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## **Drivers of Market Participation Decisions among Smallholder Yam-based System Farmers in Oyo North Area of Oyo State, Nigeria**

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**Abstract:** Participation in agricultural markets could be the main weapon against hunger, to lift smallholder farmers out of poverty traps. Unfortunately, most of the smallholders are constrained by several factors in their quest to participate in the yam market. This study, thus clarified the underpinning drivers of market participation among small-scale farmers in Oyo North Area of Oyo State, Nigeria. Using a two-stage random sample of 227 farmers, the study tests the hypothesis that factors affecting farmers' decision to participate are not necessarily the same as those affecting the extent of participation. Non-price constraints played a significant role in determining decisions on market participation. Policies that reduce transaction costs and induce farmers to commercialize could be critical alternatives to policies based on price, to promote a marketed surplus and the commercialization of agriculture by yam farmers and thereby alleviate poverty.

**Keywords:** Market participation; Double-Hurdle Model, Yam producers; Oyo North Area.

### **Introduction**

Africa is the lead player in the supplies of cassava, with 50 percent of world production and of yam, with 95 percent of world production. Research efforts have been directed to cereals but cassava is now enjoying some level of support. However, yam continues to be sidelined in national food policy programs in West Africa, which remains one of the main areas challenged by hunger and poverty. Yam can be a formidable weapon against these scourges, if investments in food crop Research and Development, specially directed on yam by national governments, regional and non-government organizations, and donors, are used to bring the crop into a central focus in national food policies (IITA, 2012).

An approach in this regard is the encouragement of yam-growing rural smallholder farmers and other stakeholders in the yam sector to participate in the market. Agricultural growth depends on agricultural/food commercialization contributing largely to economic development. According to Mathenge *et al.* (2010), market-oriented production can be highly instrumental in realizing welfare gains by exploiting the opportunities and benefits provided via specialization and comparative advantage, economies of scale, and the regular interaction and exchange of ideas. Moreover, increasing agricultural output will amount only to an exercise in futility if it is devoid of markets that effectively bind the increasingly specialized activities of widely dispersed producers into an integrated national economy. Therefore, participation in agricultural markets can be a key scheme in lifting poor small holder farmers



out of the hunger and poverty traps. Stimulating their participation in agricultural markets will help them to enjoy the benefits necessary to boost food security in the region. Enhancing returns from yam production through improved access to market can be a way-in for welfare gain and a way-out of poverty. Unfortunately, most of the small-scale farmers are constrained by several factors from benefitting from participation in the yam market for their goods and services. Farmers in the study area are confronted with marketing problems indicated by low farm gate prices in spite of the high yam market value, leaving smallholder farmers with low income. Literature on market participation in rural areas continues to be relatively scarce (Bellemare and Barrett, 2006). The present paper is primarily concerned with the question: What holds farmers back from commercialization.

This study, thus, intends to fill those knowledge gaps by clarifying the drivers of market participation among smallholder farmers in Oyo North Area of Oyo State and looks beyond the decision to participate. In the first stage, farmers who produce yam decide whether or not to sell that commodity to the market. In the second stage, farmers who decide to sell determine the extent of their participation.

### **Underlying Theoretical Background**

This paper considers farmers' participation in the market and recognizes that this decision may be made in a single or a sequential two-step process. In the sequential process, the farmers decide whether or not to participate in the market and, if they choose market participation, the next step in the decision is about the quantity to sell. Simultaneous decision-making means that the farmers make choices about market participation and quantity at the same time (Abdoulaye and Sanders, 2005; Chirwa, 2005). Increasing research on sequential decisions on market participation has been done (Croppstedt et al. 2003; Holloway et al., 2005; Ballemare and Barrett, 2006; Xu et al. 2009). The last study explicitly tests whether or not farmers make sequential or simultaneous decisions and finds the evidence necessary to support sequential decision making. None of these studies explicitly tests whether the decision could be made sequentially or simultaneously, as this study does. Small scale farmers' decision to participate in the market can be understood, based on a utility model. Any smallholder farmer in a rural area engages in a range of economically significant market activities. In modeling, the utility or satisfaction derived from the farmers' participation in yam markets, as integrated into the smallholder farming system, the economic values or benefits associated need to be considered. A typical smallholder farmer seeks to participate in the commercial market to maximize a multi-dimensional objective function, including increasing income and food security and reducing all forms of risk (Strauss *et al.* 1989). When there is a change in the economic parameters associated with market participation, the central question is related to how much compensation, whether paid or received, would make the decision-maker uninterested about the change. Thus, the change in welfare associated with this development was used as the basis for the economic valuation process. When an individual farmer faces a change in a measurable attribute, for example, higher returns or lower expenditures from participating in the market ( $p$ ), then  $p$  changes from  $p^0$  to  $p^1$  (with  $p^1 > p^0$ ).

### **Econometric specification: the Double Hurdle model**

As to be mentioned later, generally, not all smallholder farmers participated in yam market. This could be explained in two ways; the farmers do not have yam to take to market or the farmer have yam but did not take it to market, for some reason. The zero values in the former case are related to the respondents' yam ownership decisions, while those in the latter case



are termed as random zeros and they arise from random events. The traditional approach to deal with data that have many zeros (censored dependent variable), has been to use the Standard Tobit model, originally formulated by Tobin (1958). The Tobit estimator fits conceptually when we think of decisions on market participation and yam supply as being made simultaneously. Tobit's model is too restrictive as it assumes the entire zero to be the respondent's deliberate choices. Cragg (1971) modifies the Tobit model to overcome the restrictive assumption inherent in it, namely, he suggests the Double Hurdle (DH) model, to tackle the problem of too many zeros in the survey data, by giving special treatment to the participation decisions. When thinking of decisions on market participation and yam supply as a sequential process, the DH model is appropriate for analyzing the possibility that the factors influencing a farmer's decision to participate in the yam market may not affect the quantity sold. The DH model also allows us to consider that the same factor can potentially affect participation and the amount sold in different ways. We relied on this approach and estimated a DH model, using Craggit command (Burke, 2009) in Stata software (StataCorp, 2013) which combines a probit estimation with a truncated normal regression, in the second step. The first equation in the DH model relates to the decision to participate and can be expressed as follows:

$$y_i = 1 \text{ if } y_i^* > 0 \text{ and } 0 \text{ if } y_i^* \leq 0 \\ y_i^* = x_{i\alpha} + \varepsilon_i$$

Where:

$y_i^*$  is latent participation variable that takes the value of 1 if a household participates and 0 otherwise,  $x$  is a vector of household characteristics and  $\alpha$  is a vector of parameters;

The second hurdle, which closely resembles the Tobit model, is expressed as:

$$t_i = t_i^* > 0 \text{ and } y_i^* > 0 \\ t_i = 0 \text{ otherwise} \\ t_i^* = z_i\beta + u_i$$

Where:

$t_i$  is the observed response on how much yam should be conveyed to the market.

The decisions whether or not to participate in market and about how much yam to convey to market can be jointly modelled, if they are made simultaneously by the household; and independently, if they are made separately, or sequentially, if one is made first and affects the other as in the dominance model (Martinez-Espineira, 2006).

## Empirical Specification

We used a DH model. These decisions are made in a sequential manner and can be subject to two very different decision-making processes. Therefore, we used a set of explanatory variables. The choice of the variables used in this study is largely based on work by Lapar *et al.* (2003), Ballemare and Bartett (2006), Alene *et al.* (2008), and Xu *et al.* (2009), who extensively reviewed factors that influence farmers to participate in a market. The set of independent variables potentially expected to influence market participation are grouped into the following classes: household characteristics, physical assets, social capital and transaction costs.

## Data and Results

The survey was carried out between May and September, 2010. Using a carefully designed and pre-tested questionnaire; we conducted interview with yam producers in Oyo North Area of Oyo State, Nigeria. A two-stage sampling procedure was adopted for the study. Oyo North area was however, purposively selected because it is regarded as the "food basket" of Oyo

State. Random sample technique was employed to draw the final study sample. In all, a total of 240 farmers were sampled. Out of this, information from 227 farmers was found useful for the analysis. The data collected valuable information on several variables, including socio-economic, farm-related, institutional, and technological factors.

The extent of market participation was captured by the proportion of quantity of yam produced, that ended up being sold by each farmer. In the study area, about 50% of the yam produced was marketed while about 92% of the farmers participated in the yam market. This is reflective of the importance of yam as a main source of income in the area. The average age of the farmers was 57 years, an indication that the farmers in the study area are old people, who are already close to their declining production curve. Availability of labor for farming (especially family labor) was indicated by the large size of households (10). The farmers were fairly literate, as about 40% of them completed six years of primary education. The farmers cultivated small plots of land, with an average size of about 2.0 ha. Access to non-farm credit was extremely low, as a sizeable proportion of the respondents claimed that they had never had access to loan facilities from any formal or informal institutions. The yield obtained from the farms varies from farmer to farmer but are low on average (about 9t/ha).

**Table 1: Descriptive statistics**

Variables	Symbol	Obs.	Mean	Std.Dev.
<b>Dependents</b>				
Yam market participation (=1 if the farmer sold yam; 0 otherwise)		227	0.92	0.23
Proportion of yam sold		227	50.06	28.9
<b>Independents</b>				
Age of the farmers (Years)	AGE	227	57.02	13.73
Education status (=1 if farmer has 6 years schooling or more; 0 otherwise)	EDUCS	227	0.60	0.42
Household size (number)	H SIZE	227	9.75	4.36
Distance to market (Km)	DISMARK)	227	8.41	9.45
Total farm size	TFSIZE	227	2.02	1.86
Yam yield (Kg/ha)	YYIELD	227	8932	12203
Average price at which each unit of yam was sold (N/kg)	PRICE	227	250	0.42

**Source:** Field survey (2010)

The econometric estimation results of output market participation among smallholder farmers, using the DH of Cragg (1971) are discussed in this section. Correlates are hypothesized of yam market participation (whether a farmer sold yam) and extent of participation (the proportion of yam sold). The hypothesized variables focused on existing literature of interest, which will inform conclusions on this. Based on relevant statistical tests, as evidenced by the values of Wald Chi<sup>2</sup> and Log Likelihood, as well as signs and magnitude of the estimates, the regression results made better statistical sense and were therefore used in explaining market participation decisions. The probit results on the decision to participate in markets and truncated regression analysis results on the extent of market participation are presented in Table 2.

Age was negative and insignificant in influencing market participation but significant

in affecting the extent of participation, meaning that more of the older people participated in yam marketing. The rationale behind this is that younger people tend to shy away from agricultural activities due to the drudgery involved. Education was negative and significantly related to decision to participate in yam market. This implies that the more education they have, the less the willingness to sell yam by farmers. The tendency could be attributed to improved understanding of storage and possession of better storage facilities by seemingly educated yam farmers.

Farm size was positively and significantly associated with a higher probability of participating in the yam market. In addition, farm size positively and significantly influenced marketed volumes for yam. This is in agreement with the a priori expectation that farmers with large farms produce beyond what they use for home consumption. An increase in farm size naturally implies an increase in output. These results indicate the constraints that farmers who happen to have farms of smaller size face in getting access to markets due perhaps to their inability to produce a marketable surplus. The result also showed that the yield of yam was positively and significantly related to the probability of participating in marketing activities. The higher the yam yields, the higher the tendency for the farmers to sell yam. After the decision to participate in the market has been made, yield has a significant influence on the proportion of yam sold. Increased productivity results in a larger marketed surplus of yam, which could drive the commercialization of other crops.

Membership of a yam producer/marketing group/cooperative society was positively associated with the extent of participation in the yam market. After the decision to participate has been made, membership has a significant influence on the share allocated for sale. These results underscore the importance of social capital in the volume of yam sold by the poor smallholder farmers.

Contrary to expectations, the price for yam was negatively, albeit insignificantly, associated with the decision to sell. This is in agreement with the findings of Mathenge *et al.* (2010). A possible explanation for this unexpected behavior in the sign of price could be connected with the status of the farmer as net buyers of food crops. A high price could stimulate farmers to keep as much yam as possible on the farm, to prevent significant spending on the food crop. Another reason is the fluctuation in prices, occasioned by a lack of storage facilities and high perishability of yam crop.

**Table 2: Estimates of Double-Hurdle Model of Determinants of Yam Market Participation Decision and Degree of Participation**

Variable	Coefficient	Z-Value
<b>First Hurdle</b>		
AGE	-0.00034	-0.04
EDUCS	0.24161	-0.96
HSIZE	0.02231	0.61
TFSIZE	0.08444	0.84
PRICE	-0.16912	-0.69
DISMARK	0.00026	0.09
YYIELD	0.0003***	1.76
OFF-INC	3.77e <sup>-07</sup>	0.07

CONSTANT	2.14636***	3.57
<b>Second Hurdle</b>		
AGE	-0.17008***	-2.67
EDUCS	-0.86820	-0.47
HSIZE	-.05943	0.29
TFSIZE	0.87674	1.14
DISTMARK	0.03053	1.46
YYIELD	0.00068***	9.04
OFF-INC	9.94e <sup>-06</sup>	0.82
CONSTANT	62.0677***	12.83

Field survey: 2010.

### **Conclusion and Policy Implications**

Participation in agricultural markets could be the main weapon against hunger, to lift millions of poor farmers out of poverty trap. Unfortunately, most of the potential beneficiaries are constrained by several factors in their quest to participate in the yam market. The mean proportion of 50% of the production was marketed and yam was the main source of income for most smallholder farmers in the study area. Market participation is becoming crucial to motivate the farmers in increasing their farm's output, hence enabling them to earn more income. This study, thus, clarified the underpinning driver of market participation among smallholder yam farmers in the study area. Evidence from yam markets in Oyo North area suggests the presence of institutional and infrastructural barriers to participation in the yam market. Factors that suggest these are distance from the farmers' village to the nearest market and the transportation cost of supplying yams to the market, which were negatively associated with yam sale. The DH estimation reveals that market participation is governed by two independent decisions; the decision to participate in the market and the decision on the extent of participation. The estimation results show that these two separate decisions are determined by different sets of factors. Non-price constraints also played a significant role in determining decisions on market participation. Policies that reduce transaction costs, which are usually associated with agricultural marketing and value addition; and induce farmers to commercialize could be critical alternatives to policies based on price, to promote a marketed surplus and the commercialization of agriculture by yam farmers and thereby alleviate poverty.

### **References**

- Alene, A., Manyong, V., Omany, G., Mignouna, H., Bokanga, M., Odhiambo, G. (2008). Smallholder participation under transaction costs: Maize supply and fertilizer demand in Kenya; *Food Policy* 33(4), 318-328.
- Balint, B., & Wobst, P. (2005). Institutional factors and Market Participation: The case of Romania; *International Food Policy Research Institute* 48; 223-224.
- Ballemare, M., & Barrett, C. (2006). An Ordered Tobit Model of Market Participation: Evidence from Kenya and Ethiopia; *American Journal of Agricultural Economics* 88(2), 324-337.

- Barrett, C. (2007). Displaced Distortions: Financial Market Failures and Seemingly Inefficient Resource Allocations in Low-Income Rural Communities; Paper presented in Seminar on Resource Allocation among Low-Income Farmers; Cornell University, 12-15 December, 2007
- Burke, W. (2009). Fitting and Interpreting Cragg's Tobit Alternative Using Stata Journal 9(4), 584-592
- Cragg, J. (1971). Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods; *Econometrica* 39(5), 829-844
- Fischer, E., & Qaim, M. (2011). Smallholder Farmers and Collective Action: What Determines the Intensity of Participation? Proceedings of the German Development Economics Conference; Berlin 2011, No. 28; Available at: <http://hdl.handle.net/10419/48336>
- Mathenge, M., Place, F., Olwanda, J., Mithoefer, D. (2010). Participation in Agricultural Markets among the poor and Marginalized: Analysis of Factors influencing Participation and Impacts on Income and Poverty in Kenya, a study report; Tegemeo Institute of Agricultural Policy and Development, Nairobi, Kenya.

## **Growth Performance of African Catfish (*Clarias gariepinus*, Burchell 1822) Following Direct Injection with *Bagrus Bayad* Genomic DNA**

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**Abstract:** Study on the growth performance of African catfish (*Clarias gariepinus*) following direct injection with *Bagrus bayad* genomic DNA was carried out. The aim was to determine the growth and survival of African catfish injected with *Bagrus bayad* genomic DNA. Seventy five (75) *Clarias gariepinus* fingerlings were procured from Maiduguri metropolitan and conveyed to fisheries hatchery complex where the experiment was conducted. The *Bagrus bayad* samples were obtained from river Gashuwa, Yobe state and conveyed to Biotechnology Department of University of Maiduguri for DNA extraction. After the extraction, the genomic DNA was used to inject the 75 fish which were placed into 5 treatments with each having 15 fish (5 fish per replication). The fish were injected based on the DNA concentration of 0, 5, 10, 15, and 20 $\mu$ l/0.1/fingerlings based on the treatment using 2ml syringe. The injected fingerlings were reared for the period of four (4) months. After the culture period, the data on the growth and survival were subjected to analysis of variance. The result revealed that the growth and survival of the fingerlings were better in fingerlings injected with 10 and 20 $\mu$ l of the *Bagrus bayad* genomic DNA. This indicates that the growth and survival of *Clarias gariepinus* fingerlings can be improved through the use of genomic DNA from *Bagrus bayad* at 10 and 20 $\mu$ l concentrations.

**Keywords:** *Bagrus bayad*, effects, genomic, DNA, African catfish, growth, performance.

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### **1.0 INTRODUCTION**

Fish and fisheries product are regarded as best sources of food as they contain higher amount of proteins, vitamins and minerals that can simply utilize by both infants and adults (Abdullahi *et al.*, 2001). In African countries especially Nigeria, fish are eaten at its fresh form or after processing as either smoked or dried and this can be cherished by many people (Adebayo *et al.*, 2008). Fish and fisheries product constitute to 40% of the dietary animal protein consumed by humans in Nigeria. According to Adekoya and Miller (2004), more than 60% of the total animal protein taken by adults especially in rural areas comes from fish and fisheries product. Fish product is higher in nutrient and can easily be digested making it superior over other sources of animal protein (meats or beef, pork and chicken) (Amingheme,

2005). As human population increases, the demand for high quality food especially from aquatic resources is needed. The production of fish through aquaculture is highly needed in order to meet up with the increased human population (Omeji *et al.*, 2013). According to FAO (2007), aquaculture grows quickly than other agriculture sectors as it grows at a rate of 8.8% and above every year since 1970 which is greater than capture fisheries standing at 1.2%. The status of capture fisheries is at decline condition due to over-fishing, habitat destruction, increasing human population and fishing with chemical and other explosive materials (Dunham *et al.*, 2001). In Nigeria, aquaculture is considered as rapidly growing agriculture sub sector, though it was reported that it contribute only 5% to the economy on recent years (Moses *et al.*, 2006). *Clarias* belongs to the family clariidae which is divided into two genera; *Clarias* and *Heterobranchus*. They can be distinguished by the presence of rayed dorsal fin followed by large adipose fin, which is present on the *Heterobranchus* but absent in *Clarias*. In *Clarias*, the rayed dorsal fin extends the whole length of the body from its commencement (just behind the head) almost to the tail fin. Three species of *Clarias* have been described from West Africa. They are *Clarias anguillaris*, *C. submarhinatus* and *C. lazera* (Holden and Reed, 1972). They are not easy to identify because they all look similar. The vomerine teeth are the most reliable means for determining the species (Reed, 1967). *Bagrus bayad* is more or less elongated, the dorsal fin has a smooth spine, and the pectoral fins have spines with serrations on the inside. They have four pairs of barbels. The maxillary barbels may reach to the ventral fin or pelvic fins. This fish is yellow-greenish or blackish with a white belly. The fins are darker, sometimes reddish purple. Juveniles have little black spots on the sides (Froose and Pauly, 2007). *Bagrus bayad* is a species of fish that belong to the family bagridae. The fish was reported to weigh up to 12.5kg and can attain the length of 112cm. The females grow bigger and larger than the males from the same cohort (Froose and Pauly, 2007). *Bagrus bayad* are found in most Nigerian territorial water such as lakes, swamps, dams and rivers. Genomic simply refers to the study of genome. The genome constitutes the genetic made up of an organism including the DNA (deoxyribonucleic acid), genes and the non coding DNA, as well as mitochondrial and chloroplast DNA (Perry and Robert, 1976). The genome of an organism encoded by the genomic DNA is the biological information of heredity which is passed from one generation of organism to the next. Despite the effort of many hatcheries to produce fast growing fingerlings for aquacultural, there are a lot of complain by farmers on the quality of fingerlings supplied for culture. This is because most hatcheries in Nigeria uses fish from the same strain to develop fingerlings for production and the deteriorating performance of the fish declines in growth, milt quality, and disease resistance as well as body deformities. Therefore, this paper tend to produce information on the growth performance of *Clarias gariepinus* injected with genomic DNA from *Bagrus bayad* which is easier than other method of improving the fish such as hybridization, uses of hormones, introduction of ploidy, sex reversal and so on.

## 2.0 MATERIALS AND METHODS

### 2.1 Study Area

The experiment was conducted at the teaching and research fish farm of Department of Fisheries, University of Maiduguri situated between latitude 11° 51 N and longitude 13° 051 E. Maiduguri is characterized by cold dry climate starting from January to March and on average, the warmest month is April. It has a mean annual rainfall of 800mm. The rainy season usually begins in June and ends in October with the relative humidity of 5-54.5% and atmospheric temperature ranging from 38-40°C during the day which drops to 29-31°C at night (PTN, 2015).



## 2.2 Experimental Fish

*Clarias gariepinus* fingerlings used for the experiment were procured from commercial fish farm within Maiduguri metropolitan while *Bagrus bayad* sample was obtained from River Gashuwa Yobe state, both samples were transported to the hatchery unit of the Department of Fisheries, University of Maiduguri separately based on species in 25L Jerican half filled with fresh water. *Clarias gariepinus* fingerlings samples were acclimatized for 24 hours in 2 x 1m<sup>2</sup> concrete ponds before were fed 35% crude protein diet at 5% of their body weight twice daily before the commencement of the experiment. *Bagrus bayad* sample was used for the extraction of the genomic DNA which was used in the *Clarias gariepinus* fingerling samples.

## 2.3 DNA extraction from *Bagrus bayad*

*Bagrus bayad* sample was taken to Biotechnology Department, University of Maiduguri for Genomic DNA extraction. The Genomic DNA was extracted from *Bagrus bayad* tissue sample using Qiuck-DNA universal miniprep kit (catalog No.#D4068 and D4069) ZYMO RESEARCH (South Africa). The genomic DNA was extracted first by adding 400 µl of lysis solution and 20 µl of proteinase K solution to 20µl of tissue inside a sterile DNA free 1.5 µl micro tube. The content of the micro tube was mixed thoroughly by pipetting up and down or using a vortex mixer to obtain uniform suspension. The solution were incubated at 55°C for 20 minutes (using 230 volts VWR Digital Heat Block) until the cells are completely lysed. This was followed by adding one volume of genomic binding buffer to the tube, mixed thoroughly by pipetting up and down or by vortexing to ensure that the samples were homogenized. The mixture were transferred into a Zymo-Spin 11C-XL column in a collection tube and centrifuged at 12,000 x g for one minutes using Eppendorf table top centrifuge 5418. The collection tube and the flow through were discarded. The Zymo-Spin 11C-XL column was transferred to a new 2 ml collection tube, followed by addition of 400 µl DNA pre-wash to the column and centrifuged at 12000 x g for 1 minutes. After the collection tube was emptied 700, µl gDNA wash buffer was added to the Zymo-spin 11c-xl column and centrifuged at 12000 x g for 1 minute. The Zymo-spin 11c xl column was transferred into a clean 1.5 ml micro centrifuge tube and 50 µl DNA elution buffer was added directly to the column matrix. This was incubated at room temperature for 5 min and centrifuged at top speed for 1 minute to elude the DNA, the eluted DNA was used for the directly injection of the *Clarias gariepinus* fingerlings samples.

## 2.4 Experimental Design

Seventy (75) five fingerlings of *Clarias gariepinus* (six weeks old) with a total length and weight ranging from 7-10cm and 10-15g respectively were used for the research. The fingerlings were grouped into five treatments and each treatment was replicated (T1, T2, T3, T4 and T5) in a complete randomized design manner (CRD). Fifteen fingerlings were allocated to each treatment (5 fish per replicate). The extracted genomic DNA from the *Bagrus bayad* was used to inject the fingerlings using 0.1xSSC buffer. Four concentrations of 0, 5, 10, 15 and 20µl/0.1/fingerling were used for each of the treatment. The fingerlings were reared for the period of four months (4 months). During the culture period, the fingerlings were fed with commercial diet constituting 45% crude protein. They were fed twice daily at 5% of their body weight.

