in its attempt towards the attainment of these laudable goals outlined the basic objectives of teaching agricultural science at the secondary school level as follows: To stimulate and sustain students interest in agriculture; To inculcate in students farming skills; To enable students acquire basic knowledge and practical skills in agriculture; To prepare students for future studies in agriculture and; To produce prospective future farmers (FRN, 2009). The above objectives can only be attainable through effective instruction and motivation of students by teachers of agriculture.

A holistic implementation of agricultural science curriculum in secondary schools is expected to embrace classroom instruction and practical experiences which the students in agriculture are exposed to (Whyte, 2005). Beside, adequate and qualified agricultural science teachers, adequate classrooms, agricultural science laboratory and school farms are prerequisites to teaching and learning of agricultural science in schools. Though the above requirements are complementary, school farms draws more attention in view of the fact that West African Examination Council (2006) recommended that schools must keep school farms where crops are grown with at least one species of livestock, from each of the following two group: pigs, rabbit and poultry; goat, sheep and cattle and where feasible fish pond. School farms are expected to have adequate equipment, farm implements/tools, farm structure and regular supply of inputs in addition to farm space to accommodate crops and livestock managed by students under the supervision of their teachers (Ani, 1997). These are the fundamentals of an operational school farm on which students could transfer classroom instruction to practical experiences in the field.

In line with this, the school farm offers students the opportunity to acquire knowledge, skills and competencies, and demonstrate farm principles and practices, carry out field experiment which cannot be accommodated in the laboratory. In the overall, it caters for the interest of the rural dwellers whose major occupation is agriculture. They aim at giving a utilitarian and comprehensive education to the youths, farm families and others who might be interested in agriculture as a vocation (Grubb and Lazerson, 2005). In other to establish a well equipped school farm that effectively fit into the above roles, places significant demand on the students, teachers, school management, parents and the immediate community in terms of resources (Pimpa and Suwannapirom, 2008). In response to its increasing stakeholders, school farms in various secondary schools in Nigeria, with the special emphasis on Rivers State, are expanding their activities, roles and proceeds to reach its vested interest. Consequently, school farms are not just for practical experiences but embraces several other benefits. In view of this background, the discourse focuses on the role of school farm in the social and technological development of students taking into consideration the concept of school farm,

Concept of School Farm

School farm is one of the prerequisites for effective implementation of agricultural science curriculum in secondary schools. A school farm is a piece of land located within or around the school and used for cultivation of crops and / or rearing of animals. Essentially, school farms are geared towards helping students acquire necessary farming skills and ensuring that classroom theories are backed up by facts and practice. Therefore, school farm can be regarded as an educational facility (Egbule, 2004). In Nigerian schools, the agricultural Science teacher is usually responsible for the day-day directing of the execution of the work in his school farm. Often the service of farm hands or attendants are needed. The school farm programme are planned and implemented in such a way that practical activities follows the theoretical instructions in the classroom. From the farm activities and projects students can devise a genuine sense of the dignity of labour, and valuable skills through do-it yourself approach. Hence, for attainment of the

objectives of the school farm in vocational agriculture curriculum implementation, the teachers and students should appreciate the importance of the school farm in translating theory in the classroom into practice. Olaitan (1984) in Egbule (2004) summarized the activities of the school farm into crop and livestock. In crops such exercise includes
(a) Land preparation (planning, clearing, marking out the plot, bed preparation and tillage operations
(b) Nursery preparation
(c) Crop propagation and maintenance
(d) Harvesting, processing and marketing of crops,
(e) Seed storage for the next growing seasons and
(f) Keeping farm records.

In livestock, activities include (a) selection of breeding stock or types of animals to keep,
(b) Construction of livestock pens/houses
(c) Rearing the animal i.e. feeding, watering, culling, disease and pest control and
(d) Sales of animal products.

However, some specialist contended that all aspects of field demonstrations (methods and results) which includes, debeaking of birds, vaccination of birds, application of fertilizer to named crops, preparing pre-nursery and nursery, application of crop protectants are carried out on the school farm.

Nature of School Farms in Secondary Schools

It has been observed that many of the existing school farms lacked requisite structures, implements and other farm facilities, while in others these facilities are in a state of complete dilapidation consequent to total neglect of practical lessons in the school farms (Ladele, 1998). In some schools, most of the students come from rural farm families with a detailed knowledge of traditional agriculture gained from their parents. In some cases, these students' expectations from their learning experiences in school agriculture are high. But unfortunately practical experience appears elusive to them due

to lack of school farms (Ladele, 1998). Still, in some schools especially in urban areas, students have no knowledge of agriculture and so their involvement in practical experiences in the school farm is perceived as a drudge and untidy business. Furthermore, schools in urban areas lack sufficient land and site selection is usually not a problem as the agricultural science teachers are compelled to use any available piece of land within the school compound. Meanwhile in rural areas where land is abundant, site selection is done based on sound principles taking into consideration factors such as land availability, soil fertility, water availability, topography, accessibility, nearness to school and security.