## 2.5 Growth and Survival of *Clarias gariepinus* injected with *Bagrus bayad* Genomic DNA

During the culture period, the following data were recorded; final weight, final length,

survival rate and quantity of feed fed. Later, the below growth indices were calculated and estimated for each of the treatment using the formulae below;

- i) Weight gain (g) =  $W_2 - W_1$ , where  $W_2$  and  $W_1$  are the final and initial weight of fish, respectively (Buacker *et al.*, 1990).
- ii) Mean daily weight gain (MDWG) in gram =  $(W_2 - W_1) / N \times t$ , Where  $W_2$  and  $W_1$  are the final and initial weight of fish, respectively,  $n$  = number of fish and  $t$  = the culture period (days) (Ahmed *et al.*, 2012).
- iii) Final length (mm) =  $L_2 - L_1$ , where  $L_2$  and  $L_1$  are the final and initial length of fish respectively (Buacker *et al.*, 1990).
- iv) Specific growth rate (SGR % per day) =  $(\log_e W_i - \log_e W_o) / t \times 100$ , where  $\log_e W_i$  = log of final weight,  $\log_e W_o$  = log of initial weight,  $\log_e$  = logarithm and  $t$  = culture period (Ahmed *et al.*, 2012).
- v) Feed conversion Ratio (FCR) = Dry weight of feed (g) / Weight gain of fish (g).
- vi) Condition factor (K) =  $W \times 100 / L^3$ , where  $W$  and  $L$  are the weight and length of the fish (Ayoola *et al.*, 2012).
- vii) Percentage survival =  $(n_2 - n_1) / t \times 100$ , where  $n_2$  and  $n_1$  are the final and initial of the fish respectively,  $t$  = the culture period (Ayoola *et al.*, 2012).

## 2.6 Data Analysis

Data obtained from the experiments on the growth performance were subjected to one way analysis of variance for each experiment. The differences between means were determined using Fisher's LSD ( $p = 0.05$ ) with the aid of Statistix 8.0.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Growth and survival of African catfish fingerlings injected with *Bagrus bayad* genomic DNA.

Table 1 presented the growth performance of *Clarias gariepinus* fingerlings injected with *Bagrus bayad* genomic DNA. Higher final weight of 2661.6g was obtained in fingerlings injected with 20 $\mu$ l of genomic DNA from *Bagrus bayad*, followed by fingerlings injected with 10, 5 and 15 $\mu$ l of genomic DNA as 1789.1, 1302.6 and 956.20g respectively. The least value of the final weight was reported in fingerlings injected with 0 $\mu$ l of genomic DNA as 842.73g. The fingerlings injected with 5, 10, and 20 $\mu$ l did not show any significant variation ( $p > 0.05$ ) between them, fingerlings injected with 0, 5 10 and 15 $\mu$ l show no statistical differences ( $> 0.05$ ). However, fingerlings injected with 0 and 15 $\mu$ l differs ( $p > 0.05$ ) significantly with those fingerlings injected with 20 $\mu$ l of the *Bagrus bayad* genomic DNA. The final weight presented in this research was lower than the final weight reported by Mohammed *et al.* (2016) as 5.58kg when worked on the growth of *Oreochromis niloticus*. Hershberger *et al.* (1990) also reported lower value of the final weight of 250g on *Coho salmon*. The differences in the final weight are due to the effect of the experimental materials used (genomic DNA and growth hormone). Higher weight gain of 2591.4g was discovered in fingerlings injected with 20 $\mu$ l of genomic DNA from *Bagrus bayad* followed by fingerlings injected with 10, 5, and 15 $\mu$ l of genomic DNA as 1765.1, 1271.6 and 930.43g respectively. The least value of the weight gain was observed in fingerlings injected with 0 $\mu$ l of genomic DNA as 823.03g. The fingerlings injected with 5, 10, 15, and 20 $\mu$ l indicated no any statistical differences ( $p > 0.05$ ) with those fingerlings injected with 20 $\mu$ l of the *Bagrus bayad* genomic DNA. The weight gain of the present work was higher than the value.

**Table 1: Growth and survival of African catfish fingerlings injected with *Bagrus bayad* genomic DNA**

Parameters	Concentrations of genomic DNA					SEM
	0	5	10	15	20	
Initial weight (g) 3.78*	19.70 <sup>c</sup>	30.976 <sup>b</sup>	24.00 <sup>bc</sup>	25.77 <sup>bc</sup>	41.20 <sup>a</sup>	
Initial length (mm) 20.49*	351.67 <sup>b</sup>	455.00 <sup>a</sup>	391.67 <sup>b</sup>	381.67 <sup>b</sup>	455.00 <sup>a</sup>	
Final weight (g) 761.82*	842.73 <sup>b</sup>	1302.6 <sup>ab</sup>	1789.1 <sup>ab</sup>	956.20 <sup>b</sup>	2661.6 <sup>a</sup>	
Final length (mm) 741.66 <sup>ns</sup>	1496.7 <sup>a</sup>	1586.7 <sup>a</sup>	2188.7 <sup>a</sup>	987.33 <sup>a</sup>	2116.0 <sup>a</sup>	
Weight gain (g) 777.07 <sup>ns</sup>	823.03 <sup>b</sup>	271.6 <sup>ab</sup>	1765.1 <sup>ab</sup>	930.43 <sup>ab</sup>	2591.4 <sup>a</sup>	
Specific growth rate (g) 0.24 <sup>ns</sup>	1.33 <sup>a</sup>	1.33 <sup>a</sup>	1.53 <sup>a</sup>	1.30 <sup>a</sup>	1.47 <sup>a</sup>	
Feed conversion ratio 0.85 <sup>ns</sup>	2.09 <sup>a</sup>	1.03 <sup>a</sup>	0.64 <sup>a</sup>	1.27 <sup>a</sup>	0.65 <sup>a</sup>	
Condition factor 0.05*	0.54 <sup>d</sup>	0.82 <sup>c</sup>	0.82 <sup>c</sup>	0.96 <sup>b</sup>	1.22 <sup>a</sup>	
Percentage survival 21.49 <sup>ns</sup>	55.33 <sup>a</sup>	46.67 <sup>a</sup>	66.67 <sup>a</sup>	26.67 <sup>a</sup>	55.33 <sup>a</sup>	

Means with the same superscript within the same raw are not statistically different (p<0.05)

documented by Iskandar *et al.* (2018) as 4.7g of mutiara catfish after working on the growth performance of F1 transgenic mutiara catfish. El-Zaeem and Assem (2004) also documented lower weight gain of 13.27g on *Tilapia zilli* after injecting the fish with shark DNA at different doses. The variation in the weight gain reported from this study might be due to the *Bagrus bayad* and Shark DNA. Higher final length was revealed in fingerlings administered with 10µl genomic DNA from *Bagrus bayad* as 2188.7mm followed by fingerlings administered with 20, 5 and 0µl of genomic DNA from *Bagrus bayad* as 2116.0, 1586.7 and 1496.7mm respectively. The least value of the final length was found in fingerlings administered with 15µl of genomic DNA as 987.33mm. The fingerlings administered with 0, 5, 10, 15, and 20µl did not exhibit any significant differences (p>0.05) to one another. The value of the final length gotten from this research was higher than the value presented by Idowu and Afolayon (2013) as 10.80cm on *Clarias gariepinus* fed 50% of maggot meal as a supplement to fish meal. The variation in the final length could be as a result of differences in the period of the experiment and feed given. Higher specific growth rate of 1.53 was observed in fingerlings administered with 10µl of *Bagrus bayad* genomic DNA followed by fingerlings administered with 20, 0, and 5µl of genomic DNA as 1.47, 1.33 and 1.33 respectively. The least value of the specific growth rate was discovered in fingerlings injected with 15µl of genomic DNA from *Bagrus bayad* as 1.30. The fingerlings administered with 0, 5, 10, 15 and 20µl did not show any significant variation (p>0.05) between the entire treatments. Abdel-Hamid *et al.* (2000) reported lower value of SGR for carp to be 0.98% per day when fed with maize sativa diets. Variation in the SGR recorded is due to culture season. Higher feed conversion ratio of 2.09 was found in fingerlings injected with 0µl of *Bagrus*

*bayad* genomic DNA. Fingerlings injected 15, 5, and 20 $\mu$ l of genomic DNA show the values of feed conversion ratio in the sequences of 1.27, 1.03 and 0.65 respectively. The least value of the feed conversion ratio was obtained in fingerlings injected with 10 $\mu$ l of genomic DNA as 0.64. There was no any significant differences ( $p>0.05$ ) observed throughout the entire treatment in respect of the feed conversion ratio. The feed conversion ratio observed from this study was lower than the value obtained by Olude *et al.* (2008) as 2.09 for *Clarias gariepinus*. Differences in FCR from the two researches could be due to the effects of the experimental materials used. Higher condition factor of 1.22 was discovered in fingerlings administered with 20 $\mu$ l of *Bagrus bayad* genomic DNA followed by fingerlings administered with 15, 10 and 5 $\mu$ l of genomic DNA as 0.96, 0.82 and 0.82 respectively. Least value of the condition factor was revealed in fingerlings administered with 0 $\mu$ l of genomic DNA from *Bagrus bayad* as 0.54. The fingerlings injected with 5 and 10 $\mu$ l of the genomic DNA did not indicated any significant variation ( $p>0.05$ ) between them. However, fingerlings administered with 5 and 10 differs statistical ( $p<0.05$ ) with those fingerlings administered with 0, 5, 10, 15 and 20 $\mu$ l from *Bagrus bayad* genomic DNA. The condition factor of 1.81 was reported by Opiyo *et al.* (2014) which was higher than the condition factor gotten from the present research. The variation in the condition factors of the researches is due to the seasons of the research as well as the water quality of the pond management. Higher percentage survival 66.67% was observed in fingerlings injected with 10 $\mu$ l of *Bagrus bayad* genomic DNA followed by fingerlings injected with 0, 20 and 5 $\mu$ l of genomic DNA as 55.33, 55.33 and 46.67% respectively. The least value of the percentage survival was found in fingerlings injected with 15 $\mu$ l of genomic DNA as 26.67%. The fingerlings injected with 0, 5, 10, 15 and 20 $\mu$ l did not show any significant variation ( $p>0.05$ ) to one another. Sarka *et al.* (2004) reported higher value of percentage survival as 90% in Indian carp. Madu and Ita (1990) also reported higher value of the percentage survival of 78.8% in *Clarias anguilaris*. The variation on the percentage survival might be due the stocking density and proper management of the fish during the experiment.

#### 4.0 CONCLUSION

Based on the result of this study, the growth of *Clarias gariepinus* was better in fingerlings injected with 20 and 10 $\mu$ l of genomic DNA from *Bagrus bayad* in term of final weight, weight gain, final length and percentage survival. This indicates that, the growth and survival of *Clarias gariepinus* fingerlings can be improved by injecting the fish at 10 and 20 $\mu$ l of the genomic DNA from *Bagrus bayad*.

#### 5.0 RECOMMENDATION

It is recommended that, genomic DNA from *Bagrus bayad* should be injected to *Clarias gariepinus* fingerlings in other to harvest their fish in shorter time. Further studies should be carried out on other species of fish to test their genomic DNA on the growth and survival of African catfish fingerlings.

#### REFERENCES

- Abdel-Hamid, M.S.E., Hafiz, M.K., Saneyeldin, M.S., Mohammed, N.B and Ahmed, Z.I.H. (2000). Growth performance of grass carp (*Ctenopharyngodon idella*) in earthen ponds as affected by receiving varying feeding inputs. *Egyptian Journal of Applied Science*, 4(8): 125-146.

- Abdullahi S.A, Abolude D.S and Ega R.A. (2001) Nutrient quality for four oven dried freshwater catfish in Northern Nigeria. *Journal Tropical Bioscience*. 70pp.
- Adebayo-Tayo, B.C, Onilude A.A and Patrick U.G . (2008). Mycofloral of smoked- dried fishes sold in Oyo, Eastern Nigeria. *World Journal of Agricultural Sciences*, 4(3): 346 -350.
- Adekoya, B.B. and Miller, J.W. (2004). Fish cage culture potential in Nigeria. *An overview National cultures, Agriculture Focus*,1(5):10-13.
- Ahmed, M. H., Shalaby, A. M. E, Khattab, Y. A. E and Abdel-Tawwab, M. (2012). Effects of 17 $\alpha$ -methyltestosterone on growth performance and some physiological change of Nile tilapia fingerlings (*Oreochromis niloticus*). Egypt, *International Journal of Aquaculture and Biology*, 4(4): 295-311.
- Amiengheme P. (2005). The importance of fish in human nutrition. *A paper delivered at fish culture forum, Federal Department of fish Farmers, Abuja*. 21pp.
- Ataguba, G.A, P.A. Ayoola, O., Akinwale, O. T. and Fredric, C. A. (2012). Effect of the shape of culture tanks on production of catfish *Clarias gariepinus*. *Journal of Agriculture and Scientific Research*.12(1): 1-8.
- Busacker, G. P., Adelman, I. R. and Goolish, E. M. (1990). Growth method for fish Biology. *American Fisheries Society, U.S.A*, 363-387.
- Dunham R. A. Majumdar. K. Hallerman, E. and Main, G. (2001). Review of the status of aquaculture genetics. In K.R.P. Subasinghe, P. Buemo, M.J. Philipa; C. Haugh; S.E. and J.R. Arthur (eds). *Aquaculture in the third millennium. Proceedings of the conference on Aquaculture in the third millennium*, Bangkok, Thailand, 20-25 February, NACA, Bangkok and FAO, Rome, 137-186.
- El-Zaeem, S.Y and Assem, S.S. (2004). Application of Biotechnology in fish breeding: production of highly immune genetically modified Nile Tilapia, *Oreochromis niloticus* with accelerated growth by direct injection of shark DNA into skeletal muscles. *Egypt. Journal of Aquatic Biology Fisheries*, 8(3): 67-92.
- FAO (2007). *The State of World Fisheries and Aquaculture*. FAO Fisheries and Aquaculture Department. Food and Agriculture Organization of the United Nations Rome. 5 – 22.
- Froese, R. and Pauly, D (2007). "*Bagrus bayad*" in FishBase. Aug 2007 version.
- Hershberger, W.K., Meyers, J.M., McAuley, W.C. and Saxton, A.M. (1990). Genetic changes in growth of Coho salmon (*Oncorhynchus kisutch*) in marine netpens, produced by ten years of selection. *Aquaculture*, 85: 187-197.
- Holden, M. and Reed, W. (1972). *West African Fresh Water Fish* London, Longman Group. 22.
- Idowu, R.T. and Afolayan, N. (2013). The physic-chemical parameters of African Ari Zone Man Lake, 1(2): 113-119.
- Iskandar., Buwono. I D.and Mochamad., U. K. A (2018). The growth performance of F1 transgenic mutiara catfish. *Conference Series Earth and Environment Science*.137 (1): 012004
- Madu, C. T. and Ita, E.O. (1990). Comparative Growth and Survival of Hatchlings of *Clarias* sp., *Clarias* hybrid and *Heterobranchus* sp. in the Indoor Hatchery. National Institute for Fresh water Fisheries Research Annual Report. New Bussa.pp. 47-50.
- Mohammed, Z. B., Diyaware. M. Y., Raji. O A and Aliyu, M (2016). Evaluation of Camel Testicles for Masculinisation, Growth and Survival of Nile Tilapia (*Oreochromis niloticus*, Linnaeus 1758). *Fisheries Society of Nigeria (FISON)*. 117-123.

- Moses Y. Olufeagba S. O. and Rapheal, A. Z. (2006). Intra-specific hybridization in two strains of *Clarias gariepinus* (Linnaeus, 1758). *Genetics society of Nigeria 30th Annual National Conference, Nsukka, 5th-8th September*, 153-156.
- Olude, O.O., Alegbeleye, W.O.A. and Obasa, S.O. (2008). The use of soaked copra meal as a partial substitute for soybean meal in the diet of Nile tilapia (*Oreochromis niloticus*) fingerlings. *Livestock Research for Rural Development*, 20 (10): 165-169.
- Omeji, S. Obande, R. A. and Oyaje, J. (2013). Intra-specific hybridization of local and exotic *Clarias gariepinus*. *International Journal of Modern Biological Research*, 1:34-41.
- Opiyo, M.A., Githukia, C.M., Munguti, J.M. and Charo-karisa, H. (2014). Growth performance carcass composition and profitability of Nile tilapia (*Oreochromis niloticus*) fed commercial and on-farm made fish feed in earthen ponds. *International Journal of Fisheries and Aquatic Studies*, 1(5): 12-17.
- Perry, and Robert P. (1976). "Processing of RNA". *Annual Review of Biochemistry*, **45**: 605–630. doi:10.1146/annurev.bi.45.070176.003133.
- PTN (2015). *Premium time Nigeria.Com* retrieved 20-8-2016.
- Reed, W. (1967). Fish and fisheries of Northern Nigeria Ministry of Agriculture, Northern Nigeria.45-49.
- Sarka, G. D., Scilipoti, A., Mazzola, A. and Modica. (2004). Effect of fish farming waste to sedimentary and particulate organic matter in a southern Mediterranean area (Gulf of castellammare, sicily): *a multiple stable isotope study*. *Aquaculture*, 234:199-213.

## **Analysis and Evaluation of *Moringa oleifera* Leaves Extract on Performance and Carcass Characteristics of Broilers Chicks**

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**Abstract:** Eight weeks feeding trial involving 100 day-old broiler chicks was carried out in a completely randomized experimental designed (CRD) to analyze and evaluate *Moringa oleifera* Leaves Extract (MLE) for the performance indices and carcass characteristics of broilers. The birds were randomly assigned to five treatment groups containing 0, 40, 80, 120 and 160ml MLE/liter of water. Water intake was recorded daily while initial weight of the birds was taken at the beginning of the experiment and weekly thereafter. Body weight gain was calculated as the difference between the final and initial body weight. Feed conversion ratio was determined by dividing feed intake by the body weight gain. Mortality was recorded as it occurred. The effect of *Moringa oleifera* extract on carcass characteristics was also evaluated. Results showed significant ( $P < 0.05$ ) effect for all the parameters evaluated. Birds served 40ml MLE/liter of water had the highest feed intake and body weight gain than any other treatments ( $P < 0.05$ ). It was concluded that *Moringa oleifera* leaves extract at 40ml MLE/liter of water improves growth performance of broiler chickens without adverse effect on carcass.

**Keywords:** Chicks, Carcass, Broilers, *Moringa*, Organs, Weight

### **INTRODUCTION**

Antibiotics have been extensively used as feed additives and growth promoters in animal feed industry. In Nigeria, antibiotics are administered in poultry drinking water for prevention or control of bacterial contamination and as growth promoters. The benefits of such practice is to maintain good health, suppress mortality of birds, support optimum growth and feed utilization and increased profit (Murwani and Murtini, 2009). The use of antibiotics is limited due to their residual effect in poultry products, drug toxicity and development of bacteria resistance (Schwarz et al., 2001). The negative impact on consumers of meat or poultry products due to residual effects has led to the ban on the use of antibiotics as growth promoters since 2006 by the European Union. In recent years, Animal scientists and veterinarians are now turning attention to safe and natural alternatives such as plants extract to replace antibiotics. Meanwhile, the use of organic supplements such as probiotics, prebiotics, enzymes and plant or herbal extracts, are generally believed to be safer, healthier, and less subject to hazards.

Plant extracts have been used in the diets of poultry as a means of reducing high cost of conventional protein sources (Nworgu, 2007; Machebe et al., 2010) as well as growth promoter (Nidaullah et al., 2010). According to the authors, extracts also have appetizing and digestion stimulating properties. Machebe et al. (2010) and Onu (2012) indicated that the plant leaf extracts do not only serves as protein but also provides some necessary vitamins



and minerals which could complement the inadequacies in most feedstuffs. Plant antimicrobial effect has also been reported.

Plant extracts contain phytonutrients and phytochemicals (such as saponins, tannins, oxalates, phytates, trypsin inhibitors and cyanogenic glycosides), which are referred to as secondary metabolites (Machebe et al., 2010).

Secondary metabolites are applied in nutrition as pharmacologically active ingredients. Proximate and phytochemical analysis showed that plant extract contained essential nutrients and bioactive compounds (or phytochemicals) that play a role in nutrition as feed supplement and as medicines for the treatment of certain diseases (Durrani et al., 2008; Ogbe et al., 2011).

*Moringa oleifera* is one of the herbs containing bioceutical agents that could substitute synthetic growth enhancers in broiler and other livestock production. Scientific studies pertaining to its potential involved the study of Lannaon (2007). The author reported that performance of broilers given *M. oleifera* leaf decoction, improved feed consumption, daily weight gain, final weight and reduced cost of production. Furthermore, Du et al. (2007) evaluated the effects of dietary supplementation of *Moringa oleifera* on growth performance, blood characteristics and immune response of Arbor acre broiler strain. It was found out that increasing supplementation of *Moringa oleifera* decreases contents of uric acid, triglycerides and albumin/globulin ratio in the serum improving the immune response of the animals significantly. Yang et al. (2007) evaluated the effect of *Moringa oleifera* on the growth performance, immune function, and ileum microflora in broilers. Significant enhancement of immune system, duodenum traits, increased Lactobacillus counts in ileum. This study evaluated *Moringa oleifera* leave extract on the performance and carcass characteristics of Anak broilers.

## MATERIALS AND METHODS

The experiment was conducted at the poultry farm of College of Agriculture Umaru Ali Shinkafi Polytechnic Sokoto, Sokoto State of Nigeria. The State, which consists of 23 Local Government Areas (LGAs), has its capital and seat of government located in Sokoto. The State is located in the North-west geographical zone of Nigeria lying between latitudes 4<sup>0</sup>-6<sup>0</sup>40' N and longitudes 11<sup>0</sup>30'-13<sup>0</sup>50' E. It covers a land area of 28,232.37 square kilometers (SOSGD, 2011).

## EXPERIMENTAL DESIGN AND PROCEDURES

A total of one hundred (100) 3day-old broiler chicks were randomly assigned to five treatments containing 0 ml, 40 ml, 80 ml, 120 ml and 160 ml of *Moringa oleifera* leaf extract (MLE) per one liter of water in a completely randomized design (CRD). Birds in each treatment groups were further subdivided into four (4) subgroups of five birds to serve as replicate. The experimental diets fed to the animals at the starter and finisher phases are shown in Table1.

**Table 1: Composition of the experimental diet for both starter and finisher stages**

Ingredient (S)	Starter (%)	Finisher (%)
Maize	55	54
Groundnut cake	30	24
Wheat offal	5.0	12
Blood meal	5.0	4.0
Bone meal	2.0	2.5
Limestone	2.0	2.5
Premix	0.3	0.3

Methionine	0.2	0.2
Lysine	0.2	0.2
Salt	0.3	0.3
Total	100	100

Calculated analysis		
CP (%)	24.65	22.07
ME (kcal/kg)	2950	2840
Ca (%)	1.3	1.59
P (%)	0.37	0.35
CF (%)	0.37	0.35
EE (%)	5.4	5.1

The broiler starter and finisher diets were formulated to meet the NRC (1994) nutrient requirements for broilers. During the experiment, feed and water were provided *ad-libitum* to the birds and the birds were fed once daily.

#### **COLLECTION AND PREPARATION OF EXTRACT**

Fresh leaves of *Moringa oleifera* were collected from the orchard of the College of Agriculture's livestock farm of the polytechnic. Two kilogramme of freshly cut *Moringa oleifera* leaves with stalks were washed, drained, chopped and pounded in a mortar with pestle. This was then squeezed and filtered with sieve to obtain the homogenous extract of the Moringa leaves extract (MLE). The MLE was prepared at three days interval.

#### **ADMINISTRATION OF THE EXTRACT**

*Moringa oleifera* leaf extract (MLE) was administered through drinking water at three days intervals for 27 days each for starter and finisher. The birds in group 1, 2, 3 and 4 were served 40 ml, 80 ml, 120 ml, and 160 ml MLE/litre of water. After consumption, fresh water was offered for the remaining of the day. Similarly birds in group 0 (control) were given fresh water without MLE.

#### **PREPARATION OF THE BROODING HOUSE**

According to Oluyemi and Roberts (2000), brooding is the care of chick from day old to six or eight weeks of age. It consists primarily of the provision of heat, air, water and feed. Similarly, all necessary repairs were carried out. A 60 watt electric bulb was fixed in each pen. The pens were thoroughly cleaned and disinfected using Izal solution and fresh wood shaving were used as litter material. Prior to the allocation of the chick to the pens, the bulbs were switched on for 24hours to warm the room. Routine management practices including feeding, supply of water; medication and vaccination were carried out as described by Oluyemi and Roberts (2000).

#### **SOURCE OF INGREDIENTS FOR EXPERIMENTAL DIETS**

All the major ingredients for the experimental diet formulation such as maize, wheat offal, groundnut cake, Bone meal, limestone and Blood meal were sourced from Sokoto central market. Other ingredients such as Methionine, Lysine and Premix were sourced from vendors within Sokoto metropolis.

#### **DATA COLLECTION**

Feed intake was recorded daily while initial weight of the birds was taken at the beginning of the experiment and weekly thereafter. Body weight gain was calculated as the difference between the final and initial body weights. Feed conversion ratio was determined by dividing feed intake by the body weight gain. Mortality was recorded as it occurred.

## CARCASS ANALYSIS

At the end of the experiment (8 weeks) one bird per replicate were randomly selected and slaughtered to obtain the relative weight of the carcass and organs. The birds were defeathered and eviscerated manually after slaughter. The eviscerated birds were dissected and all internal organs (lungs, heart, intestine, spleen, and gizzard) and external offals (head, shank and neck) were carefully removed. Dressing percentage will be calculated using the formula.

$$\text{Dressing percentage (\%)} = \frac{\text{Carcass weight}}{\text{Live weight}} \times 100$$

## STATISTICAL ANALYSIS

All the data collected from the study were subjected to analysis of variance (ANOVA) using SPSS computer software package and Means separation were carried out using Duncan's Multiple Range Test.

## RESULTS AND DISCUSSION

The results of the effect of *Moringa oleifera* leaves extract on carcass and organs characteristics of broiler chickens 1 – 8 weeks are shown in Table 2, 3, 4 and 5.

### Body weight gain (g/bird)

Table 2: Body weight gain of broilers fed with *Moringa oleifera* leaves extract

Age of birds (weeks)	TREATMENTS					SEM
	0(0ml)	1(40ml)	2(80ml)	3(120ml)	4(160ml)	
1	357.50 <sup>b</sup>	500.00 <sup>a</sup>	475.00 <sup>a</sup>	427.50 <sup>ab</sup>	457.50 <sup>ab</sup>	61.22
2	740.00 <sup>a</sup>	870.00 <sup>a</sup>	665.25 <sup>a</sup>	725.00 <sup>a</sup>	695.00 <sup>a</sup>	64.28
3	1170.00 <sup>c</sup>	1450.00 <sup>b</sup>	4500 <sup>a</sup>	900 <sup>d</sup>	1235 <sup>c</sup>	61.15
4	2137.50 <sup>b</sup>	2327.50 <sup>a</sup>	1890.00 <sup>cd</sup>	2025.00 <sup>bc</sup>	1755.00 <sup>c</sup>	57.70
5	3150.00 <sup>b</sup>	3750.00 <sup>a</sup>	2327.50 <sup>d</sup>	2175.00 <sup>e</sup>	2977.50 <sup>c</sup>	44.52
6	4300 <sup>b</sup>	5000 <sup>a</sup>	3550 <sup>c</sup>	3500 <sup>c</sup>	3750 <sup>d</sup>	110.11
7	6250 <sup>a</sup>	6250 <sup>a</sup>	6250 <sup>a</sup>	6250 <sup>a</sup>	6250 <sup>a</sup>	32.11
8	7800 <sup>b</sup>	8175 <sup>a</sup>	6262.5 <sup>d</sup>	5800 <sup>d</sup>	7148 <sup>c</sup>	77.40
<b>TOTAL</b>	<b>25905</b>	<b>34930.24</b>	<b>28322.50</b>	<b>21832.50</b>	<b>24268.00</b>	

abc- means values on the same row with different superscript are significant (P<0.05)

There were significant difference (P<0.05) in all the performance parameters indices evaluated. The best weights gain of 1838g/bird was observed on the birds served 40 ml compared to 80 ml, 120 ml, 160 ml and control (1565g/bird, 1450g/bird, 1787g/bird and 1560g/bird) respectively. The higher weight gain of birds served 40 ml of MLE/litre of water could be as a result of higher digestion of the nutrient consumption by the birds and greater efficiency in the utilization of feed which resulted in enhanced growth. Nuhu (2010) noticed that a diet containing *Moringa* leaves extract significantly (P<0.05) increased dry matter, protein digestibility and daily weight gain. The decreased of body weight gain observed in birds served MLE at 80 ml, 120 ml and 160 ml could be attributed to the presence of anti-nutritional factors (ANFs) in the extract. These findings coincided with report of Muhammad et al. (2011) that the leaves of *Moringa oleifera* contains tannin and saponins which known to reduce feed efficiency and consequently body weight gain.

**FEED INTAKE**

Table 3: Average Feed intake (g/bird)

Age of birds (weeks)	TREATMENTS					SEM
	0(0ml)	1(40ml)	2(80ml)	3(120m)	4(160ml)	
1	105.27 <sup>b</sup>	104.27 <sup>b</sup>	103.06 <sup>b</sup>	116.94 <sup>a</sup>	190.88 <sup>a</sup>	1.25
2	178.82 <sup>a</sup>	178.27 <sup>a</sup>	162.08 <sup>c</sup>	176.96 <sup>a</sup>	166.35 <sup>b</sup>	1.282
3	232.40 <sup>a</sup>	229.86 <sup>a</sup>	223.61 <sup>b</sup>	207.86 <sup>c</sup>	215.65 <sup>c</sup>	1.282
4	260.72 <sup>b</sup>	266.07 <sup>a</sup>	252.15 <sup>c</sup>	225.08 <sup>d</sup>	258.40 <sup>b</sup>	1.92
5	310.71 <sup>a</sup>	310.71 <sup>a</sup>	307.14 <sup>b</sup>	298.57 <sup>c</sup>	310.71 <sup>a</sup>	1.61
6	335.72 <sup>b</sup>	342.86 <sup>a</sup>	328.57 <sup>c</sup>	325.00 <sup>d</sup>	335.72 <sup>b</sup>	1.38
7	385.71 <sup>a</sup>	385.71 <sup>a</sup>	369.21 <sup>c</sup>	374.28 <sup>b</sup>	382.85 <sup>a</sup>	1.56
8	417.86 <sup>a</sup>	417.86 <sup>b</sup>	416.08 <sup>b</sup>	414.29 <sup>c</sup>	417.86 <sup>a</sup>	1.71
<b>TOTAL</b>	<b>2227.21</b>	<b>2235.61</b>	<b>2161.90</b>	<b>2138.98</b>	<b>2278.42</b>	

abc: means values on the same row with different superscript are significantly different (P<0.05)

There is significant difference (P<0.05) in feed consumption among the treatments (Table 3). The group served 120 ml consumed significantly lower amount of feed (2138g/bird) respectively. The results however showed that birds offered 160 ml and 40 ml from 1 – 8 weeks consumed more feed compared to the groups containing 80 ml, 120 ml and control. This could be as a result of the availability of minerals and vitamins in the extract which enhanced the palatability of feed and consequently improved feed intake. Oluyemi and Roberts (2000) reported that the incorporation of both micro and macro nutrients in poultry diets enhances feed intake and utilization. The total feed intake of (2208.42g/bird/day) recorded across the treatments was higher than the 1251.61b/bird/day reported by Suleiman et al. (2013) when fed *Carica papaya* leaves extracts to finisher broilers. However, Nworgu et al. (2007) reported higher values of 3175.05g/bird/day when they fed *Telfaria occidentalis* leaves extract. Kakenzi et al. (2007) declared that addition of 20% and 35% of *Moringa oleifera* leaves extract to the broiler diet, significantly (P<0.05) increased feed intake and dry matter intake. Olugbemi et al. (2010) reported that levels above 45% of *Moringa oleifera* leaves extract decreased broiler performance. High level of saponins and tannin in feed can also affect feed intake and growth rate.

**WATER INTAKE**

Table 4: Water intake (bird/day)

Age of birds (weeks)	TREATMENTS					SEM
	0(0ml)	1(40ml)	2(80ml)	3(120m)	4(160ml)	
1	155.43 <sup>a</sup>	146.75 <sup>a</sup>	143.25 <sup>a</sup>	147.78 <sup>a</sup>	143.54 <sup>a</sup>	14.26
2	229.08 <sup>a</sup>	227.57 <sup>a</sup>	213.22 <sup>b</sup>	194.00 <sup>d</sup>	202.51 <sup>c</sup>	17.87
3	350.00 <sup>a</sup>	349.82 <sup>a</sup>	339.82 <sup>c</sup>	318.04 <sup>d</sup>	345.00 <sup>b</sup>	18.86
4	610.71 <sup>c</sup>	628.57 <sup>a</sup>	610.00 <sup>c</sup>	576.96 <sup>d</sup>	619.89 <sup>b</sup>	1.58
5	892.89 <sup>a</sup>	892.89 <sup>a</sup>	869.89 <sup>b</sup>	858.25 <sup>c</sup>	892.89 <sup>a</sup>	2.29
6	100.93 <sup>b</sup>	1017.86 <sup>a</sup>	983.93 <sup>c</sup>	980.36 <sup>d</sup>	1017.86 <sup>a</sup>	2.27
7	1000 <sup>a</sup>	1000 <sup>a</sup>	994.64 <sup>c</sup>	998.22 <sup>b</sup>	1000 <sup>a</sup>	2.90
8	1000 <sup>a</sup>	1000 <sup>a</sup>	1000 <sup>a</sup>	1000 <sup>a</sup>	1000 <sup>a</sup>	3.00

<b>TOTAL</b>	<b>4439.04</b>	<b>5263.46</b>	<b>5154.75</b>	<b>5073.61</b>	<b>5221.69</b>
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abc- means values on the same row with different superscript are significantly different (P<0.05)

There were significant (P<0.05) differences in the water intake among the treatments. The total water intake was highest at 40ml level concentration of *Moringa* leaves extract. The total water intake here agrees with the report of Oluyemi and Roberts (2000). The decreased of water intake observed in birds served MLE could be attributed to the presence of anti-nutritional factors (ANFs) in the extract. The total water intake here agrees with the report of Oluyemi and Roberts (2000)

### FEED CONVERSION RATIO

Table 5: Average Feed conversion ratio (g feed <sup>1</sup>-gain)

Age of birds (weeks)	TREATMENTS					SEM
	0(0ml)	1(40ml)	2(80ml)	3(120m)	4(160ml)	
1	2.47 <sup>a</sup>	1.51 <sup>b</sup>	1.93 <sup>a</sup>	1.55 <sup>b</sup>	1.14 <sup>c</sup>	14.26
2	3.51 <sup>c</sup>	3.74 <sup>d</sup>	8.68 <sup>b</sup>	16.20 <sup>a</sup>	5.03 <sup>b</sup>	2.40
3	3.79 <sup>b</sup>	2.89 <sup>b</sup>	3.65 <sup>b</sup>	15.96 <sup>a</sup>	3.10 <sup>b</sup>	1.89
4	1.89 <sup>b</sup>	1.57 <sup>b</sup>	2.45 <sup>b</sup>	1.40 <sup>b</sup>	3.64 <sup>a</sup>	1.35
5	2.21 <sup>b</sup>	1.64 <sup>b</sup>	12.19 <sup>a</sup>	8.40 <sup>a</sup>	1.97 <sup>b</sup>	2.03
6	2.04 <sup>b</sup>	1.92 <sup>b</sup>	1.92 <sup>b</sup>	1.91 <sup>b</sup>	3.08 <sup>a</sup>	2.17
7	1.38 <sup>b</sup>	2.25 <sup>a</sup>	1.37 <sup>b</sup>	1.09 <sup>c</sup>	0.98 <sup>c</sup>	1.94
8	2.05 <sup>c</sup>	1.54 <sup>c</sup>	3.33 <sup>b</sup>	3.64 <sup>a</sup>	3.66 <sup>a</sup>	1.22
<b>TOTAL</b>	<b>19.34</b>	<b>17.06</b>	<b>35.52</b>	<b>50.15</b>	<b>22.60</b>	

abc- means values on the same row with different superscript are significantly different (P<0.05)

The lower body weight gain was recorded in the birds served 80ml, 120ml, 160ml MLE/litre of water and control groups. This could be associated with the poor feed conversion ratio. The better FCR observed in birds served 40ml MLE/litre of water suggests the ability of the birds to utilize available nutrients in the feed and the extract. This could be due to lower level of *Moringa oleifera* leaves extract concentration as observed, thereby allowing for regular absorption of nutrients. These findings are in line with the reports of Nworgu et al. (2007) and Machebe et al. (2010) who reported that birds fed with leaf extracts had better feed conversion ratio than control. It could be seen from Table 4.4 that FCR improved for bird offered MLE. These findings are in line with the report of (Guo et al., 2002) that the use of some additives with medicinal properties helps to eliminate pathogenic organism and improved utilization of feeds by the birds.

Table 6: Carcass characteristics of experimental birds

Parameters	TREATMENTS				
	0 (0ml)	1(40ml)	2 (80ml)	3(120ml)	4(160ml)
<b>SEM</b>					
Live weight (g/b)	1650 <sup>a</sup>	1725 <sup>a</sup>	1625 <sup>a</sup>	1450 <sup>b</sup>	1625 <sup>a</sup>
48.73					
Dressing weight (g/b)	1500 <sup>ab</sup>	1575 <sup>a</sup>	1550 <sup>a</sup>	1387 <sup>b</sup>	1550 <sup>a</sup>
45.52					

Dressing %	91 <sup>b</sup>	91 <sup>b</sup>	95 <sup>a</sup>	95 <sup>a</sup>	95 <sup>a</sup>
1.19					
Breast muscle (g)	269.3 <sup>b</sup>	326.33 <sup>a</sup>	275.700 <sup>b</sup>	292.85 <sup>a</sup>	299.67 <sup>a</sup>
5.27					
Back (g)	176.87	143.92	148.55	136.03	166.97
1.45					
Chest (g)	91.88	95.97	113.00	93.20	96.00
1.04					
Wing (g)	74.98 <sup>b</sup>	78.29 <sup>a</sup>	70.91 <sup>c</sup>	61.00 <sup>d</sup>	58.83 <sup>e</sup>
1.47					
Drumstick (g)	192.66 <sup>b</sup>	190.77 <sup>b</sup>	200 <sup>a</sup>	195.00 <sup>a</sup>	190.00 <sup>b</sup>
1.27					
Shank (g)	46.01 <sup>a</sup>	36.200 <sup>c</sup>	44.19 <sup>a</sup>	42.100 <sup>b</sup>	47.53 <sup>a</sup>
1.27					
Head (g)	70.83 <sup>a</sup>	74.44 <sup>a</sup>	60.30 <sup>b</sup>	58.71 <sup>b</sup>	55.00 <sup>c</sup>
2.00					
Neck (g)	82.05 <sup>a</sup>	78.25 <sup>b</sup>	79.38 <sup>b</sup>	78.95 <sup>b</sup>	84.60 <sup>a</sup>
2.21					

abc- means values on the same row with different superscript are significantly different (P<0.05)

Table 7: Weights of organs

Parameters (g)	TREATMENTS				
	0 (0ml)	1(40ml)	2 (80ml)	3(120ml)	4(160ml)
<b>SEM</b>					
Liver	35.60 <sup>b</sup>	34.60 <sup>b</sup>	40.78 <sup>a</sup>	36.20 <sup>b</sup>	39.05 <sup>a</sup>
1.52					
Lungs	12.03 <sup>b</sup>	11.850 <sup>b</sup>	11.45 <sup>b</sup>	9.95 <sup>c</sup>	15.20 <sup>a</sup>
1.37					
Heart	7.97 <sup>b</sup>	7.87 <sup>b</sup>	6.27 <sup>c</sup>	7.07 <sup>b</sup>	9.40 <sup>a</sup>
1.14					
Pancreas	3.02 <sup>b</sup>	4.38 <sup>a</sup>	2.50 <sup>c</sup>	4.47 <sup>a</sup>	3.56 <sup>b</sup>
1.09					
Abdominal fat	50.33 <sup>a</sup>	33.93 <sup>a</sup>	31.65 <sup>ab</sup>	13.90 <sup>b</sup>	34.95 <sup>a</sup>
5.55					
Crop	16.25 <sup>a</sup>	17.95 <sup>a</sup>	7.28 <sup>b</sup>	7.00 <sup>b</sup>	6.25 <sup>c</sup>
2.22					
Small intestine	42.18 <sup>b</sup>	37.90 <sup>c</sup>	71.33 <sup>a</sup>	44.73 <sup>b</sup>	38.88 <sup>c</sup>
2.2					
Large intestine	29.05 <sup>d</sup>	32.75 <sup>c</sup>	52.38 <sup>a</sup>	37.80 <sup>c</sup>	43.53 <sup>b</sup>
1.98					
Ceacum	15.08 <sup>a</sup>	12.13 <sup>c</sup>	10.85 <sup>c</sup>	11.68 <sup>b</sup>	11.78 <sup>b</sup>
5.62					
Gizzard	46.93 <sup>b</sup>	39.71 <sup>c</sup>	50.20 <sup>a</sup>	38.9 <sup>c</sup>	40.20 <sup>c</sup>
4.22					
Spleen	2.00 <sup>a</sup>	1.80 <sup>b</sup>	2.30 <sup>a</sup>	1.98 <sup>b</sup>	2.00 <sup>a</sup>
3.11					

Proventriculus	7.50 <sup>a</sup>	7.50 <sup>a</sup>	7.10 <sup>a</sup>	6.20 <sup>b</sup>	6.30 <sup>b</sup>
1.28					

abc- means values on the same row with different superscript are significantly different (P<0.05)

The results of the carcass characteristics and organ weight (Table 4.5 and 4.6) showed that there is significant differences (P<0.05) between the treatments for the weight of various parts of the birds measured. Birds served 40ml MLE/litre of water has the highest live weight of 1725g .

Compare to other groups. The improvement in the live weight of the birds served 40ml MLE/litre of water could be attributed to the fact that *Moringa oleifera* contains some medicinal properties. These coincided with reports of Doyle (2001) who reported that application of medicinal plants allowed chicken to grow strong and healthy. The dressing percentage recorded were fall within the range of 91.13 – 95.24 obtained by Akintunde *et al.*, (2012). In the same vein prime cuts of shank, breast muscle, wing, drumstick and other internal organs are statistically similar. The significant differences observed could be due to tissue synthesis for these parts. Abbas and Ahmed (2012) reported that an addition of 20% - 45% of Moringa leaves extract increased carcass weight. However, the increase in the size of liver and gizzard could be related to increased activity to overcome the effect of toxic anti-nutritive compounds in the extract. Contrary to the lants extracts on liver, gizzard, kidney and lung weight

Table 8: Proximate composition of Moringa leaves extract

Parameters	Moringa extract
Moisture content (%)	64
Ash content (%)	0.2
Crude fiber content (%)	3.1
Crude protein content (%)	3.4
Carbohydrate content (%)	4.2

The results of the proximate composition of Moringa extract are shown in Table 8. The moisture contents are higher than the values reported for baobab seed flour (4.20%) Adubiaro *et al.* (2011). The protein content of these extract samples give an indication of their usefulness in human diet and as livestock feed.

## CONCLUSION

It could be concluded from the results of this study that giving *Moringa oleifera* leaves extract at 40 ml MLE/litre water to chicks in drinking water improves the growth performance of broiler chickens without adverse effect on carcass.

## RECOMMENDATIONS

- Since the test ingredients (*Moringa oleifera*) are abundant in the study area, there is need to utilize them as an alternative antibiotic growth promoter. This will reduce the risk of side effect occasioned by the routine use of convectional antibiotics on broiler chickens to maximize the production of safe meat for consumption.
- *Moringa oleifera* leaves extract at 40 ml MLE/litre of water is recommended at 3-days interval for improved feed intake and weight gain.



## REFERENCES

- Abbas, T. E. and Ahmed, M. E. (2012). Use of *Moringa oleifera* seeds in broilers diet and its effects on the performance and carcass characteristics. *International journal of poultry Research*, 1:1-4
- Adubiario. H. O., Olaofe, O., Akintayo, E. T. and Babalola, O. O. (2011). Chemical Composition, calcium, zinc and phytate interrelationships in baobab seed flour. *Advance Journal of food Science and Technology*, 3(4), 228-232.
- Akintunde, A. R., Omage, J. J. and Bawa, G. S. (2012). Effect of Allzyme supplementation on carcass characteristics of finisher broilers fed two levels of fermented pigeon pea seed meal. Proceeding of 17<sup>th</sup> Annual conference of Animal science Association of Nigeria held in Abuja. 65, 330-333.
- Du, P. L., Lin, P. H. and Yang, R. Y (2007). Effect of dietary supplementation of *Moringa oleifera* on growth performance, blood charascristics and immune response in broilers. *Journal of Chinese Society of Animal Science*, 36(3), 135-146.
- Doyle, E.(2001). Alternatives to antibiotic use for growth promotion in animal husbandary. *Food research institute*.
- Durrani, F. R., Sanaullah, N., Chand, Z. D. and Alchitar, S. (2008). Using aqueous extract of aloe agel as anticoccidial and immunostimulant agent in broiler production. *Sarhad Journal of Agriculture*, 24(4), 665-669.
- Guo, F.C., Williams, B. A., Kwakkel, R. P., Li, X. P., Luo, J.Y., Li, W. K. and Venstegen, M.W.A. (2002). Immunoactive, medicinal properties of mushroom and herb polysaccharides and their potential use in chicken diets. *World Poultry Science Journal*, 59, 427-440.
- Kakenzi, A. M. V., Kaijage, J. T., Sarwatt, S.V., Mutayoba, S.K., Shem, M.N. and Fujihara, T. (2007). Effect of *Moringa oleifera* leaf meal as a substitute for sunflower seed meal on performance of laying hens in Tanzania. *Livestock Research for Rural development*, 19(8), 120.
- Lannaon, W. J. (2007). Herbal Plants as Source of Antibiotics for Broilers. *Agriculture Magazine*, 11(2): 55.
- Lampe, T.W,(1999). Health effect of vegetables and fruits : Assessing mechanisms of action in human experimental studies. *The American Journal Of Clinical Nutrition*, 70, 475—490.
- Machebe, N. S., Agbo, C.U. and Onuaguluchi, C.C. (2010). Performance of finisher broilers served *Gongronema latifolia* Benth Leaf extracts as supplementary source of vitamins and minerals, in *Proceedings of the 15<sup>th</sup> Annual Conference of Animal Science Association of Nigeria*.
- Murwani, R.and Murtini, S. (2009). Effect of chlortetracycline additive in broilers fed local diets on antibody titers to NDV vaccine. *International Journal of Poultry Science*, 8(8): 755-759.
- Muhammad, A. and Tsafe, A.I. (2011). Proximate minerals and anti-nutritional factors of *Gardenia aqualla* (Gauden dutse ) fruit pulp. *Pakistan Journal of Nutrition*, 10 (6), 577-581.
- Nidaullah, H., Durran, F.R., Ahmad, S., Jan, I.U. and Gul, S. (2010). Aqueous extract from different medicinal plants as anticoccidial, growth promotive and immunostimulant in broilers. *ARPN Journal of Agricultural and Biological Science*, 5(1), 1990-6145.

- Nuhu, F. (2010). Effect of *Moringa* leaf meal (MOLM) on nutrient digestibility, growth, carcass and blood indices of broilers. M Sc Faculty of Agriculture and Natural Resources, KwameNkuruma University of Science and Technology, Kumasi, Ghana.
- NRC, (1994). Nutrient Requirement of Poultry. 9<sup>th</sup> Revised Edition. Washington D. C. National Academy Press.
- Nworgu, A. A. (2007), Evaluation of antibiotics residue on the quality of pork sold for human consumption in Oyo State, South West Nigeria. *Journal of Animal Science advances* (in press).
- Nworgu, F. C., Egbunike, G. N., Ogundola, F.I., Salako, R.A. and Fakeye, O. E. (2001). Effects of different dietary proteins levels on the performance and carcass characteristics of broilers. ASSET Series A., I, 75-87. Nidaullah,
- Ogbe A. O., Efenu P., Nicholas U., Pam A., Abarshi A., Banyigyi S. and Odugbo M. (2011). Response to treatment of skin ailments in Animal Patients using aqueous Ganoderma extract, *EJEAFCh*, 10(1), 1816-1820 (2011).
- Olugbemi, T.S., Mutayoba, S.K. and Lekule, F.P. (2010). Effect of *Moringa oleifera* inclusion in cassava based diets fed to broiler chickens. *International Journal of Poultry Science*, 9 (4), 363 – 367.
- Oluyemi, J.A. and Roberts, F.A. (2000). *Poultry production in warm wet climate*. 2<sup>nd</sup> edition, Macmillan Publishers Ltd, London. 77-80.
- Onu, (2010). Rational use of drugs in broiler meat production. *International journal of Agriculture and Biology*, 2(3), 269-272
- Schwarz, S., Kehrenberg, C. and Walsh, T. R. (2001). Use of antimicrobial agents in veterinary medicine and food animal production. *International Journal of Antimicrobial Agents*. 17, 431-437.
- Sokoto State Government (SOSG) (2011). Sokoto State Government Diary. Yearly Publication by the Home Affairs Department. Sokoto State. 371 .
- Suleiman B. Abubakar, A., Bashar, Y.A and Agaie, B.M. (2013). Growth performance of finisher broiler birds served *C. papaya* leaf extract, in proceedings of the 47<sup>th</sup> Annual conference of Agricultural Society of Nigeria (ASN) held in Ibadan. Pp 1076-1078.
- Yaung, S.A. and Du, S.S. (2007), Use of Organic acids herbs and their combination for improve the utilization of commercial low protein broiler diet. *International journal of poultry science*. 8(1), 14-20.

## Effect of Dietary Grit Inclusion on the Performance of Broiler Chicken

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**Abstract:** A 42 day feeding trial was conducted using 240 broiler chicks to reveal the effect of different dietary inclusion levels of grit (0,3 and 4%) in the diet containing whole millet grain as main energy source in a completely randomize design. Each of the four dietary treatments was further replicated two times. The treatment contained ground millet 0, whole millet 0, whole millet 3, and whole millet 4 grit kg/100kg designated diet 1,2,3and 4 respectively. There were two controls in the experiment, a negative control which contained ground millet (T1) and a positive control with a whole grain (T2) without additive grit. Result showed that, dietary grit inclusion had effect on some of the performance parameters of the birds, as it improved feed conversion ratio, dressing percentage and carcass weight. Significant difference ( $p<0.05$ ) was observed in most of the performance parameters between birds fed with and without additive grit. The study recommended 3% level of inclusion in diet containing whole millet grains for effective utilization by the birds.