However, in-line with West African Examination Council (2006) requirements for practical agricultural purposes, most secondary schools have created space for school farm in the school compound and have acquired improved farm equipments such as surveying equipment (measuring tapes, ranging poles, compass, pegs etc), spade, hoe, matchet, rake, basin and livestock rearing equipments (Alhaji, 2008)

Social Development of Students

Agricultural science curriculum in secondary school is practical oriented, aimed at suitable skill acquisition for a successful transition to the world of work in agri-business endeavours. Emeya, and Ojimba, (2012) noted that the emphasis of integrating productive work into the educational programme could fail if farm resources were not available in the schools to actualize the vocational ends to which agriculture curriculum in secondary schools are aimed at. Additionally, Smith, Peterat and Bartosh (2006) stipulated the benefits students derived from school farm to include:

- Changes in the students' views of the environment.
- development of scientific farming and environmental knowledge
- Have more personal relationship with the environment.
- Shift from seeing the environment as an object or a place, to a view characterized by the inter-connectedness of humans and environment.

- A greater appreciation of the farming enterprises gained, knowledge of scientific and environmental concepts and learning about caring for and helping plants to grow.
- Changes in students perception of farm and farmers as well as develop a sound understanding of land and its significance in supporting human life and development of social skills.

In view of this, Akubuilo (1991) reported that school farms should be divided into plots, for each student to own a plot and grow crops assigned to him/her by the teacher while some may rear simple livestock. The availability of school farm triggers the establishment of Young Farmers' Club in schools. Young Farmers Club is one of the professional responsibilities of agricultural science teacher which has proven as a veritable means of inculcating in young ones the sense of civic pride, willingness to work for the good of the community and development of mutual respect and cooperation between older and younger members of the community. School farm helps to develop the spirit of team work in students as they engage in cooperative learning. Furthermore, students in the course of interaction between two or more members of the group, structuring and restructuring of situations, perceptions and expectations of the members develop leadership skills and qualities. Leadership qualities such visions, sincerity, self control, accountability, humour, empathy, decisive and initiative are crucial in fostering socialization and survival in the modern environment (Egbule, 2004). These are all parts of learning in practical terms which has stepped-up the social way of life of students to which vocational agriculture advocates.

Technological Development of Students

Crops and livestock of various classes are raised in the school farm using adaptable facilities for special needs of the students. Feasible technologies in crop production recommended by NGO's include: multiplication for cassava, water yam, cocoyam, production, maize-telferia intercrop, fertilizer application, cassava, maize-melon intercrop, pineapple production, oil palm production and plantation of seedlings, dry season vegetable production, sole

cropping and intercropping technologies. The technologies recommended sets out to address issues such as better techniques of land development/management, better crop management practices, better qualities crops and high yields of crop through supply of improved varieties (Nsa, Offiong, Robert and Bishie-Unung, 2016). Also, technologies in animal breeding, hatching of poultry eggs and fingerlings, animal pest and disease management, housing, pond construction e.t.c. could be acquired by students through the utilization of school farms.

Students utilize school farms as instrument for trial of new farming techniques. The whole essence of school farm to students is to sustain their interest for agriculture so they can embrace new technologies and at the same time become more efficient in production not just to themselves but the nation at large. School farms hold several technological benefits for the students, teachers, school and the community (Salami, 2008).

There are diminishing opportunities for formal employment, educational institutions are being encouraged to provide relevant form of education designed to promote self reliance and responsible entrepreneurial capacity for self employment. Thus, entrepreneurial skill programmes are gaining prominence in the developing nations (Pimpa and Suwannapirom, 2008). The school farm is fashioned within the principles of entrepreneurial skill development.

School farm provides a means by which students can develop their farming skills and technologies in planning, surveying and farm-stead layout, management and evaluation of farming enterprise and a useful background for future agriculturalists. Farm surveying essentially deals with making vertical and horizontal measurements distances between objects, determining artificial and natural features present on the farm area by means of figures, tables or layouts and using such information for planning (Egbule, 2004). In the course of exposing students to various farm layout practices they tend to acquire skills and techniques in the use of various farm

surveying equipments such as tapes, ranging poles, offset staff, theodolite, gunter's chain, pins and pegs e.t.c.

In this technological era where Information Communication Technologies(ICTs) is indispensible in every area of human endeavour, school farm could trigger the development of ICT skills for Mathematical computation, keeping farm records, accessing agricultural information and sharing of agricultural innovations among students and between students and agricultural science teacher. Computer, software internet, mobile phones and other ICT gadgets facilitate efficiency while carrying out the above mentioned agricultural activities associated with school farm.

CONCLUSION

The discourse carried out to identify the role of school farm in social and technological development of students in secondary schools. The major problem that necessitated the study was that despite the fact that many secondary schools in have the benefit of being sited in government or community land with relatively good space to accommodate and operate a school farm for effective teaching and learning of the subject, the full social and technological benefits of the school farms are yet to be realized in many secondary schools. Although, some schools lack the necessary space to accommodate and operate school farms, it is a prerequisite for effective social and technological development in agriculture. In conclusion, The school farm programme, when properly executed will be of obvious benefits to the social and technological development of students: students would be able to appreciate the practice of farming within the provision of available technology; be better motivated toward making a career in agriculture; and appreciate the profitability of farming as a venture as well as experience different aspects of farming activities.

RECOMMENDATION

The study recommended that:

(i) Agricultural Science teachers in secondary schools should utilize the school farm as a serious teaching aid to complement classroom instructions in agriculture

(ii) The school authorities (management) should partner with relevant agricultural agencies like ADP for the development and operation of school farms.

(iii) The school management should raise and allocate funds for the procurement of farm facilities, equipment and material inputs in the school farm,

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