**Keywords:** Grit, Grain, Inclusion, Whole Millet and Broiler

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### INTRODUCTION

One of the unique aspects of the avian digestive system is the presence of gizzard, where a combination of muscular contraction, grinding action and enzyme help to reduce feed material into absorbable portion (Adeniji, 2010). Grit, a kind of angular and hard crushed rock preferentially derived from granite, is used by the birds in place of "teeth" and hence enhances mechanical digestion by the gizzard (Ali *et al.*, 2006). For this reason, it is important in poultry nutrition when high fiber diets are used or when whole grains are fed

Birds commonly ingest and maintain grits in their muscular gizzard to help grind up food (Gionfriddo *et al.*, 1999). The incorporation of whole grain into poultry feeds has become a more common practice especially in European countries as a way of reducing feed cost due to handling and processing. This practice has resulted in some beneficial effects associated with increased gizzard activity, such as improvement in feed conversion ratio (Plavaik *et al.*, 2002), increased starch digestibility (Hetland *et al.*, 2002) and greater apparent metabolizable energy (Svihus *et al.*, 2004).

Whole pearl millet can be readily broken down by young broilers and thus be incorporated into their diets (Hidalgo *et al.*, 2004). The inclusion of pearl millet in poultry diets has gained interest due to the favorable nutritional characteristics of this grain. The metabolizable energy is comparable to that of corn (Davis, *et al.*, 2003). Furthermore, pearl

millet has higher crude protein (12 to 14%) and lysine (0.38 to 0.41%) concentration than either corn or sorghum (Adeola *et al*, 1994), Ojewola and Oyin (2006) reported that millet has higher crude fiber (7.92%) and ash (3.83%) than maize or sorghum. Pearl millet also has higher oil content than other common cereal grains (Hill *et al*, 1990), and it is a better source of linolenic acid (Rooney, 1978). Based on the performance of broilers fed pearl millet, it appears that pearl millet is equivalent or superior to corn as a grain source for poultry rations (Collins *et al*, 1994).

Pearl millet is a good alternative source of energy for broilers up to seven weeks. Broilers can be fed pearl millet-soybean based diets since it can replace maize in a maize-soybean based diet. The proposed replacement rates range from 10% to 100%, though most authors suggest replacing 50% of maize or more (Davis *et al*, 2003; Raju *et al*, 2003; Choudhary *et al*, 2005; Udeybir *et al*, 2007; Udeybir *et al*, 2009).

### **Justification of the Study**

Poultry production forms an important commercial enterprise involving thousands of birds. However, there is the need to further improve the efficiency of poultry in terms of feed preparation and utilization to maximize profit margin (Eduvie, 2002).

To aid the action of the gizzard, the average local chicken picks up a few stones while scavenging for food. It is thought that, these stones aid the digestion of materials which the local chicken picks up (Fritz, 1937; Salverson, 1996). Birds reared under intensive management have no access to such stones. There is possibility that, incorporation of grit (stones) into the diet of intensively reared birds may increase the amount of nutrients extractable from these diets (Adeniji, 2009). Besides, the use of whole grains saves the farmer additional cost of grinding the grains into powder or amorphous state. The increase in the price of maize has adversely affected the cost of production of poultry and pigs in Nigeria as these animals depend almost entirely on concentrate feeds. Therefore there is the need for exploitation of other energy sources as alternative to maize if the growth of the poultry enterprise in the country is to be sustained (Udeidibie *et al*, 2004).

Most of the sub- Sahara communities grow millet as source of grains because of its tolerance to low rainfall and high ambient temperature, which does not favour the growing of maize and much of sorghum.

Sokoto state is one of the highest millet producing states. It is grown by almost every farmer during the short rainy season resulting in higher tonnage that is surplus for human consumption and hence available for poultry feeding. Hence, it is pertinent that poultry farmers use millet as source of energy in a more economical form that cut cost and increase the profit margin of the enterprise.

### **PROBLEM STATEMENT**

Modern birds are fed predominantly on low fiber diet without access to grit and as a result, their gizzards are small and the proventriculi may be dilated. This results in food passing very quickly arriving in the duodenum still in a particulate form. Recent research indicates that fine grinding does not improve the nutritional value of grain and may even be detrimental to performance (Tim, 1999).

### **AIMS AND OBJECTIVES OF THE STUDY**

The aim of the study is to assess the effect of dietary inclusion of grits as additive in whole millet based diets on the performance of broilers.

#### **Objectives**

1. To determine the impact of different additive levels of grit inclusion on general performance of broilers at the starter and finisher phase.

2. To evaluate the carcass characteristics of broilers fed different additive grit levels of 0, 3 and 4kg in whole millet based diets at starter and finisher phases

## MATERIALS AND METHODS

### Study Area

The study was conducted at the poultry production and research unit of the Department of Animal Health and Production Technology, Umaru Ali Shinkafi Polytechnic Sokoto. Data was collected within 6 weeks. Four weeks for starter phase and two weeks for finisher phase.

Sokoto State is located between latitudes 12<sup>0</sup> and 13<sup>0</sup>N and between longitudes 4<sup>0</sup> and 6<sup>0</sup>E in the northern part of Nigeria and at an altitude of 250m above sea level (Mamman et al., 2000). The state falls within the Sudan savannah vegetation zone to the south and Sahel savannah to the north with alternating wet and dry seasons. The hot dry spell extends from March to May and some time to June in the extreme Northern part. A short cool, dry period (Harmattan) occurs and lasts between late October and late February (Malami et al., 2001). Mean annual temperature is 34.9<sup>0</sup>C with the highest in April ranging from 38 to 41<sup>0</sup>C and lowest in January ranging from 13 to 16<sup>0</sup>C (Reuben, 1981).

### Experimental Design

A total of 240, 8 day old broilers were used. The birds were randomly allocated to four dietary treatments of different levels (ground, 0, 3 and 4kg) of Grit (2-3mm), with each treatment having two replicates of 30 birds in a completely randomized design (CRD). There were two controls in the experiment, a negative control which will contain ground millet and a positive control containing whole millet without additive inclusion of grits. The other two experimental diets will contain 3 and 4kg/100kg additively included in the diet containing whole millet grains.

### Management of the Birds

Necessary medications were provided according to the recommendation of Oluyemi and Roberts (2000). The birds were housed on a deep litter with open side walls. The housed pens were cleaned, washed and disinfected prior to the arrival of the birds. They were also been fed with diet that meets their nutrients requirement at starter and finisher levels. The gross and calculated nutrients composition of the experimental diets are shown in tables 1, 2 and 3.

**Table 1: Gross Composition of the Starter diet**

Ingredients%	Trt 1 Ground millet (Control 1)	Trt 3 Whole millet	Trt 4 Whole millet	Trt 2 Whole millet (Control 2)
Millet	60.25	60.25	60.25	60.25
GNC	27.00	27.00	27.00	27.00
Wheat Offal	6.50	6.50	6.50	6.50
Bone meal	2.00	2.00	2.00	2.00
Blood meal	2.30	2.30	2.30	2.30
Salt	0.30	0.30	0.30	0.30

Premix	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20
Limestone	1.00	1.00	1.00	1.00
Total	100	100	100	100
Grit	0	3	4	0

**Table 2: Gross Composition of the Finisher diet**

Ingredients%	Trt 1 Ground millet (Control 1)	Trt 3 Whole millet	Trt 4 Whole millet	Trt 2 Whole millet (Control 2)
Millet	61.00	61.00	61.00	61.00
GNC	22.25	22.25	22.25	22.25
Wheat Offal	13.00	13.00	13.00	13.00
Bone meal	2.80	2.80	2.80	2.80
Blood meal	-	-	-	-
Salt	0.30	0.30	0.30	0.30
Premix	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20
Limestone	1.00	1.00	1.00	1.00
Total	100	100	100	100
Grit	0	3	4	0

**Table 3: Nutrient Composition of the Diets**

Nutrient	Starter	Finisher
Crude Protein%	22.95	19.67
Calcium%	1.11	1.42
Phosphorus	0.44	0.64
Crude fibre%	6.75	7.10
M.E kcal/kg	3000.1	2966
Ether extract%	4.30	4.2

### Data Collection

Records of feed intake were taken on daily basis, while weight gain was monitored weekly. Data for feed intake and weight gain were used to compute feed conversion ratio of the birds for each treatment. Mortality was recorded as it occurs throughout the period of the experiment. At the end of the finisher phase, four best performed birds per treatment were slaughtered and dressed for carcass evaluation and to assess the impact of grit inclusion on the growth and development or otherwise of internal organs such as the proventriculus and gizzard.

### Data Analysis

Data collected from the trial were subjected to ANOVA using statistical package for social science (SPSS, 2012).

## RESULTS

**Table 4:** Performance Characteristics of Experimental Birds.

Parameters	Diet				SE
	1	2	3	4	
Initial weight g/b	76.70 <sup>a</sup>	76.70 <sup>a</sup>	78.33 <sup>ab</sup>	78.33 <sup>ab</sup>	0.21
Final body weight g/b	1760.00 <sup>a</sup>	1710.00 <sup>c</sup>	1720.00 <sup>b</sup>	1700.00 <sup>d</sup>	5.90
Weight gain g/b	1689.00 <sup>a</sup>	1633.30 <sup>c</sup>	1641.67 <sup>b</sup>	1621.67 <sup>d</sup>	6.62
Feed intake g/b/d	83.00 <sup>a</sup>	78.06 <sup>b</sup>	76.09 <sup>c</sup>	75.50 <sup>d</sup>	0.76
Feed conversion ratio	2.06 <sup>a</sup>	2.01 <sup>c</sup>	1.95 <sup>a</sup>	1.96 <sup>b</sup>	0.01
Mortality%	6.70 <sup>a</sup>	13.30 <sup>c</sup>	11.70 <sup>b</sup>	6.70 <sup>a</sup>	0.76

abcd: means within the same row with different superscript are significantly different ( $p < 0.05$ ).

### Performance Characteristics

Final body weight differed significantly ( $p < 0.05$ ) between those fed ground millet and (1760g/b) compared to broilers fed whole millet (1710g/b) and broilers fed with 3 and 4% grit (1720g/b and 1700g/b, respectively). Feed intake, feed conversion ratio and mortality also differ significantly ( $p < 0.05$ ) between the treatment. The values ranged between 75.50 to 83g/b, 1.95 and 2.06kg, and 6.70 and 13.30% respectively for feed intake, feed conversion ratio and mortality.

**Table 5:** Effect of Dietary Grit Inclusion on Carcass Characteristics of Experimental Birds.

Parameters	Diet				SE
	1	2	3	4	
Live weight g/b	2200.00 <sup>a</sup>	2083.00 <sup>c</sup>	1988.00 <sup>d</sup>	2113.00 <sup>b</sup>	19.55
Carcass weight (g)	1400.00 <sup>a</sup>	1353.00 <sup>c</sup>	1318.00 <sup>d</sup>	1393.00 <sup>b</sup>	8.52
Dressing percentage (%)	63.64 <sup>d</sup>	64.95 <sup>c</sup>	66.30 <sup>a</sup>	65.93 <sup>b</sup>	0.27
Proventriculus & gizzard(g)	62.75 <sup>c</sup>	63.50 <sup>a</sup>	63.50 <sup>b</sup>	62.00 <sup>d</sup>	0.66

abcd: means within the same row with different superscript are significantly different ( $p < 0.05$ ).

### Carcass Characteristics

Live weight showed significant difference ( $p < 0.05$ ) the control groups and the birds fed additive grit. The values ranges from 1988g/b to 2200g/b. carcass weight also shows significant difference ( $p < 0.05$ ) between the treatment. Birds fed ground millet recorded the highest value (1400g) while bird fed with 3% grit has the lowest value (1318g). Birds fed 3%



grit had the best dressing percentage (66.30%) while birds fed ground millet recorded the least dressing percentage (63.64%). Proventriculus and gizzard weight also showed significant difference ( $p<0.05$ ) between the treatment groups. The values range between 62.00g to 68.50g.

### **Discussion**

The differences observed for final body weight, weight gain and feed conversion ratio between birds on treatment 2 and 3, is in line with the findings of Idachaba et al. (2003) who reported improved feed utilization with incorporation of grit in the diet of broiler chicken. But the values recorded for treatment four (4%) does not support the findings of Idachaba et al. (2003). The result is also in line with the findings of Adeniji (2010) who reported better feed to gain ratio ( $p<0.05$ ) for chicks fed 5% grit compared to those fed diet without grit.

The mortality rate recorded was above the normal recommended or accepted level of 5% (Oluyemi and Roberts, 2000). This could be as a result of sudden death syndrome which affects the heavier birds in the flock. Mahmood (2012) reported that, poultry nutritionist suggest that, the higher growth rate in modern broiler chicks could be the main reason for the problem.

The significant difference ( $p<0.05$ ) recorded for mortality is not in line with the findings of Ali et al. (2006) who reported that, mortality showed no significant difference ( $p>0.05$ ) between birds fed acid insoluble granite grit (AIGG) and control diet without grit.

Live weight, dressed weight and dressing percentages showed significant difference between the treatments. This result contradicts the findings of Ali et al. (2006) who reported that, feeding granite grit had little or no effect on carcass weight and dressing percentage. The significant difference ( $p<0.05$ ) recorded on weight of gizzard and proventriculus, is not in line with the findings of Silva Junior et al. (2003) who reported that, insoluble granite grit in broiler diet increase gizzard and proventriculus weight.

### **CONCLUSIONS**

It could be concluded that,

- Dietary grit inclusion improved the performance of broiler chickens without detrimental effects.
- Significance difference ( $p<0.05$ ) was observed in most of the performance parameters between those fed with or without additive grit and those fed whole millet and ground millet.

### **RECOMMENDATIONS**

- The study recommended 3% level of inclusion as it recorded better performance values in terms of feed conversion ratio, final body weight and carcass weight when compared with other group with 4% level of inclusion.
- The study also recommended grinding whole millet coarsely, instead of feeding whole grains to avoid selection of feed ingredients and feed wastage by the broiler chickens.

### **REFERENCES**

- Adeniji, A.A. (2010). Effect of dietary grit inclusion on the Utilization of Rice husk by pullet chicks. *Tropical and Sub Tropical Agro ecosystem* 12 (1) 175-180.
- Adeniji, A.A (2009). Effect of dietary grit inclusion on the utilization of palm kernel cake by pullet chicks. *Animal Nutrition and feed Technology* (9) 29-36.
- Adeola, O. and J.C. Rogler (1994). Pearl millet in diet of white peckin duck. *Poult Sci.* 73:425-435.

- Ali, B.G., E. Guray and O. Nuh (2006). Voluntary intake of insoluble Granite-grit offered in free-choice by broilers. *Asian-Aust. J. Anim. Sci.* 19(4) 549-553.
- Collins, V.P., A.H. Cantor, A.J. Pescatore, M.L. Straw and M.J. Ford (1994). Evaluation of pearl millet as feed ingredient for poultry. *Poult. Sci.*(1):34. (Abstr.).
- Davis, A.J., N.M. Dale and F.J. Ferreira (2003). Pearl millet as an alternative feed ingredient in broiler diets. *Journal of Apply Poultry Research*, 12 (2): 137-144.
- Eduvie, L.O (2002). Poultry Production in Nigerian, a training manual. Published by National Animal Production Research Institute, Shika ABU, Zaria Pp4.
- Fritz, J.C. (1937). The effect of feeding grit on digestibility in the domestic fowl. *Poultry Science*, 16: 75-79.
- Giofriddo, J.P. and L.B. Best (1999). Grit use by birds: A review. *Curr. Ornithol* 15, 89-148.
- Hetland, H., B. Svihus and V. Olaisen (2002). Effect of feeding whole cereal on performance, starch digestibility and duodenal particle size distribution in broiler chickens. *Br. Poult Sci* 43: 416-423.
- Hills, G.M. and W.W. Hanna (1990). Nutritive characteristics of pearl millet grain in beef cattle diets. *J. Anim. Sci* 68: 2061-2066.
- Hidalgo, M.A., AX Davis, N.M. Dale and W.A. Dozier III (2004). Use of whole pearl millet in broiler diets. *J. Appl Poult. Res.* 13: 229-234.
- Idachaba, C.U., Abeke, F.O., Olugbemi, T.S., Anoh, K.U. and Ademu, L.A. (2013): Effect of graded levels of stone grit on the utilization of rice offal based diet by broiler chickens. *International Journal of Applied Research*.13:125-131.
- Mahmood, S. (2012). Feed restriction in broiler chicks production. A review: IDOSI publication Iran. *Global Veterinaria* 8 (5):449-458.
- Malami, B.S., U.G. Rambo and M. Nasirudeen (2000). A note on indigenous knowledge on treating Camel (*Camelus dromedary*) disease among farmers in Sokoto State, Nigeria. *Journal of Agriculture and Environment* 2(1): 159-163.
- Ojewola, G.S. and S. Oyim (2006). Comparative evaluation of maize, sorghum and millet in growing cockerels ration. *Agricultural Journal*, 1 (3): 176
- Oluyemi, J.A. and F.A. Robert (2000). Poultry Production in warm wet Climate. Second edition, Macmillan Publishers London. Pp 77-80.
- Plavnik, I., B. Macovsky and D. Sklan (2002). Effect of feeding whole wheat on performance of broiler chickens. *Anim. Feed Sci. Technol.* 96:229-236.
- Reuben, K.U. (1981). Geographical Region of Nigeria. Published by Hein mad, London, U.K
- Salverson, C.A. (1996). Grit feeding in caged layers. *Poultry Science*, 75-112.
- Silva-Junior, V.L. de, Cotta, J.T.B.de and Oliveira, A.I.G.de (2003). Effect of the forms of presentation of corn and the use of grit in the ration on the performance in broiler. *Ciencias Agriculture*. 27:1165-1171.
- SPSS (2012). Statistical package for social science. International Business Machine (IBM). Version 20.

## **Seroprevalence of Lumpy Skin Disease in Cattle Slaughtered at Sokoto Metropolitan Abattoir, Sokoto State, Nigeria**

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**Abstract:** A seroprevalence study was carried out on serum samples obtained from blood of cattle slaughtered at Sokoto metropolitan abattoir, Sokoto, Nigeria. Systematic random sampling was used to select the animals. Serum samples of 192 cattle of different sexes, age and breeds were analysed using ID Screen® Capripox Double Antigen ELISA Test kit for the presence of lumpy skin disease virus (LSDV) antibodies. Thirty seven (37) representing 19.2% of the samples were found positive for the antibodies against lumpy skin disease virus (LSDV). More female animals appeared to have LSDV antibodies than the males ( $P > 0.05$ ). However, young animals appeared to have more infection than the adults ( $P > 0.05$ ). Similarly, white fulani breed of cattle recorded the highest number of positive cases of LSDV ( $p > 0.05$ ). None of the potential risk factors considered (age, sex and breed) shows significant association with the occurrence of the disease within the study area. The result of this research suggests that there is an existence of LSDV within the study area and that the spread of the LSDV antibodies seems to cut across sex, age and breed of cattle within the state. It is suggested that virological research on LSDV should be carried out in the state.

**Keywords:** Lumpy skin disease virus, antibodies, cattle, Sokoto Metropolitan Abattoir

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### **INTRODUCTION**

Economic farming of livestock in Africa is challenging. Infectious diseases are amongst the major factors which limit the production and productivity of large and small ruminants. Lumpy skin disease (LSD) is one example of a disease which frequently affects bovine production systems due to its devastating effect as well as threats it poses to the dairy industries in Nigeria (Adedeji *et al.*, 2017). The disease has also been reported in Africa, Middle East, Asia and several European countries.

The disease has been categorized as a notifiable disease by World Organisation for Animal Health (OIE) because of its severe economic impact during outbreaks (Tuppurainen and Oura, 2012). However, it manifest as an acute, severe and economically important transboundary disease of cattle caused by a virus called Lumpy Skin Disease Virus (LSDV) (Tuppurainen and Oura, 2012). The virus is a double stranded DNA virus which belongs to the genus *Capripoxvirus*, subfamily *chordopoxvirinae* and the family *Poxviridae*. Other members of the genus includes goatpox virus (GTPV) and sheeppox virus (SPPV) (Tulman *et al.*, 2001). There is however, a close genetic relatedness of these capripoxvirus isolates. The

disease mainly affects cattle, sheep and goats but has it has also been seen in giraffes, African buffalo and Impalas (Carter and Wise, 2006).

The disease was first identified in East Africa in Kenya in 1957 and the Sudan in 1972, and in West Africa in 1974, spreading to Somalia in 1983. From 1929 to 1986 the disease was restricted to countries in sub-Saharan Africa, although its potential to extend beyond this range had been suggested (Davies, 1981). In Sub Saharan Africa, LSD has become enzootic in all the countries in which it has occurred and has proved impossible to eradicate. Restrictions on cattle movements have not prevented its spread within countries.

The incidence of the disease is highest in wet summer weather (rainy season) but it may occur in winter (Davies, 1982). It is most prevalent along water courses and on low ground (areas conducive to insect multiplication). Biting insects play a major role in the transmission of the virus even though there is little hard data incriminating any particular insect species as a vector of LSD.

Infection occur mainly by contact, however, the disease can also be transmitted through sharing of common drinking troughs as well as suckling calves from infected dams. Animals can also be infected experimentally by inoculation from cutaneous nodules or blood. Breeds of *Bos Taurus*, imported in to Africa are far more susceptible than the indigenous *Bos Indicus* cattle, while the channel island breeds are particularly severely affected by LSD.

Morbidity for LSD varies from 3-85% (Weiss, 1968) and likely depends on the prevalence of the mechanical insect vector and the susceptibility of the cattle (Mac Owen, 1959). Mortality is generally low, about 1–3% but 40%- 75% mortality has been reported in naive animals (Babiuk *et al.*, 2008).

The characteristic clinical signs of LSD include lacrimation, fever (40–41<sup>0</sup>C), lymphadenopathy, nodular skin lesions that progress to sit-fasts lesions, which can persist for many months (Babiuk *et al.*, 2008). In some LSD outbreaks affected animals develop swelling of one or more legs and lameness; and oedema of the dewlap (Tuppurainen and Oura, 2012). The disease is severe in cows during peak lactation and causes a sharp drop in milk yield, which may lead to secondary bacterial mastitis, in addition LSD may also cause temporary or permanent infertility in cows and bulls (Tuppurainen and Oura, 2012). Emaciation of infected animals and a convalescence period lasting for several months causes a decreased growth rate in beef cattle (Ayelet *et al.*, 2014).

### **Statement of the Problem**

- The disease is associated with significant production losses because of reduced milk yield, decreased weight gain, increased abortion rates, damage to wool and hides, and increased susceptibility to pneumonia and fly strike, while also being a direct cause of mortality (Yeruham, *et al.*, 2007).
- The disease is amongst the top ten most important diseases of cattle in the world (OIE/World bank 2011). The disease is also a commonly reported livestock disease and the fourth most widely distributed transboundary disease in Africa in the years 2013 and 2014 (AU-IBR year book 2014).
- There is paucity or dearth of information on the disease status by the researchers in Nigeria.

### **Justification**

There is need to update and enrich the available literature on the disease situation in Nigeria. There is the need to determine the current status of the disease among the cattle population in the study area. The results of the research will be the first report on the seroprevalence of

Lumpy skin disease virus in Sokoto State. Information generated can also be used by policy makers in drawing out control and preventive measures.

### **Aim and Objectives of the Research**

The aim of this research is to determine the seroprevalence of lumpy skin disease virus (LSDV) in cattle slaughtered at Sokoto metropolitan abattoir.

The specific objectives are:

1. To examine the sera obtained from cattle within the study area for antibodies to LSD virus.
2. To determine the distribution of the antibodies according to age, sex and breed in cattle within the study area.

## **MATERIALS AND METHODS**

### **Experimental Design and Location**

This study was carried out in Sokoto. One hundred and ninety two (192) cattle were sampled for the purpose of this research by systematic method of sampling. On the average, 150 cattle of both sexes are slaughtered every day in the abattoir. Based on this estimate, every 10<sup>th</sup> animal slaughtered was sampled, giving a total of 15 samples collected everyday of visitation. The visitations to the abattoir were twice every week, to enable sample collection over longer span of time (3-4 month).

For a better understanding of the dynamic of LSDV infection within the study area, animals were categorized in two groups; male and females respectively. In addition, information with regards to the age and breed of the animals commonly seen in the abattoir (Sokoto Gudali, White Fulani, Azawak and Mixed breeds) were also collected.

### **Sample Size Determination**

The sample size was estimated using the formular  $n = \{z^2 p (1-p)\}/d^2$  (Thrustfield, 2002)

Where **n** is sample size, **z** is level of confidence (1.96 SE at 95%), **P** is prevalence from previous works 15% (Fentie *et al.*, 2017), and **d** is the desired precision (5%).

$$n = \{1.96^2 \times 0.15 \times (1-0.15)\}/0.005^2$$

$$n = \{3.8416 \times 0.15 \times 0.0225\}/0.0025$$

$$n = 195.92$$

$$n = 196.$$

Therefore, a minimum of 196 samples were needed.

### **Sample Collection and Processing**

From each selected animal, an approximately 10ml of blood sample was collected in a sterile test tube at the point of slaughter in the abattoir. The blood was collected in a test tube as it rushes out of the jugular vein, and then transferred in to sterile plain sample bottles. The samples were labeled appropriately, and then transported in an ice packed kit to the Central Research Laboratory of the Faculty of Veterinary Medicine of Usman Danfodiyo University Sokoto.

Serum was extracted according to the methods described by Henry, (1979). Whole blood was collected in a covered test tube that does not contain an anticoagulant. The blood was then allowed to clot after which the clot was then removed by centrifugation at 1500rpm for 10minutes. The resulting supernatant designated as serum was then immediately transferred in to a clean polypropylene tubes using a Pasteur pipette and then stored in a freezer (-20C) until the time for analysis.

### **Elisa Test Procedure**

ID Screen<sup>®</sup> Capripox Double Antigen ELISA test kits specific for the detection of antibodies against capripox viruses including lumpy skin disease virus (ID.Vet) was used in detecting lumpy skin disease virus antibodies in the serum samples collected. The test was conducted according to the manufacturer's description as follows:

50µl of the dilution buffer were added to each well in the plates, and 50µl of the positive controls were then added to wells A1 and B1. 50µl of the negative controls were then added to wells C1 and D1 and 50µl of each sample to be tested were added to the remaining wells. The plates was then incubated at 37c for 45 minutes, and then washed three times with 300µl of the wash solution. 100µl of the ready-to-use conjugate were then added to each well, and the plates were again incubated at 21c for 30 minutes. The plates were then washed again three times with 300µl of the wash solution. 100µl of the substrate solution were then added to each well, and the plates were again incubated at 21c for 15 minutes in the dark. 100µl of the stop solution were then added to each well in order to stop the reaction. The optical density (OD) for each well was read with an EL800 plate reader (Biotek, South Africa) at a wavelength of 450 nm.

### **Interpretation of Results**

For each of the samples, competition percentage was calculated using the formula:

$$\text{Competition (\%)} = \frac{\text{OD}^{\text{sample}} - \text{OD}^{\text{NC}}}{\text{OD}^{\text{PC}} - \text{OD}^{\text{NC}}} \times 100$$

Where OD<sup>sample</sup> is the optical density of the sample as shown by spectrophotometer, OD<sup>NC</sup> is the mean value of the optical densities of the negative control and OD<sup>PC</sup> is the mean value of the optical densities of the positive control.

Samples presenting a competition percentage:

- Less than 30% are considered negative
- Greater than or equal to 30% are considered positive

Note: Seropositive animals were considered infected since there is no history of vaccination against LSDV in the study area.

### **DATA PRESENTATION AND STATISTICAL ANALYSIS**

The results were presented in form of tables and charts. Chi square test ( <sup>2</sup>-test) of independence was used to test for any significant association (using InStat statistical package, version 3.05 [2000]) between the occurrences of lumpy skin disease virus antibodies with the age, sex and breed of the animals sampled.

## RESULTS

Within the period of three months, one hundred and ninety two (192) samples were collected from cattle slaughtered at Sokoto metropolitan abattoir. Thirty seven (37) samples out of one hundred and ninety two (192) tested samples were found positive for antibodies against lumpy skin disease virus, thus, revealing a seroprevalence rate of 19.27% (Table 1). Lumpy skin disease virus infection was found to be more prevalent in female cattle (22%) than in male cattle (17%) (Table 1). Similarly, lumpy skin disease virus infection was also found to be higher in the young animals (31%) when compared with the adults (13%) (Table 2). In terms of breed distribution, the highest prevalence was recorded in white Fulani (24%) while the least prevalence was recorded in Azawak (19%) (Table 3).

**Table 1:** Sex distribution of LSDV antibodies in cattle slaughtered at Sokoto metropolitan abattoir

Sex	Number of animals in the group (n)	No of animals Positive	Prevalence (%)
Male	111	19	17.11
Female	81	18	22.22
Total	192	37	19.27
P=0.3758		$X^2=0.7845$	

**Table 2:** Age distribution of LSDV antibodies in cattle slaughtered at Sokoto metropolitan abattoir

Age	Number of animals in the group (n)	No of animals Positive	Prevalence (%)
Young	67	21	31.34
Adult	125	16	12.80
Total	192	37	19.27
P=0.2358		$X^2=1.406$	

**Table 3:** Breed distribution of LSDV antibodies in cattle slaughtered at Sokoto metropolitan abattoir

Breed	Number of animals in the group (n)	Number of animals Positive	Prevalence (%)
Sokoto Gudali	55	8	14.54
White Fulani	50	12	24.00
Azawak	42	8	19.04
Mixed Breeds	45	9	20.00
Total	192	37	19.27

P=0.6765

X<sup>2</sup>=1.525

## DISCUSSION AND CONCLUSION

From the results of the study, it is evident that in a representative systematic random sampling of one hundred and ninety two (192) cattle from the abattoir, thirty seven (37) were found seropositive. This gives rise to the overall seroprevalence rate of 19.27% of lumpy skin disease virus antibodies in cattle slaughtered at Sokoto metropolitan abattoir.

This is the first report on the seroprevalence of lumpy skin disease virus in Sokoto State. The prevalence observed in this study is slightly higher than the 15.5% seroprevalence reported by Fentie *et al.*, (2017) in Amhara region of Ethiopia. Higher seroprevalences have also been reported by Gari *et al.*, (2012) and Molla *et al.*, (2018) whom reported a seroprevalence rate of 23-31% and 26.5% respectively. Similarly lower seroprevalences have also been reported by two researchers in Ethiopia; one study by Abera *et al.*, (2015) reported 6.3% seroprevalence while the other study by Hailu *et al.*, (2014) reported 7.4% seroprevalence in North-eastern Ethiopia. The substantial difference in prevalence observed in the current study leads us to stress that the results of the former studies describe only a snapshot of the spread of an endemic disease which is likely to fluctuate over time. The differences could however be attributed to the climatic and environmental conditions, differences in husbandary practices as well as variations in the techniques employed by former researchers in the analysis of sera.

Sex distribution, according to this study indicates that female cattle had the higher seroprevalence (22%) than the male cattle (17%) (P>0.05). This could be due to the fact that most of the female animals presented to the abattoir for slaughter are aged animals and as such their immunity against diseases is weak. It could also be due to fact that female animals stay more in the herd for reproduction than the male animals (Sonfada and Garba, 2000). This is in agreement with the findings of Fentie *et al.*, (2017) who reported that female animals were at high risk of contracting LSD than their counterparts.

Data with regards to age distribution indicates that young animals had the higher seroprevalence rate (31%) when compared with the adults (13%) (P>0.05). This is in agreement with the work of Adedeji *et al.*, (2017) whose study revealed that lumpy skin disease affected mostly calves below one year of age. The probable reason could be that the



adults had prior exposure to lumpy skin disease virus and therefore may have developed immunity to the virus.

In terms of breed distribution, white Fulani breed of cattle had the highest seroprevalence rate (24%) of lumpy skin disease virus antibodies, followed by mixed breed (20%) and the Azawak (19%). Sokoto Gudali breed of cattle recorded the least seroprevalence rate (14.5%) ( $P>0.05$ ). White Fulani are the most predominant breeds of cattle found in Sokoto (often referred to as indigenous breeds) commonly reared for beef or milk production. This could be the reason why they are mostly seen in the abattoir for slaughter and could also explain why they had the higher seroprevalence rate than the Azawak breed of cattle that enters Nigeria from Niger and are mostly kept for Normadism.

## CONCLUSION

In conclusion, at the end of this study, it is clear that the result of this research suggests an existence of lumpy skin disease virus antibodies within the study area. It is also clear that the spread of the LSDV antibodies seems to cut across age, sex and breeds of cattle within the study area.

## RECOMMENDATIONS

There is need to establish the actual prevalence of lumpy skin disease virus in Nigeria as a whole in order to provide a broad based data for policies and further researches. There is also the need for further research in order to determine other capripox viruses that are in circulation within the study area and to determine the morbidity and mortality of the virus in Nigeria as a whole. There is also the need for the control and elimination of the virus within the study area and Nigeria at large.

## REFERENCE

- Abera Z, Degefu H, Gari G, Kidane M (2015). Sero-prevalence of lumpy skin disease in selected districts of west Wollega zone. *BMC Vet Res* [Internet]. 1–9. Available from. <https://doi.org/10.1186/s12917-015-0432-7>
- Adedeji A.J, Adole J.A, Dogonyaro B.B, Kujul N, Jekki I.S, Asala O.O, Chima N.C, Dyek Y.D, Maguda A.S and Aba-Adulugba, E.P. (2017): Recurrent outbreaks of Lumpy Skin Disease and its Economic Impact on a Dairy Farm in Jos, Plateau State, *Nigeria. Nig Vet Jnl* 38(2)151-158 ISSN 0331-3026
- Ayelet G , Haftu R, Jemberie S, Belay A, Gelaye E, Sibhat B, Skjerve E and Asmare K. (2014). Lumpy skin disease in cattle in central Ethiopia: outbreak investigation and isolation and molecular detection of lumpy skin disease virus. *Rev. sci. tech. Off. int. Epiz.* 33 (3), 1-23.
- Babiuk S, Bowden TR, Boyle DB, Wallance DB, Kitching RP (2008). Capripox viruses: an emerging worldwide threat to sheep, goats and cattle. *Transbound Emerg Dis.* 55: 263–72.
- Carter, G. R., and Wise, D. J. (2006). “Poxviridae”. A Concise review of Veterinary Virology. Retrieved 2006-07-25.
- Davies, F. G. (1982). Observations on the epidemiology of lumpy skin disease in Kenya. *J. Hyg. Camb.* 88: pp 95-102.
- Davies, F.G. (1981). “Virus disease of food animals” vol. 2. London Academic press.
- Diesel, A.M. (1949). The epizootiology of lumpy skin disease in South Africa. *Proc. 14<sup>th</sup> Int. Vet. Cong.*, London, 2: 492-500.

- Fenner, Frank J., Gibbs, E., Paul J., Murphy, F.A., Rott, Rudolph., Studdert, Michael J., and White, David O. (1993). *Veterinary Virology*. 2<sup>nd</sup> edition. *Academic Press Inc.* ISBN 0-12-253056-X.
- Fentie T, Nigusie F, Samson L, Wassie M, Birhanu A, Yechale T, Seleshe N and Ashenafi A (2017): Seroprevalence, risk factors and distribution of sheep and goat pox in Amhara Region, Ethiopia. *BMC Veterinary Research* **13**:385 available from DOI <https://doi.org/10.1186/s12917-017-1312-0>.
- Gari G, Grosbois V, Waret-Szkuta A, Babiuk S, Jacquet P, Roger F (2012). Lumpy skin disease in Ethiopia: Seroprevalence study across different agro-climate zones. *Acta Trop.* **123**(2):101–6.
- Hailu B, Tolosa T and Gari G (2014). Estimated prevalence and risk factors associated with clinical lumpy skin disease in North-Eastern Ethiopia. *Prev Vet Med* [Internet]. **115** (1– 2):64–68. Available from: <https://doi.org/10.1016/j.prevetmed.2014.03.013>.
- Henry, J. B. (1979). Clinical diagnosis and management by laboratory methods. Vol. 1, W.B Saunders Company, Philadelphia, P.A. p.60.
- Mac OWEN, K.D.S (1959). Observation on the epizootiology of lumpy skin disease during the first year of its occurrence in Kenya. *Bull. Epiz. Dis. Afr.*, **7**: 7-20.
- Molla W, Frankena K, Gari G, Kidane M, Shegu D, Jong MCM De (2018). Seroprevalence and risk factors of lumpy skin disease in Ethiopia. *Prev Vet Med* [Internet];Availablefrom: <https://doi.org/10.1016/j.prevetmed.2018.09.029>.
- OIE Terrestrial Manual (2012). Aetiology Epidemiology Diagnosis Prevention and Control References Oie.1–5. World Organisation for Animal Health(OIE). Lumpy Skin Disease: Aetiology Epidemiology, Diagnosis, Prevention and Control References. Paris:Organization Internationaldes Epizootics;2012. [http://www.oie.int/fileadmin/Home/eng/Animal\\_Health\\_in\\_the\\_World/docs/pdf/Disease\\_cards/LUMPY\\_SKIN\\_DISEASE\\_FINAL.pdf](http://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/LUMPY_SKIN_DISEASE_FINAL.pdf).
- Sonfada, M. L. and Garba, H. S. (2000): A retrospective study of bovine tuberculosis in cattle slaughtered in Sokoto abattoirs. *Sok. J. Vet. Sci.* Pp: 36-39.
- Thomas, A.D. and Mare, C.V.E. (1945). “Knopvelsiekte”. *J.S. Afr. Vet. Med. Assoc.*, **16**: pp36-43.
- Thrushfield, M. (2002). Surveys. In: *Veterinary Epidemiology*, 3<sup>rd</sup> Edition. Blackwell Sciences, United Kingdom. Pp 228-242.
- Tulman E, Afonso C, Lu Z, Zsak L, Kutish G & Rock D. (2001). Genome of LSDV. *J Virol* **75**, 7122–7130.
- Tuppurainen ESM and Oura CAL. (2012). Review: lumpy skin disease: an emerging threat to Europe, the Middle East and Asia. *Transbound. emerg.Dis.* **59**: 40–48.
- Von Backstrom, U. (1945). Ngamiland cattle disease. Preliminary report on a new disease, the aetiological agent probably being of an infectious nature. *J. S. Afr. Vet. Med. Assoc.*, **16**: 29-35.
- WEISS, W.E. (1968). Lumpy Skin Disease. In *Emerging Disease of Animals*. FAO Agricultural Studies Bulletin No. **61**, pp 179-201.
- Yeruham I, Yadin H, Van Ham M, Bumbarov V, Soham A, Perl S (2007). Economic and epidemiological aspects of an outbreak of sheep pox in a dairy sheep flock. *Vet Rec.* **160** (7):236–7.



## **Climate Change: An Implication on Poultry Production in Kontagora Local Government Area of Niger State**

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**Abstract:** *The study assessed the climate change: an implication on poultry production in Kontagora Local Government Area of Niger State. Twenty five (25) poultry farmers were interviewed to elicit relevant information in line with the objectives of the study. Findings revealed that majority (93%) of the respondents are aware of climate change, 78%, 98% and 86% of the respondents agreed that temperature fluctuation, increased in sunshine intensity and global warming has a negative effects on poultry production. 72% of the respondents agreed that prices of feed grains are usually high in hot and dry seasons which may affect cost of production and number of birds to raise for egg and meat production, 73% of the respondents agreed that climate change has effect on feed grain availability, this implies that high temperature and low rainfall are climatic factors that affect general grain harvest, their supply to the market and ultimately cost of poultry production. 94% of the respondents agreed that climate change affects egg and meat production pattern and 95% of the respondents agreed that moist climatic conditions encouraged the distribution and development of diseases. It is recommended that extension agents and other development agencies need to educate the poultry farmers more about the effects posed by climate change on poultry production and intensify awareness campaign to poultry farmers on how to reduce the effects of climate change on poultry production. Training workshops should also be organized among the farmers on how best they can cope with the implication of climate change and improve technology that is simple and compatible with environmental factors that should be developed.*

**Keywords:** *Climate change, Poultry and Production*

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### **I INTRODUCTION**

Poultry plays an important economic, nutritional and socio-cultural role in the livelihood of rural households in many developing countries, including Nigeria. Poultry are birds that include fowl, turkey, duck, goose, ostrich, guinea fowl, etc. which render not only economic services but contribute significantly to human food as a primary supplier of meat, egg, raw materials to industries (feathers, waste products), source of income and employment to people compared to other domestic animals (Demeke, 2004).

Poultry flocks are particularly vulnerable to climate change because there is a range of thermal conditions within which animals are able to maintain a relatively stable body temperature in their behavioural and physiological activities. Hence, birds can only tolerate narrow temperature ranges to sustain the peak of their production for human consumption and any unpredictable climatic changes will therefore trigger a series of adjustment and readjustments by livestock and poultry birds in the struggle for survival which may have negative consequence on the viability of poultry production (Amos, 2006).

Climate change has become a global issue. The current world average temperature is 15°C and this is increasing at an alarming rate. The destruction of forest areas, carbon emissions, methane output, industrial activities, an increase in the concentration of harmful greenhouse gases, increase in sea level etc. are continuously contributing to global warming. There is a possibility of increasing world temperature by 3-5°C within the near future resulting in a further increase of sea level by 1.5 meter. The impact of climate change is detrimental for agricultural production. Although world leaders are thinking to find ways to reduce the negative impact of climate change, little progress has been made so far. Production on the other hand, is the process of converting inputs (scarce resources) into output (products) (Olanrewaju et al., 2010). It is the utilization of raw materials to create output in the form of goods or services, which has exchange and utility value (Kotler and Keller, 2006).

The agricultural production including poultry can be threatened by its detrimental effects. Climate change alters global disease distribution, affects poultry feed intake, encourage outbreak of diseases which invariably affects poultry output (egg and meat) and also cost of production (Gray, 2009).

Elijah and Adedapo, (2006) reported that high rainfall and relative humidity provides a conducive environment for breeding of parasites that causes outbreak of diseases which invariably reduces egg production. Poultry production is a major source of protein which has empowered poultry farmers to secure a means of survival and livelihood. Climate change affects poultry production by reducing poultry yield and nutritional quality of feeds, increasing disease and disease-spreading pests, reducing water availability and making it difficult for birds to survive (Spore, 2008).

Farmers are facing a lot of challenges due to climate change and it may not be clear in empirical terms what loss farmers incur but it is known to cause more harm to their production than good. There are many human factors that are responsible for climate change across the globe like poor environmental sanitation, deforestation, bush burning, drilling of boreholes, fuel combustion, and cement manufacture etc. (FAO, 2007).

## II METHODOLOGY

The study adopted the descriptive survey design. A random sampling technique was used to select respondents for the study. Fifteen (15) poultry farmers were randomly selected from each ward (Gabas, Yamma, Kudu and Arewa ward) making a total sample of sixty (60) respondents for the study. Data were analyzed using descriptive statistics such as frequencies distribution, and percentages to determine the perception of the respondents on implication of climate change on poultry production in the study area, while Chi-square test of significant was used to test the formulated hypothesis.

## III RESULTS AND DISCUSSION

A total number of 60 questionnaires were administered to the respondents with regard to the research study. In analyzing the data, respondents were classified and tabulated for easy interpretation. Also simple percentage and descriptive statistical test were applied.

**Table 1:** Perception of Respondents According to Level of Awareness on Climatic Change

Variables	Yes	Percentage	No	Percentage
	Frequency	%	Frequency	%
High Temperature	160	88.9	20	11.1
Unfamiliar disease systems	154	85.6	26	14.4
Varying rainfall pattern	172	95.6	8	4.4
High rainfall intensity	125	69.4	55	30.6
Drier air	106	58.9	74	41.1
Prolonged dry season	94	52.2	86	47.8

Table 1 show that change in climate is obvious and needs no second thought. Poultry Farmers were well aware of higher temperature (88.9%), higher rainfall intensity (69.4%), unfamiliar poultry disease symptoms (85.6%), and unpredictable rainfall (95.6%). Result of analysis is in concordance with Elijah and Adedapo (2006) and implies that variations in climate are simple and evident; they revolve around heat and rainfall intensities and deviations.

**Table 2:** Poultry Farmers Sources of Information on Climate Change

Variables	Yes	Percentage	No	Percentage
	Frequency	%	Frequency	%
Radio	159	88.3	21	11.7
Television	72	40.0	108	60.0
Extension Agents	20	11.1	160	88.9
Friends & Family	160	88.9	20	11.1
Print	67	37.2	113	62.8
Internet	10	5.6	170	94.4
Other Poultry Farmers	154	85.6	26	14.4

As shown in table 2, poultry farmers are not well informed about how well to mitigate the effects of climate change. Majority of them get their information from radio, family and friends. This supports the findings of Hassan, (2008) that radio is a potent source of information to farmers and their families. However, radio air agricultural programs that are more crops inclined, than livestock specific. Also, family and friends are not to be trusted with professional information, even information from other poultry farmers could be more of trial and error sourced.

**Table 3:** Poultry Farmers' Perception of the Effects of Climate Change on Poultry Production

Variables	SA	A	U	D	SD
Increased feed intake	29.4	50.0	5.0	5.6	10.0
High feeding cost	72.2	15.6	2.8	6.7	2.8
Feed wastage	14.4	25.0	5.6	27.8	27.2
High maintenance cost	22.2	34.4	11.7	27.2	4.4
Higher disease outbreak	25.6	44.4	7.8	13.9	8.3
Smaller poultry product	22.2	51.1	6.7	3.3	16.7
Other Poultry Farmers	19.4	22.2	19.4	26.1	12.8

From all indications, table 3 implies that climate change increases the production cost of poultry keepers. The value of poultry products were reduced as a result of incessant ill health and profit is consequently reduced. This is in support of Spore, (2008) which asserts that climate change will cause increase in diseases and disease pests. Research survey reports the production of thin egg shells, small egg sizes and bird life weight, agreeing with (Demeke, 2004) that, this threatens protein production and utilization as well as the achievement of food security.

**Table 4:** Poultry Farmers' Perceived Effects of Climate Change on Poultry Disease Distribution

Variables	Yes	Percentage	No	Percentage
	Frequency	%	Frequency	%
Does climate change have effect on the distribution of poultry diseases?	75	90.4	8	9.6
Are there more poultry diseases now than in the past due climate change?	65	78.3	18	21.7
Moist climatic conditions encourage the distribution and development of diseases?	79	95.2	4	48.20
Has climate change led to the development of new poultry diseases?	57	96.7	26	31.3

From the results in table 4, majority (90%) of the respondents reported that climate change has effect on distribution of poultry diseases, close to three quarter (78%) of the respondents claimed that there are more poultry diseases than in the past as a result of effect of climate change. It further revealed that majority (95%) of the respondents agreed that moist climatic conditions encouraged the distribution and development of diseases and (68%) of the respondents also confirmed that climate change has led to the development of new poultry diseases in the study area. High rainfall and relative humidity provides a conducive environment for breeding of parasites that causes outbreak of diseases which invariably reduces egg and meat production (Elijah and Adedapo, 2006).

Variables	Yes	Percentage	No	Percentage
	Frequency	%	Frequency	%
Change in feed formulation	135	75.0	45	25.0
Well ventilated housing	156	86.7	24	13.3
Tree planting around pens	105	58.3	75	41.7
Chemotherapy	32	17.7	148	82.2
More space per bird	150	83.3	30	16.7
More water served	170	94.4	10	5.6
Better hygiene	162	90.0	18	10.0
Less heat supply	102	65.0	63	35.0

**Table 5:** Measures for Controlling Effects of Climate Change on Poultry Production

Table 5 shows that poultry farmers change feed formulation, use well ventilated housing system, increase space per bird, provide water and ensure better hygiene. These are common measures in climate change mitigation among poultry farmers as also concluded by Olanrewaju et al. (2010). Respondents were of the opinion that the use of concrete made roofing slabs will prevent heat, though costly, they expected it to last longer. Giving more spacing per average bird will prevent generation of heat from birds and well ventilated housing will stabilize the relative humidity which will reduce the outbreak of pests and diseases.

**Table 6:** Relationship between Socio-Economic Characteristics of Respondents and Perceived Effect of Climate

Change on Poultry Production Variables	N	X	SD	R	Significant	Decision
Socio-Economic Characteristics	83	1.2	0.53	0.454**	0.001	H <sub>0</sub>
Perceived Effect	83	1.24	0.49	0.454**	0.001	Rejected

The result of chi-square analysis in table 4.3.1 shows that there is a significant relationship between respondents' socio-economic characteristics and perception of poultry farmers on effects of climate change on poultry production since  $p > 0.05$  ( $r = 0.454$ ,  $p=0.001$ ). The  $r^2$  value of 0.454 shows a good relationship between socio-economic characteristics and perception of poultry farmers on effects of climate change on poultry production. This implies that socio-economic characteristics influence the perception of the poultry farmers on the effect of climate change on poultry production in the study area. This may be explained on the basis of the fact that majority of the men and women, the young and old, the literate and illiterate as well as people that practice different systems of poultry farming are aware of climate change in the study area.

#### **IV CONCLUSION**

Egg and meat production pattern are affected by climate change because periods of high temperature and sunshine intensity makes the birds to drink more water and reduce feed intake which many at times results to high mortality of the chickens, low egg production and low feed conversion ability of the birds to meat, hence, low meat production (ICAR, 2010). Climatic changes influence the emergence of new poultry diseases and increased its distribution. There is dire need to intensify awareness campaign to poultry farmers on how to reduce the effects of climate change on poultry production. Extension agents and other development agencies need to educate the poultry farmers more about the effects posed by climate change on poultry production.

#### **V REFERENCES**

- Amos, T. T. (2006). Analysis of Backyard Poultry Production in Ondo State, Nigeria. *International Journal of Poultry Science*, 5(3), 247 – 250.
- Demeke, S. (2004). Egg Production Performance of Local and White Leghorn Hens Under Intensive and Rural Household Conditions in Ethiopia. *Livestock Research for Rural Development*, 16, (2): 1-5
- Elijah, O. A., Adedapo, A. (2006). The Effect of Climate on Poultry Productivity in Ilorin Kwara State, Nigeria. *International journal of poultry Science*, 5(11), 1061-1068.
- FAO., 2007. Climate Change: Climate Change Impacts, Adaptation and Vulnerability. IPCC WG II Assessment Report. <http://www.ipcc.ch/SPM6avr07.pdf> (accessed November, 2007).

- Gray, W. M. (2009). Climate change: Driven by the ocean, not human activity. 2<sup>nd</sup> annual Heartland Institute conference on climate change. Retrieved February 13, 2013, from <http://tropical.atmos.colostate.edu/Includes/Documents/Publications/gray2009.pdf>
- Hassan, R. (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. *AFJARE* 2(1):83-103
- India Council of Agricultural Research (ICAR). 2010-11 Annual Report *Pp 13*.
- Kotler, P. and Keller, K.L. (2006) Marketing Management, 12th edn., Prentice Hall, Upper Saddle River, NJ.
- Olanrewaju, H. A., Purswell, J. L., Collier, S. D. and Branton, S. L. (2010), Effect of Ambient Temperature and Light Intensity on Growth Performance and Carcass Characteristics of Heavy Broiler Chickens at 56 Days of Age. *International Journal of Poultry Science*, 9(8), 720-725.
- Spore Magazine (2008). Climate Variation: Pests and Diseases Page 5-6 *Spore Magazine*, August Special Issue: CTA.





## **Development of a Palm Kernel Cracking and Separation Machine**

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**Abstract:** *In an attempt to ease, the production of palm kernel oil, a palm kernel cracking and separating machine was developed to crack effectively various sizes as well as to separate the palm kernel nuts from the shell. The palm kernel cracking and separating machine was designed and fabricated with locally available materials from the opinion of a new idea which aims at easing the pain, stress, intensive labour, time consuming, unduly cost and cumbersome operation encountering in the traditional/existing processes of cracking and separating palm kernel nuts from it shell. The machine was tested to ascertain its performance, both performance efficiency and overall efficiency had their highest values at speed of 1600 rpm for 94.75% and 93.329% respectively while the average percentage of broken nuts is 2.1%.*

**Keywords:** *Cracking, Separating, Performance Efficiency, Broken Nuts.*

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### **1. INTRODUCTION**

#### **1.1 Background of the Study**

Oil palm (*Elaeis guinensis*) is an indigenous plant to West Africa. It is the Highest oil yielding crop per hectare in the plant kingdom (Kurki et al, 2008). The palm tree bears its fruits in bunches which vary in weight from 10 to 40kg. It is made up of outer skin (exocarp), a pulp (mesocarp) containing the palm oil in a fibrous matrix, a central nut consisting of a shell (endocarp) and the kernel which itself contain an oil.

Over the years, extracting and expression of oil from oil seeds involve a wide range of traditional, chemical and chemical processing (Tang, 1985, Olayanju, 2004, Kurki, 2008). However, survey results show that 80 percent of Nigeria's oil palm resource exist in small oil palm plantation and wild grove (Badmus, 2002), this is the nation oil palm industry still subsistent with few large estate plantation that makes large mills and imported mills relatively expensive and unaffordable by most farmers, thereby making the traditional and small scale mill to predominate. (Sami and Adegbenjo, 2002) also reported that while the palm oil production

stages in the processing line had undergone a great deal of mechanical. A major viable oil in Nigeria is obtained from the kernel of the palm tree after cracking the palm kernel nut. The kernels are not useful until the kernels are separated from the shell. But the usual way of cracking palm nut to get the kernel is a time consuming and labour intensive process (Badmus, 1990). A safer and more efficient method of cracking palm kernel and separating kernels from shells is desired. Therefore, cracking and the separating processes are two major operations that need serious development for drastic improvement in quality and quantity of palm kernel oil produced in Nigeria. Kernel contains 46 to 54% oil with a free fatty Acid, (FFA) of about 4% and this oil is more stable than palm oil. (Derek and Wiberley, 1997). The by-product after extraction of palm kernel oil can also be used as a valuable substitute for cocoa butter as well as palm kernel cake, animal feed, soap, candle and varieties of industrial used. Palm kernel industry had remained very popular in third world because of the dependency of many companies on palm kernel oil as raw material, which is quite inadequate (Hartley, 1987). Nigeria is one of the world largest exporters of palm kernel product in early sixties, providing about 400,000 metric tons amounting to 65% of the world trade. Nigeria palm kernel nut export reduced drastically within seventies, from 65% to 15% when there was an oil boom (Ndegwe, 1987). Based on high dependent of many companies like soap, vegetable oil and body cream industries within and outside the country. An efficient palm kernel-processing machine is therefore not only necessary but also important to revitalize the production of palm kernel in other to meet up with the ever increasing industrial demand. Removal of palm kernel from its shell involves cracking and separating processes. There are two widely methods commonly used for these processes. Manual (traditional) method and mechanical method.

The manual method of palm nut processing is the traditional way of cracking and separating palm kernel. It is a typical business venture for local youth and old women in the villages in which nuts are cracked using stones and kernel separated by hand picking from the shell at the same time. This method is labour intensive, time consuming and very slow to meet the demand for growing industries (Badmus, 1990). There are two basic mechanical effect that can be use to crack the shell of the nut. The shock caused by an impact against a hard object and the application of direct mechanical pressure to crush, cut or shear through the shell. Palm nut cracking machines are developed on the principle of hurling of palm nut at a high speed against stationary hard surface (Okoli, 1997). Generally, two types of nutcracker are used in palm oil mill; roller crackers and centrifugal impact cracker. In rollers cracker, the nuts are cracked in between two flated rollers revolving in opposite directions. The clearance between the rollers is variable but the nuts are of different sizes which makes the machine to be operating at reduced efficiency. The other cracker is centrifugal impact cracker that uses principle of centrifugal force to flap the palm kernel nuts on the stationary hard surface. This method involves using a shock caused by an impact against hard objects to shear, crush or cut through the shell (Badmus, 1990). Mechanical method will only crack the nut.

## **1.2 Statement of the problem**

The separation of kernel from shell is a very difficult process. The manual (traditional) method of palm nut processing is the traditional way of cracking and separating palm kernel.

It is a method which nut are cracked using stones and kernel are separated by hand picking from the shell at the same time. This manual method is labour intensive, time consuming, cumbersome and very slow to meet the demand of growing industries. The imported machines for cracking palm kernel are very expensive for local farmers to buy. Therefore, there is need to develop a low cost palm Kernel Cracker.

### 1.3 Objectives of the Study

The main objective of the work is to develop a machine that will crack palm kernel and separate kernel nut from the shell.

**The specific objectives are:**

1. To design a palm kernel cracking machine
2. To construct the palm kernel cracking machine
3. To evaluate the performance of the palm kernel cracker

### 1.4 Justification of the study

This project work seeks to proffer solution to the teeming population of local palm kernel and medium scale industries involved in palm kernel business in their quest for a convenient, available and cheap method of cracking their palm nuts, which in most cases are still being done manually due to either very high cost or unavailability of cracking machines.

## 2. MATERIALS AND METHOD

In the existing cracking machine, the different sizes of nuts were not put into consideration. when a mixture of different sizes of nuts are fed into the existing cracking machines some will be too small or too big to crack which will be the major reason for low efficiency of the machine. Base on the above findings an experiment will be carry out to determine the average size, average mass, moisture content strength and coefficient of friction of shell and kernel to aid in the design and fabrication of the machine.

### 2.1 MATERIALS

The use of palm kernel cracking machine is limited to local farmers and medium scale industries whose quantity of palm nuts for cracking does not exceed 1000kg per day.

The improve design is made-up of some components.

#### 2.1.1 Function of the components of the machine

##### 1. The hopper

The hopper is made up of mild steel materials plate. it serves as an inlet through which the kernel enters into the spinning bowl. The top of the hopper will be wide enough to take sufficient kernels at a time. The volume, which was obtained as follows:

$$V = L.B.H \text{ (m}^3\text{)}$$

Where:

V=Volume of hopper

L= Hopper length

B= Hoppers breath

H= Hoppers height

##### 2. Rotor (Rigid Beater)

The rotor is a rotating part of the machine. The rotor receives palm kernel from the hopper at high speed and flap it against the cracking wall for easy cracking of the nuts.

##### 3. The Shaft

The shaft is a rotating element made from a mild steel rod of which aid the cracking of palm kernel nut. The reason for its selection is based on its high tensile strength, resistance to wear and low cost. (Khurmi and Gupta, 2007)

$$d^3 = \frac{16}{\pi S_s} \sqrt{(K_b M_b)^2 + (K_t M_t)^2}$$

Where:

S<sub>s</sub>= Maximum shear stress (N/m)

m<sub>t</sub>= Torizonal moment (N/m)

$m_b$  = Combine shocks and factors applied to bending moment (N/m)

$k_t$  = or for bending and torsional moment respectively [N/m]

#### **4. Bearing**

This takes pure radial loads, pure thrust load or the combination of both.

A unit has its own bearing housing

It has self-alignment ability

It has longer life than ball bearing

It is easier to replace

It has the ability to reduce friction to the minimum

It has the ability to withstand weight of shaft and can easily be mounted.

$$L = \frac{[C]k}{P} \times 10^6 \text{ revolution}$$

Where ;

L = rated life

P = equivalent

C = basic dynamic load

K = constant = 3 for ball bearing

#### **5. Supporting Frame**

The stand is made up of 2 inches angle iron cut into sizes and welded together to form a frame structure. A foundation with a mixture of sand, cement, aggregates and water will be provided to prevent vibration of the machine.

The machine will be installed on the required stand through the foundation base on the stand.

The frame is design to withstand shock and vibration to prevent twisting and maintain firm stability.

#### **6. Pulleys**

The recommended pulleys for this machine is mild steel. The criteria for selecting mild steel material is base on the comparatively lighter weight than cast iron pulley, higher strength and durability, less tendency of failure or breakage, both pulley grooved and belt run on v-groove pulley.

$$N_1 D_1 = N_2 D_2 \quad (\text{Ndirika, 1993})$$

Where:

$N_1$  = speed of driven pulley

$N_2$  = speed of driven pulley

$D_1$  = Diameter of driven pulley (mm)

$D_2$  = Diameter of driven pulley (mm)

#### **7. Electric Motor**

The main purpose of electric motor is to drive the rotor at a very high speed. The combined effect of centrifugal force and kinetic energy of rotating are employed in palm kernel cracking machine that can be obtain from electric motor of two [2] horse power and revolution per minute.

#### **8. V-Belt**

The selected v-belt for the machine is a single v-belt. A belt provides convenient means of transmitting power from the electric motor shaft to the cracking rigid beater through shaft..

This belt operates on v-groove pulley. The selection of v-belt is based on obtaining long, trouble free life, and quiet running. The important part in absorbing shock load and in damping out and isolate the effect of vibration by (Khurmi and Gupta, 2007).

$$L = \frac{\pi}{2}(D + d) + 2c + \frac{(D-d)^2}{4c}$$

Where

C = distance between the driving and driven pulleys (mm)

D = diameter of driven pulley (mm)

d = diameter of driving pulley (mm)

## 9. Main Housing (Cracking Drum)

The main housing was constructed from medium carbon steel with reliable strength, toughness and good weld ability. This is to make the machine easier for servicing and repair when maintenance is necessary.

## 10. Bolts and Nuts

This help to fasten the front case of the cracking drum for easy opening during either preventive or breakdown maintenance. It is also used to fasten the two palm kernel separating sieve.

### 2.1.2 Operating Principle of a Palm Kernel Cracking and Separating machine

The palm nuts are fed into the machine through the hopper and its slanting nature facilitates the smooth movement of the kernels as feeding continues. As the nut are fed from the hopper at moderate speed through the centralised hole in the flywheel, they first make impact with the cracking flywheel and the walls of the cracking rectangular channel welded to the flywheel rotating at a **high speed of 2500 rpm** and giving rise to a very great impact force that eventually cracked the palm nuts. The cracked kernels and shells thereafter passes or falls into the cracking drum and finally goes out through the outlet at the bottom part of the cracking drum on the first screen attached to the supporting frame. The cracked kernels with average size of 11mm from observation and cracked shells with size less than 12mm falls through the first separating screen (sieve) which will be design with hole of 12mm there by retaining cracked shells with sizes bigger than 12mm as well as very few kernels bigger than 11mm. The second filter will be design with holes of 10mm retains 90% of kernels and filter off nearly all cracked shells with size 10mm and less than 10mm that falls on it from the first sieve. The kernels will be remove or collected from the second screen while, the cracked shells will also be remove from the first screen and underneath the second screen.

### 2.2.1 Force to crack palm kernel nut (F)

The cracking strength of palm kernel as determined from an experiment was  $1423.25\text{NM}^{-2}$  (Okoli, 1997)

$$F = A \times S$$

Where,

A = area of palm kernel cracking

S = strength

F = cracking force

### 2.2.2 Angle of repose ( ) of shell and kernels

Angle of repose ( ) is the angle at which the separating tray is tilt for kernel and shell to move down with uniform velocity.

Where,

$$\mu = \tan \theta$$

$\mu$  = Coefficient of friction,  $\theta$  = Angle of repose,  $\theta_s$  = Angle of repose shell,  $\theta_k$  = Angle of repose of kernel,  $\mu_s$  = Coefficient of friction of shell = 0.50 and  $\mu_k$  = Coefficient of friction of kernel = 0.26 (Okoli, 1997)

$$\theta_s = \tan^{-1} \mu_s = \tan^{-1} 0.5 = 26.6^\circ$$

$$\theta_k = \tan^{-1} \mu_k = \tan^{-1} 0.26 = 14.57^\circ$$

### 2.2.3 Power required to vibrate the separating screen (sieve)

$$P_t = (F_t + W_{pt}) V_t$$

Where,

$W_{pt}$  = weight of the pulley

$V_t$  = Peripheral Velocity of the Can

$F_t$  = Vibrating force

$P_t$  = Power

### 2.2.4 Design Concept and Calculation

The machine was developed to cater for all the physical characteristics of the palm kernels varieties (Dura and Tenera) such as the different size of the palm kernel (from local sampling) the shell and kernel weight of palm kernel and as well as coefficient of friction for shell and kernel with respect to carbon steel was put into consideration. For best performance to be released before the fabrication of the machine, different palm kernel nuts were randomly picked and measured with average measurement size of 11.0 to 18.0mm in diameter and the thickness size of shell ranged from 0.8 to 2.7mm.

### 2.2.5 Determination of engine power for cracking

The cracking force required ( $F_c$ ) was calculated as follow by equation (1) to (3).

$$F_c = mw^2r$$

Where:  $M$ = mass of the nuts (g)

$w$ = speed in radian per second (rad/s).

$r$ = radius of the rotor (m).

$N$ = revolution per minute (rpm).

$$F_c = mw^2r$$

$$\text{Density } \rho \left( \frac{kg}{ms} \right) = \frac{\text{mass (kg)}}{\text{volume (cm)}}$$

$$\text{Mass} = \rho v = m$$

$$F_c = \rho V w^2 r$$

Density of carbon steel used  $\rho = 7.85 \times 10^3 \text{ kg/ms}$  the volume of the rotor  $V = 1 \times b \times t = (350 \times 50 \times 10) \text{ mm}^3$

$$W = \frac{2\pi N}{60}$$

The maximum and minimum speeds for the machine to crack are 2,400 and 800 rev/mm respectively based on literature review where some authors used a minimum of 800 and maximum of 2400rpm (Oke, 2007).

$$\text{Average speed} = \frac{2400+800}{2} = 1,600 \text{ rpm}$$

From equation (4):  $w = 157.08 \text{ rad/s}$

Radius of the rotor  $r = 0.175 \text{ m}$

From equation (1)

$$F_c = 7.85 \times 10^3 \times 0.00028 \times (157.08)^2 \times 0.175 = 9.49 \text{ kw.}$$

Note: one horsepower is equivalent to 0.746 kw

$$1 \text{ HP} = 0.746 \times \text{service factor table (www.rathicouplings.com).}$$

$$\text{Then } 9.49 \text{ kw} = 8.48 \text{ hp}$$

8.48hp was determined to crack the palm kernel nuts therefore 9.0hp engine was selected from what is available in the market.

Impacted forces on the shaft

Figures 1 and 2 shows the tension on two sides of the belt.

The net force  $F_N$  impacted by the belt on the shaft was calculated by Equation.

$$F_N = F_1 - F_2$$

### 2.2.6 Torque acting on the engine pulley TEP was determine by equation

$$\text{TEP} = \text{force} \times \text{radius of engine pulley} = (F_1 F_2) \left( \frac{DEP}{2} \right)$$

Torque acting on the machine pulley TMP, was also calculated by equation.

$$\text{TMP} = (F_1 F_2) \left( \frac{DMP}{2} \right)$$

Where:

DEP = Engine pulley diameter

DMP = Machine pulley diameter

The magnitude of the net driving force is computed from the torque transmitted by equation.

$$F_N = \frac{mt}{D/2}$$

The machine pulley diameter was 250 mm and the engine pulley diameter was 110 mm.

$$\text{Diameter ratio } R = DMP/DEP = 2.3$$

### 2.2.7 Calculating Torque Acting on the Shaft

Pulley Engine rated horse power = 9 HP (6.71kw)

$$\text{Torque } M_t = \frac{\text{power transmitted}}{2\pi N}, \text{ at } 2400 \text{ rpm} = 26.714 \text{ Nm}$$

For machine pulley

$$F_N = \frac{M_t}{\text{pulley radius}} = 53.40 \text{ N}$$

$$\text{Therefore; } F_1 - F_2 = \frac{M_t}{R_2}$$

$$M_t = R_2(F_1 - F_2)$$

$$\frac{F_1}{F_2} = 2.3$$

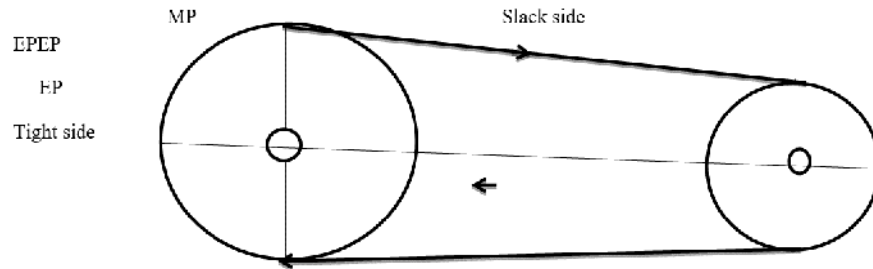
Then  $F_2 = 41.08 \text{ N}$  and  $F_1 = 94.48 \text{ N}$

$$\text{Tension of the belt } T_b = F_1 + F_2 = 135.56 \text{ N}$$

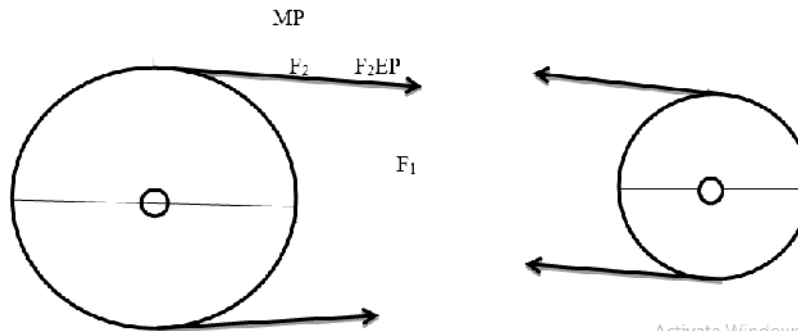
Where;

$M_t$  = Torsional moment on the shaft,  $F_1$  = Tight side tension,  $F_2$  = Slack side tension.

$R_2$  = Radius of driven (machine) pulley.



**Figure 1: Tight and slack sides of belt tension**



**Figure 2: Impacted forces by the belt**

Where:

MP = Machine Pulley and EP = Engine pulley

### 2.2.8 Design of pulleys

The v-belt class B type (17x1325) were selected for the drive of this machine. The width of pulleys grooves (w) were selected based on the suggestion that the width of pulley must be about 25% more than the width of the belt (Ndukwu and Asoegwu, 2000). The design of the pulley is shown in figure 1.

$$W = t + (25\% \text{ of } t) \text{ (mm)}$$

Where,

W = width of the pulley,

t = width of the v-belt.

For machine and engine pulleys

$$W = 17 + (25\% \times 17) = 21.25\text{mm}$$

### 2.2.9 Speed Ratio

The speed ratio and the pulley diameters were designed using equations;

$$\frac{N_1}{N_2} = \frac{D}{d}$$

Where;

$N_1$  = Speed of engine pulleys (rev/min);

$N_2$  = Speed of machine pulley ( rev/min.);

D = diameter of the large pulley (machine) (mm);

d =diameter of the smaller pulley

## 2.3 EVALUATION PARAMETERS

### (i) Throughput capacity (kg/h)



This is the quantity of the nuts fed into the hopper divided by the time taken for the cracked mixture to completely leave the collecting chute (Cornish, 1991). It is given by equation:

$$\text{Throughput} = \frac{M}{T}(\text{kg/h}) \quad (19)$$

where:

M = total mass of the palm nuts fed into the hopper (kg)

T = total time taken by the cracked mixture to leave the chute (h)

**(i) Bulk density**

The bulk density was calculated with the method described by Akintunde (2007); this was done by packing some seeds in a measuring cylinder. The seed was taped gently to allow the seed to settle into the spaces. The volume occupied by the seed in the cylinder was used to calculate the bulk density as shown in equation:

$$\text{Bulk Density (BD)} = \frac{\text{Mass of packed palm kernel nuts}}{\text{Volume occupied by the palm kernel nuts}} (\text{N/m}^3)$$

**(iii) Performance Efficiency ( $\epsilon_p$ )**

$$\begin{aligned} \epsilon_p (\%) &= \frac{\text{Total mass of un - broken}}{\text{Total mass of expected kernel}} \\ &= \frac{M_{UN}}{M_{UB} + M_{BN} + M_{PK} + M_{UC}} \times 100 \end{aligned}$$

**(iv) Percentage of Broken Nuts**

$$\begin{aligned} PD(\%) &= \frac{\text{Mass of Broken Nuts}}{\text{Total Mass of expected kernel}} \\ &= \frac{M_{BN}}{M_{UB} + M_{BN} + M_{PK} + M_{UC}} \times 100 \end{aligned}$$

**(v) Cracking Efficiency ( $\epsilon_c$ )**

$$\begin{aligned} \epsilon_c(\%) &= \frac{\text{Mass of cracked nuts}}{\text{Total Mass of the nut feed in}} \\ &= \frac{M_{TN} - M_{UB}}{M_{TN}} \times 100 \end{aligned}$$

**(vi) Overall Efficiency,**

$$(\epsilon_o)(\%) = \epsilon_p \times \epsilon_c$$

where:

$M_{UB}$  = weight of un-broken kernel from the chute

$M_{BN}$  = weight of broken nuts from the chute

$M_{PK}$  = weight of partially cracked kernels

$M_{TN}$  = Total weight of the nut feed into the hopper

$M_{UC}$  = weight of the un-cracked nuts



Figure 3a: Isometric View of the Machine

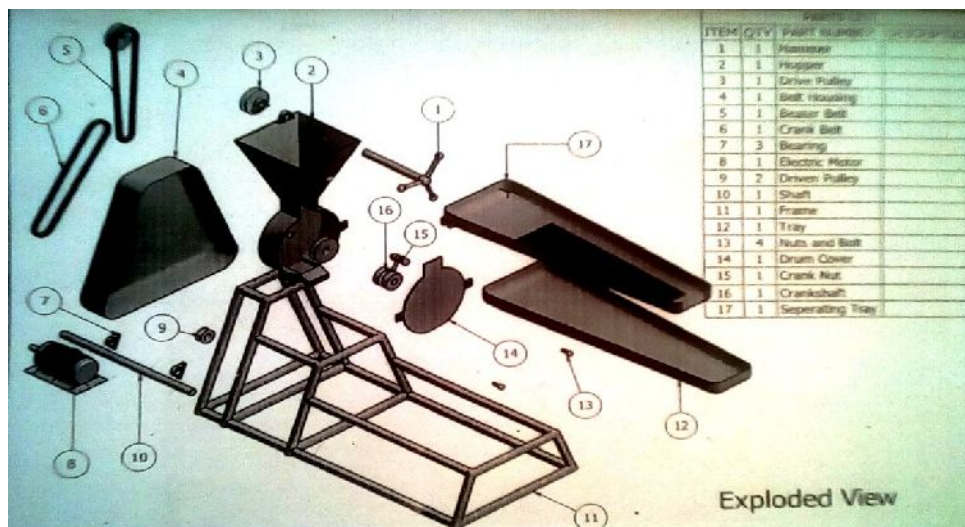


Figure 3b: Exploded View of the Machine

### 3. RESULTS AND DISCUSSIONS

#### Evaluation Performance of the Developed Machine

Table 1 shows the performance tests for the developed palm kernel nuts cracking machine, with minimum speed of 800 rpm and highest speed of 2400 rpm. It was noticed that the total number of cracked palm kernel nuts increased with increase in the speed of the shaft while the number of un-cracked nuts decreased. It was also observed that the partially cracked palm kernel nuts at 800 rpm was 2.75 % and at the highest speed of 2400 rpm was 1.75 %. Also the least un-broken kernels (1.50 %) was noticed at shaft speed of 1600 rpm. The highest broken nuts (3.25 %) was observed at the highest shaft speed of 2400 rpm.

**Table 1: Performance Tests on the Developed Palm kernel Nuts Cracking Machine**

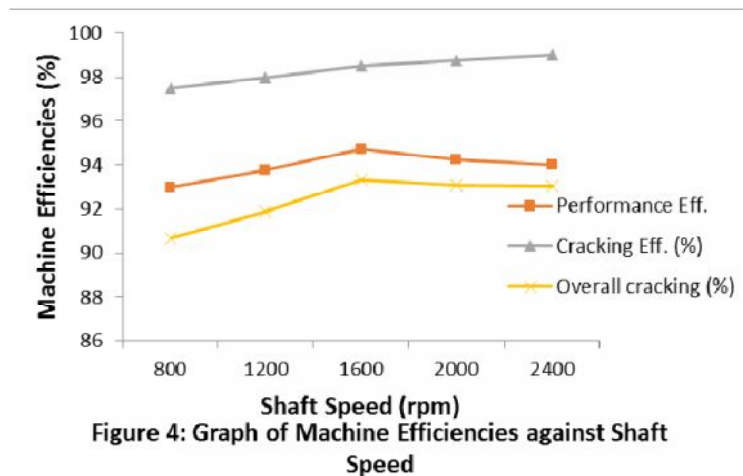
Number of palm kernel nuts (4Reps)	Shaft speed (rev/min)	Cracking time taken (s)	Un-cracked nuts (%)	Partially cracked nuts (%)	Un-broken kernels (%)	broken kernels (%)
400	800	64	2.50	2.74	93.01	1.75
400	1200	44	2.02	2.74	93.74	1.50
400	1600	33	1.52	2.24	94.74	1.50
400	2000	21	1.26	2.02	94.24	2.50
400	2400	20	1.02	1.74	94.01	3.25

The cracking time and the throughput of the developed machine are shown in Table 2. The cracking time in seconds declined (from 64 to 20 seconds) with increased in shaft speed from 800 to 2400 in revolution per minute. The experimental test that was carried using the designed machine showed that throughput capacity increased from 11.5625 to 37.0000 g/s with an increase in shaft speed from 800 to 2400 rpm. Plate 1 shows the developed palm kernel nut cracking machine for the research work. The total cost of production of this machine was found to be fifty five thousand Naira only (N73,000.00). The price range of similar imported palm kernel nuts cracking machine capacity was found to be ranged between N250, 000 to N300,000.

**Table 2: Cracking Time and the Throughput of the machine**

No of palm kernel nuts (4 Rep)	Mass of kernels (g)	Shaft speed (rpm)	Cracking time (s)	Throughput (g/s)
400	740	800	64	11.5625
400	739	1200	44	16.7955
400	741	1600	33	22.4546
400	738	2000	21	35.1429
400	740	2400	20	37.0000

Figure 4 shows the graph of machine efficiencies against the shaft speed and it was noticed that both performance efficiency and overall efficiency had their highest values at speed of 1600 rpm for 94.75 and 93.329% respectively while cracking efficiency increased with an increase in shaft speed from 97.5 to 99%. The percentages of broken nuts were 1.75, 1.5, 1.5, 2.5, 3.25% at speeds of 800, 1200, 1600, 2000 and 2400 rpm respectively (with average 2.1%).



## 4.1 CONCLUSION AND RECOMMENDATION

### 4.1.1 Conclusions

In this research, a Palm kernel nut-cracking machine was developed and constructed; the materials used are locally available. The fabricated machine is a good replacement for the foreign ones. The locally made machine is economical for the establishment of small scale industry especially in the developing countries like Nigeria. The newly developed machine has broken the bearer of cost implication of the existing ones in the market, which ranges from ₦250, 000.00 to ₦300, 000.00 while this developed machine cost just only ₦73, 000.00 for unit production, which is readily affordable from the result of this study. Conclusively, the locally-produced machine was economical for the establishment of small-scale industry especially in the developing countries like Nigeria.

### 4.1.2 Recommendations

The following recommendations are made for the developed palm kernel cracking and separating machine.

1. The design consideration should minimise noise and vibration by using a low-noise bearing.
2. The design should be made in order to regulate the number of nuts going into the cracking chamber.

## REFERENCES

- Badmus, G.A, 1990. Design of Vertical Shaft Centrifugal Palm nut Cracker. *Seminar Pape Presented to Nigerian Society of Agriculture*. Uni. Agric. Makurdi, Nig., Pp: 64-48.D. O. Ataga, C.O Ilechi
- Umoti, U. (1993).“Small-Scale Palm Processing Technology in Nigeria” Paper presented to BUROTROP-AFOPD A *Seminar on Small and Medium Palm and Coconut Technologies*, Accra, Ghana,
- Derek, J and J. Wiberley, (1997). *Tropical Agriculture Handbook*. Published by Glasgow Casel Ltd London, Pp: 64-82.
- Harley, CW.S, 1987. *The project of oil Palm and the Extraction in the palm* Published by Longman. London, Pp:40-48.

- John A.A., and E.S. Owoniho, (2004). Development of a Sneak Palm Kernel. Cracking Machine, Nig. J. Eng. Res. Dev., Pp: 3-4.
- Ndegwe, N.A., (1987). *The oil Palm in Rivers State of Nigeria*. Pp: 103-104.
- Nidirika B. N. (1993). Determination of Pulley Dimension: *National Engineering Conference Series. Vol. 5*.
- Okoli, J.U., (1997). *Determination of Optimum Hurling Speed for Effective Palm Nut Cracking*. Harison Publishing Co. Portharcourt Rivers State, Nigeria.
- Olakanmi, E.O., 2004. *Development and Performance testing of a Palm Kernel Cracker*, compendium of Engineering Monographs, Pp: 11-3.
- Stork, A.F, (1962). *Kernels Recovering*, Palm oil Review Amsterdam Holland, Vol 2.



## **Appraisal of Crop Farmers' Access to Agricultural Information for Enhanced Food Security in the COVID-19 Era in Nigeria**

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**Abstract:** This study, "Appraisal of Crop Farmers' access to Agricultural Information for Enhanced Food Security in the COVID-19 era in Nigeria" investigated how crop farmers have access to agricultural information and the value of their exposure to such information on food security in the COVID-19 in Nigeria. Specifically, the objectives of the study were: to find out the kinds of agricultural information accessible for crop farmers; examine the kinds of crops that farmers access information on; ascertain the sources from which crop farmers access their agricultural information; determine the source of agricultural information more credible to crop farmers; investigate the extent to which crop farmers satisfy with the agricultural information accessible for them; and explore how the agricultural information accessed is used by farmers to enhance the production crops and food security in the COVID-19 era in Nigeria. Descriptive survey research design was adopted and the questionnaire was used as the research instrument for data collection. The population of the study comprised 2708690 registered crop farmers in Nigeria from which a sample size of 1067 was statistically drawn, using Qualtrics<sup>SM</sup> online sample size calculator. Multistage sampling involving stratified, purposive and proportionate techniques were used in sampling the respondents. Primary and secondary sources were used to collect the data while descriptive method was adopted for data analysis with Multivariate Frequency Distribution Tables and SPSS used as the statistical tools for data analysis in this study. Findings revealed that information on fertilizer application was accessed by crop farmers more followed by weed control, while there was a decline in the rate of information accessibility for loans application, pest control, seeds selection, agric marketing among others. The information accessible to crop farmers enabled them to engage more in timely fertilizer application and early control of weeds while there was poor application of other forms of agricultural information. The study concluded by stressing that access to adequate and useful agricultural information by crop farmers is essential for enhanced food production as inadequate access to such information will result to poor application of agricultural innovations capable of preventing the country from attaining food sufficiency and security. The study recommended amongst other considerations the prioritizing of agricultural information to increase farmers' access to agricultural information. Training of crop farmers through workshops and seminars with strict adherence to COVID-19 guidelines was also considered a milestone in the enhancement of food security.

**Keywords:** Appraisal, Crop Farmers' Access, Agricultural Information, Food Security, COVID-19 Era

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## INTRODUCTION

The relevance of information in all areas of human endeavours has been examined by different scholars (Olaniyi and Ogunkunle, 2018; Bankapur and Bhavanishankar, 2018; Idiake-Ochei, Onemolease & Erie, 2016; Demet, Nilay, Marco & Tunç, 2016; Awili, White & Kimotho, 2016; Odoemelam and Olojede, 2016; Kamba 2009; Moore 2007; Sharma and Fatima, 2004; UNDP, 2001, UN, 2001). One of the areas that information is required for necessary action is agriculture and food security. Improved knowledge in the production of agriculture and food security has been linked to access to timely and quality agricultural information (Saleh, Burabe, Mustapha & Nuhu, 2018; Ayalew, 2017; Anju and Satbir, 2017; Idiake-Ochei, Onemolease & Erie, 2016; Ukachi, 2015; Opara, 2008; Adomi, Ogbomo & Inoni, 2003; Chen, Liu and Yang, 2011; Rodman, 2006). The Food and Agricultural Organisation for instance argues that sustainable food security is based less on material inputs such as seeds and fertilizer; rather, it is based on investing in people involved in their use. Thus, a critical factor in meeting the challenge of ensuring food security is human resources development through knowledge building and information sharing (FAO, 1998 in Mulauzi and Zulu, 2012). This is because information and knowledge are powerful tools that enable farmers to put agricultural science and production inputs to best use in order to be food secure. Without information and knowledge, farmers cannot succeed in their agricultural efforts (Munyua, 2000 in Mulauzi and Zulu, 2012).

The areas by which crop farmers seek to access information that can improve food production security have equally been examined (Meitei and Devi, 2009 in Demet, Nilay, Marco and Tunç, 2016). Field acquisition, agricultural inputs (seeds, pesticides, agricultural equipment, weather conditions, harvest technology etc), agricultural technology, agricultural credit (e.g. terms of loans), agricultural marketing, and food technology are some agricultural information accessible to farmers (Olumuyiwa and Tajudeen, 2018; Sunil, Sangeetha & Shaik, 2018; Acheampong, Frimpong, Asante, 2017; Salau, Saingbe and Garba, 2014; Babu, Glendenning, Kumar, S. & Govindarajan, 2012; Meitei and Devi, 2009; Munyua, 2000). Availability of information and knowledge helps farmers to make meaningful decisions and solve problems effectively hence leading to sustainable agricultural production and food security (Kaniki, 1989 in Mulauzi and Zulu, 2012). Additionally, agricultural information and knowledge results in sustainable agriculture productivity and bumper harvests for consumption within and outside the producing country, leading to food security and foreign exchange vital for economic development of the country (Alemma, 1995 in Mulauzi and Zulu, 2012).

A number of sources exist through which access to information on agricultural production to enhance food security among crop farmers is made possible (Stringer, Robert & Pinchbeck, 2019), with fellow farmers, extension agents, radio, family members and friends, community libraries with adequate agricultural sources, visits to organic farms, researchers and Community-based Organizations (CBOs), mobile phones, possible attendance at seminars and regional meetings, audio-visual sources and serving as some of the many sources of agricultural information for farmers (Mapiye, Makombe & Dzama, 2020; Antidius, 2020; Brhane, Mammo & Negusse, 2017; Mbanda-Obura, Tabu & Obura, 2017; Adio, Abu, Yusufu & Nansoh, 2016; Bello and Obinne, 2012, Olajide, 2011; Ukachi, 2007). Shortage of infrastructure, lack of ICT and service fee, lack of interest and inadequate users' skill and knowledge among many others have been pointed as the challenges limiting farmers' access to the required agricultural information (Brhane, Mammo & Negusse, 2017; Acheampong, Frimpong, Asante, 2017).

Food security which refers to a state where "all people have access to safe, nutritious and affordable food that provides the foundation for active and healthy lives" (Fawole, Ilbasimis &



Ozkan, 2015, p. 5) is the basic necessity of life. However, this basic necessity of life is right now under threat more than ever before due to the outbreak of the COVID-19 pandemic (Schlein, 2020; Ehui, 2020; Community on World Food Security, 2020; United Nations, 2020; Aminou, Guillaume, Patricio & Matty, 2020). Community on World Food Security (2020) and United Nations (2020) reports, for instance, indicate that the impacts of COVID-19 on food supply and demand will directly and indirectly affect all four pillars of food security and nutrition (FSN): availability, access, utilization and stability with severe consequences for health and nutrition. According to the World Food Programme (2020, p. 1) projected that:

The COVID-19 pandemic could almost double the number of people suffering acute hunger, pushing it to more than a quarter of a billion by the end of 2020. The number of people facing acute food insecurity stands to rise to 265 million in 2020, up by 130 million from the 135 million in 2019, as a result of the economic impact of COVID-19.

Access to information which is a critical area in improving knowledge which leads to the improvement in food security is also expected to be affected by the COVID-19 pandemic. However, previous reports that captured the impact of the COVID-19 on food security were not definite on how the pandemic affects crop farmers' access to agricultural information and the way it affects the production of food crops for enhanced food security in Nigeria. It is the intention of this empirical paper to therefore bridge this research gap.

### **Statement of the Problem**

The outbreak of the COVID-19 pandemic has posed a serious threat to food security globally and Nigeria is not an exception in the share of the impact. There are already reports that acknowledged the direct and indirect impacts of the COVID-19 on all four pillars of food security and nutrition (FSN), which are: availability, access, utilization and stability with severe consequences for health and nutrition (Schlein, 2020; Ehui, 2020; Community on World Food Security, 2020; United Nations, 2020; Aminou, Guillaume, Patricio & Matty, 2020). However, from these reports, it seems to be a gap on how COVID-19 impacts food security with regards to crop farmers' access to agricultural information in Nigeria. How crop farmers access agricultural information and the value of such accessibility on improved knowledge for enhanced food security in the COVID-19 pandemic era in Nigeria is therefore, the problem this study investigates.

### **Objectives of the Study**

The overall objective of this study is to appraise the way crop farmers access agricultural information for enhanced food security in the COVID-19 era in Nigeria. The specific objectives of this study, therefore, are:

- i. To find out the kinds of agricultural information crop farmers access for enhanced food security in the COVID-19 era in Nigeria.
- ii. To examine the kinds of crops farmers access information on for enhanced food security in the COVID-19 era in Nigeria.



- iii. To ascertain the sources through which crop farmers access agricultural information from for enhanced food security in the COVID-19 era in Nigeria.
- iv. To determine the source of agricultural information more credible for crop farmers in the era of COVID-19 in Nigeria.
- v. To investigate the extent to which crop farmers are satisfied with the agricultural information accessible to them for enhanced food security in the COVID-19 era in Nigeria.
- vi. To explore how the agricultural information accessed is used by farmers to improve crops production for enhanced food security in the COVID-19 era in Nigeria.

### **Research Questions**

- i. What kinds of agricultural information do the crop farmers access for enhanced food security in the COVID-19 era in Nigeria?
- ii. What kinds of food crops do the crop farmers seek to access information for enhanced food security in the COVID-19 era in Nigeria?
- iii. What sources do the crop farmers access agricultural information from for enhanced food security in the COVID-19 era in Nigeria?
- iv. Which of the sources of agricultural information is more credible for crop farmers in the era of COVID-19 in Nigeria?
- v. To what extent do the crop farmers satisfy with the kinds of agricultural information accessible to them for enhanced food security in the COVID-19 era in Nigeria?
- vi. How do crop farmers utilize the agricultural information accessed to improve crops production for enhanced food security in the COVID-19 era in Nigeria?

### **LITERATURE REVIEW**

Food security which is a state where “all people have access to safe, nutritious and affordable food that provides the foundation for active and healthy lives” (Fawole, Ilbasimis & Ozkan, 2015, p. 5) is the basic necessity of life. However, the food sector now is under threat more than ever before due to the outbreak of the COVID-19 pandemic (Schlein, 2020; Ehui, 2020; Community on World Food Security, 2020; United Nations, 2020; Aminou, Guillaume, Patricio & Matty, 2020). Community on World Food Security (2020) and United Nations (2020) reports, for instance, indicate that the impacts of COVID-19 on food supply and demand will directly and indirectly affect all four pillars of food security and nutrition (FSN): availability, access, utilization and stability with severe consequences for health and nutrition. According to UN (2020) report:

The COVID-19 crisis threatens the food security and nutrition of millions of people, many of whom were already suffering. ... The control and mitigation measures enforced worldwide, combined with the massive economic impacts of these necessary measures, are the proximate causes of this emergency. Conflict, natural disaster, and the arrival of pests and plagues on a transcontinental scale all preceded COVID-19 and serve as additional stresses in many contexts. But there are also deep structural problems in the way our food systems function, which we can no longer ignore.

The fact from the above excerpt is that the outbreak of the COVID-19 pandemic has posed a serious challenge in the food sector and much needed to be done to avert the severe ominous food crisis globally. Massive improvement in the production of agricultural food crops is a sure way of averting the impending crisis in the food sector and this cannot be done without farmers' access to information as Kursat, Huseyin, Vedat, Savas & Osman (2008, p. 2) affirmed:

Agricultural information interacts with and influences agricultural productivity in a variety of ways. It can help inform decisions regarding land, labour, livestock, capital and management. Agricultural productivity can arguably be improved by relevant, reliable and useful information and knowledge.

Information brings about knowledge, and a knowledgeable community is also an informed community. This signifies that a community cannot develop without knowledge, and a community can only become knowledgeable if they recognize and use information as their tool for development (Omotayo, 2018; Kamba, 2009; Mchombu, 2006, Singh & Satija, 2006), as "appropriateness of information is a critical factor needed to stimulate the right knowledge and attitude of farmers towards sustainable transformation of agriculture" (Odoemelam and Alocha, 2015, p 98). Access to the right information by rural farmers can help them to acquire the skills, knowledge and confidence sufficient enough to participate fully in agricultural activities (Moore, 2007; Odini, 2005). Limited access to agricultural information is one of the key factors that have narrowed agricultural development in the developing countries. Failure of agricultural service providers to meet the information needs of farmers in relation to agricultural inputs, agricultural technology, extension education, agricultural credit and agricultural marketing in the recent past has been established (Abdu`Rahman, 2018).

Agricultural information accessible to farmers are in different ways, including information on pests and disease control, improved seeds/seedlings, crop and animal husbandry, farm credits, marketing information, fertilizer and agrochemicals, post-harvest technology, control of weeds, modern technology, climate and weather forecast, farm location, food safety and hygiene, among others (Lughlugh, 2020; Olaniyi and Ogunkunle, 2018; Baba, 2018; Abdu`Rahman, 2018; Adetimehin, Okunlola and Owolabi, 2018; Ifejika, 2016; Odoemelam and Olojede, 2016; Idiake-Ochei, Onemolease and Erie, 2016; Oyeniyi and Olofinsawe, 2015; Olajide, 2015; Saingbe and Garba, 2014; Ezech, 2013; Ayubu, Malongo, Siza & Respickius, 2012). Salau, Saingbe and Garba (2014), in their study found that the respondents' information needs were numerous and diverse which included information on pests and disease control, improved seeds/seedlings, crop and animal husbandry, farm credits and marketing information among others. In the study by Lughlugh (2020), the findings were that fertilizer and agrochemicals, pest and diseases control, agricultural finance, improved seedling, post-harvest technology, control of weeds, modern technology application among others were some of the information needs of farmers for sustainable agricultural development in Benue State. Finding in the study conducted by Olaniyi and Ogunkunle (2018) revealed that farmers' agricultural and nutritional information needs included climate and weather forecast, location and availability of inputs, food safety and hygiene, markets where farm produce are exchanged for other farm produce and disease control. Olajide's (2015) study revealed that crop farmers had adequate access to information on land preparation, organic farming, harvesting of crops and adjudged information from the broadcast as appropriate for their enterprise.

The information accessed by farmers is useful in different ways, including improved

farmers' productivity, increased income and proper use of improved varieties crops (Ogunniyi and Ojebuyi, 2020; Lughlugh, 2020; Asa and Uwem, 2017; Odoi, 2017; Adegebo, 2016; Ifejika, 2016; Folitse, Osei, Dzandu & Obeng-Koranteng, 2016; Olajide, 2015; Banya, 2014; Oriakhi and Okoedo-Okojie, 2013). In their study Asa and Uwem (2017) revealed that Getting information from fellow farmers, marketing of produce, accessing inputs for farming, getting agricultural information from radio and the internet, and accessing extension services were the major agricultural uses of mobile phones by farmers in the study area. A study conducted by Folitse, Osei, Dzandu & Obeng-Koranteng (2016) revealed that farmers had gained knowledge in various improved practices as a result of the Royal FM agricultural programme and increase in knowledge has resulted in increased agricultural output and productivity leading to higher sustainable incomes. Olajide's (2015) study revealed that crop farmers utilised information accessed on land preparation, organic farming, harvesting of crops, integrated pest management techniques and site selection for crop production.

Different sources exist for farmers to access agricultural information (Statrasts, 2004; Riesenbergs and Gor, 1999; Adhiguru, BIRTHAL and Kumar, 2009; Ogboma, 2010; Babu, Glendenning, Asenso-Okyere & Govindarajan, 2011; Meitei and Devi, 2009; Mtega and Benard, 2013; Daudu, Chado & Igbashal, 2009; Ogboma, 2010; Similarly, Bozi and Ozcatalbas, 2010; Asa and Uwem, 2017; Ezech, 2013; Ijiekhuamhen and Omosekejimi, 2016; Oluwatoyin, 2016; Suleiman, Ogakason & Faruk, 2018; Umunakwe, Nnadi, Chikaire and Nnadi, 2014; Olaniyi and Ogunkunle, 2018; Yohanna, Ndaghu & Barnabas, 2014; Ogunsola, Ogunsola, Alarape, Oloba and Osalusi, 2019; Pamphily, Harrison and Emily, 2017; Odoemelam and Alocha, 2015; Ha, Okigbo and Igboaka, 2008; Ekoja, 2003; Kleih, Okoboi and Janowski, 2004; Mwakaje, 2010; Kari, 2007; Weiss, Van Crowder and Bernard, 2000; AgREN, 2000; Kalusopa, 2005; Alimi, Olugbenga and Ayoola, 2017; Ifejika, 2016; Uzuegbu and Naga, 2016; Saleh, Burabe, Mustapha and Nuhu, 2018; Odoemelam and Alocha, 2015; Wulystan, 2018; Oriakhi and Okoedo-Okojie, 2013). The selection of an information source depends on a number of factors; including level of income, farm size, age, geographical location, level of education (Riesenbergs and Gor, 1999). Using the Indian NSSO 2003 survey, Adhiguru, BIRTHAL and Kumar (2009) found that small and marginal farmers accessed less information and from fewer sources than medium and large Scale farmers. Ogboma (2010), Babu, Glendenning, Asenso-Okyere & Govindarajan (2011), Meitei and Devi (2009), and Mtega and Benard (2013) have mentioned some information sources used by farmers in accessing their agricultural information including: newspapers, journals, bulletins, community leaders, and farmer groups.

Another study by Daudu, Chado & Igbashal (2009) revealed that farmers used agricultural extensions, posters, televisions, and radios as their source of information. Ogboma (2010) noted the sources of information used by rice farmers were personal experience, workshops and Seminars, training, friends and neighbours, Ministry of agriculture, magazines of agriculture, extension officers, local Government officers, non-Government organization, libraries of agriculture and posters. Bozi and Ozcatalbas (2010) and Yohanna, Ndaghu & Barnabas (2014) in their separate study revealed that family members, neighbour farmers, extension services, input providers and mass media were key sources of information for Turkish farmers. According to the study conducted by Asa and Uwem (2017), majority of the respondents (98.7%) had access to mobile phones in the study area and majority of them (90.5%) actually owned mobile phones. Meanwhile, Kursat, Huseyin, Vedat, Savas & Osman (2008, in their study concluded that lack of information support from the institutional sources resulted in the development of personal information sources to exchange information and diffuse

technology among the farmers themselves.

The challenges in accessing agricultural information by farmers have been revealed in previous studies (Tologbonse, Fashola & Obadiah, 2008; Adegebo, 2016; Ogar, Dika and Atanda, 2018; Ifejika, 2016; Toluwase and Apata, 2017; Byamugisha, Ikoja-Odongo, Nasinyama & Lwasa, 2008; Aina, 2004; Owolade and Kayode, 2012; Babu, Glendenning, Asenso-Okyere & Govindarajan, 2011; Mtega and Benard, 2013, Mbagwu, Benson and Onuoha, 2018; Awili, White and Kimotho, 2016; Thuo, 2018; Abdul-Aziz and Baba, 2017; Oladimeji, 2006). Tologbonse, Fashola & Obadiah (2008), in their study revealed that the challenges facing farmers in accessing agricultural information were outdated information, language barrier, lack of awareness on existence of different information sources, lack of funds to acquire information and poor format of information carriers. The study by Daudu (2009) pointed out some of the problems encountered by farmers in Nigeria in accessing agricultural information such as financial problems, inadequacy of facilities/professionals, incomplete or irrelevant information. Adegebo (2016) and Ifejika (2016) in their separate study revealed that irregular visits by extension agents, inadequate knowledge and skill, poor loan access, poor radio transmission signals and network services, and poor electricity supply were some of the constraints hindering their access to agricultural information. Ogar, Dika and Atanda (2018), in their study have identified wild spread of illiteracy, poverty, hunger, and disease, absence of basic infrastructure such as water, roads, schools, electricity and health services as having negative impact on agriculture and rural development.

### **Theoretical Framework**

This study is anchored on the diffusion of innovations theory propounded by B. Ryan and N. Cross (1943); Everett Rogers (1960), showing how information spreads to the users and the way the information transmitted enables the user to become aware of an innovation and embraces it. Bittner (2003) in Anaeto, Onabajo and Osifeso (2008) opines that, in the innovation diffusion process, the media presents information that makes us aware of the existence of an item. From there, the person gets interested, constantly evaluates the item, takes a trial of the item and finally acquires it. This theory is relevant to the current study because it guides us to understanding how access to agricultural information through the relevant and appropriate channels of communication among crop farmers is essential in making them aware of the innovations in agriculture that can enhance the production of food crops sufficient enough to avert the impending food crisis due to the outbreak of the COVID-19 in Nigeria.

### **RESEARCH METHODOLOGY**

Survey research design was adopted and the questionnaire was used as the research instrument for data collection in this study. Survey research was used because it enabled us to access a large amount of the quantitative data from the respondents. The population of the study comprised crop farmers across the six geo-political zones of Nigeria. Registered crop farmers from one state in each of the six geo-political zones of the country formed the population of the study as thus: (i) Oyo- 401384, (ii) Enugu- 288611, (iii) Edo- 227166, (iv) Kaduna- 798640, (v) Bauchi- 639170, and (vi) Plateau- 353719 (National Bureau of Statistics, 2012). Therefore, the population of the study comprised 2, 708, 690 registered crop farmers in Nigeria. The sample size of the study was 1067 which was determined using Qualtrics<sup>XM</sup> online sample size calculator under the confidence level of 95% and 3% error margin (<https://www.qualtrics.com/experience-management/research/determine-sample-size/>). Stratified sampling technique was used to group the country into six zones based on the already existing

stratifications, after which purposive sampling technique was used to select one state from each of the strata. Purposive sampling technique was used because it enabled us to select one state from each geopolitical zone that was agrarian in nature and crop farmers were most affected by the COVID-19 pandemic as at the time of the study. Based on this, the states sampled in the study were (i) Oyo (South West), (ii) Enugu (South East), (iii) Edo (South South), (iv) Kaduna (North West), (v) Bauchi (North East), and (vi) Plateau (North Central). Respondents were sampled proportionate to the population size of each state using the formula thus:

$$\frac{S \times n}{N}$$

Where;

S = Size of State

n = Sample Size

N = Total Population

Bauchi	$\frac{639170}{2708690} \times \frac{1067}{1} = 252$
Kaduna	$\frac{798640}{2708690} \times \frac{1067}{1} = 315$
Plateau	$\frac{353719}{2708690} \times \frac{1067}{1} = 139$
Enugu	$\frac{288611}{2708690} \times \frac{1067}{1} = 114$
Oyo	$\frac{401384}{2708690} \times \frac{1067}{1} = 158$
Edo	$\frac{227166}{2708690} \times \frac{1067}{1} = 89$

Based on the proportionate sampling technique used, 252 respondents were sampled in Bauchi State, 315 in Kaduna, 139 in Plateau, 114 in Enugu State, 158 in Oyo, and 89 respondents in Edo State. The research instrument used in the study was the questionnaire which was administered on the respondents through face-to-face using the research assistants in the area who were trained how to carry out the exercise. Data in this study were collected through primary and secondary sources. Under primary sources, the questionnaire was used for data collection, while journal articles, books, Internet and materials were used as sources of the data under secondary sources of the data collection. The data collected were analysed using a descriptive method. Multivariate Frequency Distribution Tables and SPSS were used as statistical tools for data analysis under descriptive method.

## RESULTS AND DISCUSSION

A total of 1032 representing (96.7%) out of the 1067 copies of the questionnaire administered on the respondents returned in good shape for analysis while 35 copies representing (3.3%) suffered mortality because some copies of the questionnaire were not returned while others were returned

but not suitable to be used for analysis because they were wrongly completed by the respondents. The breakdown of the number of the questionnaire returned and not returned according to the States sampled in the study is as follows: In Bauchi, 244 (97.8%) returned while 8 (3.2%) out of the 252 copies of the questionnaire administered on the respondents suffered mortality; in Kaduna, 306 (97.1%) copies were returned for analysis while 9 (2.9%) out of the 315 copies suffered mortality; in Plateau, 132 (95.0%) copies were returned while 7 (5.0%) suffered mortality; in Enugu, 111 (97.4%) copies returned while 3 (2.6%) suffered mortality; in Oyo, 153 (96.8%) copies returned while 5 (3.3%) suffered mortality; while in Edo State, 86 (96.6%) copies returned while 3 (3.4%) suffered mortality. Therefore, the 1032 representing 96.7% return rate out of the 1067 copies of the questionnaire administered on the respondents is significant enough and therefore formed the basis for analysis in this study while the mortality rate of 35 representing 3.3% is regarded insignificant to affect the data for this study. The analysis of this study is therefore based on the 96.7 percent rate of the questionnaire returned in the study which is 1032.

**Table 1: Kinds of Agricultural Information Crop Farmers Access for Enhanced Food Security in the COVID-19 era in Nigeria**

Variable	No. of Respondents												Total	
	Bauchi		Kaduna		Plateau		Enugu		Oyo		Edo			
Fertilizer application	65	26.6	81	26.5	35	26.5	32	28.8	37	24.2	25	29.1	275	26.6
Agriculture loans	15	6.1	25	8.2	9	6.8	7	6.3	16	10.5	9	10.5	81	7.8
Weed control	35	14.3	44	14.4	19	14.4	17	15.3	21	13.7	13	15.1	149	14.4
Pest control	13	5.3	15	4.9	5	3.8	3	2.7	5	3.3	3	3.5	44	4.3
Seed selection	9	3.7	11	3.6	3	2.3	2	1.8	3	2.0	1	1.2	29	2.8
Agric marketing	21	8.6	23	7.5	13	9.8	12	10.8	15	9.8	5	5.8	89	8.6
Crop rotation practices	7	2.9	9	2.9	2	1.5	1	0.9	5	3.3	2	2.3	26	2.5
Land preparation	10	4.1	12	3.9	4	3.0	6	5.4	11	7.2	4	4.7	47	4.6
Disease control and treatment	15	6.1	17	5.6	6	4.5	4	3.6	6	3.9	3	3.5	51	4.9
Storage methods	21	8.6	31	10.1	13	9.8	9	8.1	14	9.2	9	10.5	97	9.4
Farm irrigation	11	4.5	10	3.3	5	3.8	3	2.7	4	2.6	1	1.2	34	3.3
Planting methods	9	3.7	11	3.6	7	5.3	4	3.6	3	2.0	3	3.5	37	3.6
Farm mechanization	13	5.3	17	5.6	11	8.3	11	9.9	13	8.5	8	9.3	73	7.1
Total	244	100	306	100	132	100	111	100	153	100	86	100	1032	100

**Source: Field Survey, 2020.**

Table one is concerned with the kinds of agricultural information crop farmers have access to for enhanced food security in the COVID-19 pandemic era in Nigeria. Data revealed that 26.6% out of the total number of respondents sampled said fertilizer application was one of agricultural information accessible to them with Edo crop farmers having the highest response rate, 7.8% out of the respondents were of the opinion that information on agricultural loan was accessible to them, 14.4% of the respondents said information on weed control was accessible to them, 4.3% of the respondents were of the opinion that pest control information was accessible to them, 2.8% of the respondents were of the opinion that information on seed selection was accessible to them, 8.6% of the respondents accessed information on agric marketing, 2.5% of the respondents accessed information on crop rotation practices, 4.6% of the respondents accessed information on land preparation, 4.9% of the respondents accessed information on disease control and treatment, 9.4% of the respondents accessed information on storage methods, 3.3% of the respondents accessed information on farm irrigation, 3.6% of the respondents have access to agricultural information on planting methods, while 7.1% of the respondents accessed information on farm mechanization.

The result above implies that crop farmers accessed different kinds of agricultural information in the era of the COVID-19 pandemic but information on fertilizer application was more accessible to them, followed by the one on weed control, while information on loans application, pest control, seed selection, agric marketing, crop rotation, land preparation, disease control and treatment, crop storage methods, farm irrigation, planting methods and farm mechanization were least accessed by them. This finding agrees with previous scholars which pointed out different agricultural information accessible to the respondents (Lughlugh, 2020; Olaniyi and Ogunkunle, 2018; Baba, 2018; Abdu`Rahman, 2018; Ifejika, 2016; Odoemelam and Olojede, 2016; Idiake-Ochei, Onemolease & Erie, 2016; Oyeniyi and Olofinsawe, 2015; Salau, Saingbe and Garba, 2014; Ezech, 2013; Ayubu, Malongo, Siza & Respickius, 2012). Many of these studies indicated that farmers access information in fewer areas than they do in many other areas.

**Table 2: Kinds of Food Crop Farmers Access Information on for Enhanced Food Security in the COVID-19 era in Nigeria**

Variable	No. of Respondents												Total	
	Bauchi		Kaduna		Plateau		Enugu		Oyo		Edo			
Yam	16	6.6	25	8.2	11	8.3	13	11.7	27	17.6	18	20.9	110	10.7
Maize	32	13.1	90	29.4	26	19.7	21	18.9	29	19.0	21	24.4	219	21.2
Rice	34	13.9	21	6.9	22	16.7	14	12.6	19	12.4	15	17.4	125	12.1
Sorghum	27	11.1	28	9.2	5	3.8	2	1.8	2	1.3	1	1.2	65	6.3
Soybean	17	7.0	13	4.2	3	2.3	3	2.7	5	3.3	2	2.3	43	4.2
Potato	19	7.8	11	3.6	21	15.9	4	3.6	9	5.9	1	1.2	65	6.3
Cassava	15	6.1	19	6.2	4	3.0	29	26.1	21	13.7	16	18.6	104	10.1
Wheat	18	7.4	23	7.5	5	3.8	3	2.7	5	3.3	1	1.2	55	5.3
Beans	25	10.2	35	11.4	19	14.4	6	5.4	6	3.9	2	2.3	93	9.0
Guinea corn	14	5.7	19	6.2	6	4.5	5	4.5	7	4.6	1	1.2	52	5.0
Millet	16	6.6	9	2.9	3	2.3	3	2.7	18	11.8	1	1.2	50	4.8
Others	11	4.5	13	4.2	7	5.3	8	7.2	5	3.3	7	8.1	51	4.9
Total	244	100	306	100	132	100	111	100	153	100	86	100	1032	100

**Source: Field Survey, 2020.**

Table two is concerned with the kinds of food crops that farmers access information on in the COVID-19 era in Nigeria. Data revealed that 10.7% of the respondents accessed information on yam crop, 21.2% of the respondents accessed on maize crop, 12.2% of the respondents accessed on rice crop, 6.3% of the respondents accessed on sorghum crop, 4.2% of the respondents accessed information on soybean crop, 6.3% of the respondents accessed information on potato crop, 10.1% of the respondents accessed information on cassava crop, 5.3% of the respondents accessed information on wheat, 9.0% of the respondents accessed information on beans crop, 5.0% of the respondents accessed information on guinea corn crop, 4.8% of the respondents accessed information on millet, while 4.9% accessed information on other crops not mentioned here.

It implies therefore that information on maize crop was more accessible to crop farmers follow by rice, yam and cassava, while information on sorghum, soybean, potato, wheat, beans, guinea corn and millet were least accessible to crop farmers in the COVID-19 pandemic era in Nigeria. A study conducted by Adetimehin, Okunlola and Owolabi (2018) revealed that farmers in the study area have a variety of information on rice production including information on pests and diseases management practices, mechanical land preparation and planting, use of farm machines, improved storage methods and agricultural credit/loan. Olajide's (2015) study which was on food crops generally revealed that crop farmers had adequate access to information on land preparation, organic farming and harvesting of crops.

**Table 3: Sources Crop Farmers access Agricultural Information from for Enhanced Food Security in the COVID-19 era in Nigeria**

Variable	No. of Respondents												Total	
	Bauchi		Kaduna		Plateau		Enugu		Oyo		Edo			
Radio	30	12.3	41	13.4	16	12.1	14	12.6	19	12.4	11	12.8	131	12.7
Television	11	4.5	17	5.6	6	4.5	3	2.7	7	4.6	5	5.8	49	4.7
Newspaper	7	2.9	11	3.6	4	3.0	2	1.8	3	2.0	4	4.7	31	3.0
Magazine	3	1.2	6	2.0	2	1.5	1	0.9	2	1.3	1	1.2	15	1.5
Mobile phones	33	13.5	43	14.1	18	13.6	16	14.4	22	14.4	13	15.1	145	14.1
Social media platforms	21	8.6	23	7.5	11	8.3	7	6.3	9	5.9	5	5.8	76	7.4
Posters	6	2.5	9	2.9	3	2.3	1	0.9	2	1.3	2	2.3	23	2.2
Agriculture Extension Officers	4	1.6	7	2.3	2	1.5	1	0.9	3	2.0	1	1.2	18	1.7
Family members	52	21.3	59	19.3	29	22.0	29	26.1	39	25.5	18	20.9	226	21.9
Fellow farmers	41	16.8	47	15.4	22	16.7	21	18.9	28	18.3	16	18.6	175	17.0
Village leaders	13	5.3	14	4.6	5	3.8	3	2.7	4	2.6	2	2.3	41	4.0
Farmers' clubs/Associations	3	1.2	5	1.6	2	1.5	1	0.9	2	1.3	1	1.2	14	1.4
Churches/Mosques	19	7.8	21	6.9	11	8.3	9	8.1	11	7.2	5	5.8	76	7.4
Community libraries	1	0.4	3	1.0	1	0.8	3	2.7	2	1.3	2	2.3	12	1.2
<b>Total</b>	<b>244</b>	<b>100</b>	<b>306</b>	<b>100</b>	<b>132</b>	<b>100</b>	<b>111</b>	<b>100</b>	<b>153</b>	<b>100</b>	<b>86</b>	<b>100</b>	<b>1032</b>	<b>100</b>



**Source: Field Survey, 2020.**

Table three is concerned with how crop farmers access their information for enhanced food security in the COVID-19 era in Nigeria. Data available revealed that 12.7% of the respondents accessed agricultural information through the radio, 4.7% of the respondents accessed through television, 3.0% of the respondents accessed through the newspaper, 1.5% of the respondents accessed through the magazine, 14.1% of the respondents said they access agricultural information through their mobile phones, 7.4% of the respondents accessed their agricultural information to enhance food security through the social media, 2.2% of the respondents accessed agricultural information through posters, 1.7% of the respondents accessed their agricultural information through agriculture extension officers, 21.9% of the respondents accessed agricultural information through family members, 17.0% of the respondents accessed through follow farmers, 4.0% of the respondents accessed agricultural information through village leaders, 1.4% of the respondents accessed through farmers' clubs/associations, 7.4% of the respondents accessed through Churches/Mosques, while 1.2% of the respondents accessed through community libraries.

It means therefore that crop farmers access the agricultural information through different sources but the most accessible sources to them was family members followed by fellow farmers and mobile phones, while the radio, television, newspaper, magazine, mobile phones, social media platforms, posters, agriculture extension officers, village leaders, farmers' clubs/associations, Churches/Mosques, and community libraries the least accessible sources of agricultural information to crop farmers for enhanced food security in the era of COVID-19 in Nigeria. This finding is in tandem with the findings from different previous studies which revealed that farmers obtain agricultural information through different sources even though some sources are more accessible to farmers than others (Kursat, Huseyin, Vedat, Savas & Osman, 2008; Bozi and Ozcatalbas, 2010; Yohanna, Ndaghu & Barnabas, 2014; Ogunsola, Ogunsola, Alarape, Oloba & Osalusi (2019); Olaniyi and Ogunkunle (2018); Ha, Okigbo and Igboaka, 2008; Ekoja, 2003; Pamphily, Harrison and Emily, 2017; Odoemelam and Alocha, 2015; Kursat, Huseyin, Vedat, Savas & Osman, 2008). Kursat, Huseyin, Vedat, Savas & Osman (2008) in their study, for instance, concluded that lack of information support from the institutional sources resulted in the development of personal information sources to exchange information and diffuse technology among the farmers themselves.

**Table 4: Source of Agricultural Information more Credible for Crop Farmers in the Era of COVID-19 in Nigeria**

Variable	No. of Respondents												Total	
	Bauchi		Kaduna		Plateau		Enugu		Oyo	Edo				
Radio	45	18.4	63	20.6	29	22.0	29	26.1	37	24.2	18	20.9	<b>221</b>	<b>21.4</b>
Television	33	13.5	35	11.4	18	13.6	16	14.4	19	12.4	14	16.3	<b>135</b>	<b>13.1</b>
Newspaper	12	4.9	15	4.9	5	3.8	3	2.7	5	3.3	4	4.7	<b>44</b>	<b>4.3</b>
Magazine	9	3.7	5	1.6	2	1.5	1	0.9	3	2.0	2	2.3	<b>22</b>	<b>2.1</b>
Mobile phones	19	7.8	23	7.5	9	6.8	7	6.3	8	5.2	6	7.0	<b>72</b>	<b>7.0</b>
Social media platforms	7	2.9	11	3.6	7	5.3	5	4.5	7	4.6	4	4.7	<b>41</b>	<b>4.0</b>

Posters	5	2.0	7	2.3	3	2.3	1	0.9	3	2.0	1	1.2	<b>20</b>	<b>1.9</b>
Agriculture														
Extension Officers	35	14.3	47	15.4	24	18.2	24	21.6	30	19.6	16	18.6	<b>176</b>	<b>17.1</b>
Family members	23	9.4	26	8.5	9	6.8	6	5.4	8	5.2	5	5.8	<b>77</b>	<b>7.5</b>
Fellow farmers	11	4.5	17	5.6	5	3.8	3	2.7	5	3.3	3	3.5	<b>44</b>	<b>4.3</b>
Village leaders	15	6.1	18	5.9	7	5.3	5	4.5	6	3.9	4	4.7	<b>55</b>	<b>5.3</b>
Farmers'														
clubs/Associations	9	3.7	13	4.2	4	3.0	2	1.8	3	2.0	1	1.2	<b>32</b>	<b>3.1</b>
Churches/Mosques	19	7.8	23	7.5	9	6.8	8	7.2	16	10.5	7	8.1	<b>82</b>	<b>7.9</b>
Community														
libraries	2	0.8	3	1.0	1	0.8	1	0.9	3	2.0	1	1.2	<b>11</b>	<b>1.1</b>
<b>Total</b>	<b>244</b>	<b>100</b>	<b>306</b>	<b>100</b>	<b>132</b>	<b>100</b>	<b>111</b>	<b>100</b>	<b>153</b>	<b>100</b>	<b>86</b>	<b>100</b>	<b>1032</b>	<b>100</b>

**Source: Field Survey, 2020.**

Table four is concerned with the sources of agricultural information more credible for enhanced food security crop farmers in the COVID-19 era in Nigeria. Data revealed that 21.4% respondents said radio was more credible among the sources of agricultural information accessible to them, 13.1% respondents said television was more credible among the sources of agricultural information accessible to them, 2.1% of the respondents were of the opinion that magazine was more credible among the sources of agricultural information accessible to them, 7.0% of the respondents said more phones were more credible as sources of agricultural information to enhance food security, 4.0% of the respondents were of the opinion that social media platforms were more credible to them, 1.9% of the respondents said poster was more credible, 17.1% of the respondents said agriculture extension officers were sources more credible among the accessible sources, 7.5% of the respondents said family members were the sources more credible for them, 4.3% of the respondents were of the opinion that fellow farmers were the sources more credible for them, 5.3% of the respondents said village leaders were more credible as sources of agricultural information to enhance food security for them, 3.1% of the respondents said farmers' club/associations were the sources more credible for them, 7.9% of the respondents said Churches/Mosques were the sources more credible for them, while 1.1% of the respondents said community libraries was more credible for them to be used to enhance food security in the COVID-19 era in Nigeria.

This implies that crop farmers have various credible sources of agricultural information to enhance food security in the COVID-19 era in Nigeria, but radio is more credible for them followed by agriculture extension officers and television. This finding agrees with the one by Olajide (2015) which revealed that crop farmers had adequate access to information and adjudged information from the broadcast media as appropriate for crop production more than other sources. Oriakhi and Okoedo-Okojie (2013) revealed in their study that crop farmers preferred radio as the most used channel of agricultural information to other sources.

**Table 5: The Extent Cop Farmers are satisfied with the Kinds of Agricultural Information Accessible to them for enhanced Food Security in the COVID-19 era in Nigeria**

Variable	No. of Respondents												Total	
	Bauchi		Kaduna		Plateau		Enugu		Oyo		Edo			
To a great Extent	41	16.8	54	17.6	21	15.9	16	14.4	25	16.3	13	15.1	170	16.5
To a little extent	195	79.9	241	78.8	108	81.8	91	82.0	121	79.1	71	82.6	827	80.1
Difficult to say	8	3.3	11	3.6	3	2.3	4	3.6	7	4.6	2	2.3	35	3.4
Total	244	100	306	100	132	100	111	100	153	100	86	100	1032	100

**Source: Field Survey, 2020.**

Table five is on the extent to which crop farmers are satisfied with the kinds of agricultural information accessible to them to enhance food security in the COVID-19 era in Nigeria. Data revealed that 16.1% out of the respondents sampled in the study said they were satisfied with the extent to which agricultural information was accessible to them to a great extent, 80.1% of them were satisfied to a little extent, while 3.4% of them found it difficult to comment. It implies therefore that farmers have access to agricultural information but to a little extent. This finding reminds us about the observation by Moore (2007) and Odini (2005) that access to the right information by farmers can help them to acquire the skills, knowledge and confidence to participate fully in agricultural affairs, and according to Abdu`Rahman (2018), limited access to agricultural information is one of the key factors that have narrowed agricultural development in the developing countries.

**Table 6: Ways Crop Farmers make use of the Agricultural Information to Improve Crops Production and enhance Food Security in the COVID-19 era in Nigeria**

Variable	No. of Respondents												Total	
	Bauchi		Kaduna		Plateau		Enugu		Oyo		Edo			
Involve in timely fertilizer application	43	17.6	67	21.9	31	23.5	29	26.1	41	26.8	27	31.4	238	23.1
Apply for agricultural loans	15	6.1	17	5.6	11	8.3	11	9.9	13	8.5	9	10.5	76	7.4
Engage in early weed control	31	12.7	38	12.4	16	12.1	15	13.5	27	17.6	13	15.1	140	13.6
Engage in early pest control	17	7.0	19	6.2	7	5.3	5	4.5	8	5.2	5	5.8	61	5.9
Select appropriate seeds	19	7.8	21	6.9	8	6.1	6	5.4	5	3.3	3	3.5	62	6.0
Involve in agric marketing	23	9.4	25	8.2	11	8.3	7	6.3	6	3.9	4	4.7	76	7.4
Involve in the practice of crop rotation	13	5.3	15	4.9	5	3.8	3	2.7	5	3.3	2	2.3	43	4.2

Engage in early land preparation	16	6.6	18	5.9	8	6.1	5	4.5	6	3.9	1	1.2	54	5.2
Engage in early disease control and treatment	9	3.7	13	4.2	5	3.8	3	2.7	4	2.6	4	4.7	38	3.7
Involve in crop storage	21	8.6	24	7.8	10	7.6	14	12.6	21	13.7	8	9.3	98	9.5
Engage in farm irrigation	9	3.7	11	3.6	6	4.5	4	3.6	5	3.3	3	3.5	38	3.7
Engage in early planting	17	7.0	25	8.2	9	6.8	6	5.4	7	4.6	4	4.7	68	6.6
Involve in farm mechanization	11	4.5	13	4.2	5	3.8	3	2.7	5	3.3	3	3.5	40	3.9
<b>Total</b>	<b>244</b>	<b>100</b>	<b>306</b>	<b>100</b>	<b>132</b>	<b>100</b>	<b>111</b>	<b>100</b>	<b>153</b>	<b>100</b>	<b>86</b>	<b>100</b>	<b>1032</b>	<b>100</b>

**Source: Field Survey, 2020.**

Table six which is about the ways crop farmers utilize the agricultural information they accessed to improve crop production for enhanced food security in the COVID-19 era in Nigeria revealed that 23.1% of the respondents have made use of the agricultural information they accessible to involve in timely fertilizer application, 7.4% of them made use of the information accessible to apply for agricultural loans, 13.6% of the respondents have made use of the information accessible to engage in early control of weeds, 5.9% of the respondents have made use of the information accessible to engage in early pest control, 6.0% of the respondents made use of the information to select appropriate seeds, 7.4% of the respondents made use of the information to involve in agric marketing, 4.2% of them made use of the information to engage in the practice of crop rotation, 5.2% of the respondents made use of the information to engage in early land preparation, 3.7% of the respondents engaged in early disease control and treatment, 9.5% of the respondents engaged in crop storage, 3.7% of them engaged in farm irrigation, 6.6% of the respondents engaged in early planting, while 3.9% of them engaged in farm mechanization due to the information accessible to them.

This implies that agricultural information accessible to crop farmers is used in different ways to enhance food security in the COVID-19 era but most particularly in the area of timely fertilizer application and early control of weeds. However, there is still low usage of agricultural information by crop farmers in areas such as the loans application, pest control, seed selection, agric marketing, crop rotation practices, land preparation, disease control and treatment, crop storage, farm irrigation, planting, and farm mechanization. This finding agrees with the diffusion of innovations theory which reveals how information spreads to the users and the way the information transmitted enables the user to become aware of an innovation and embraces it (Ryan and Cross, 1943; Rogers, 1960 in Anaeto, Onabajo and Osifeso, 2008). Bittner (2003) in Anaeto, Onabajo and Osifeso (2008) hold that, in the innovation diffusion process, the media presents information that makes us aware of the existence of an item. From there, the person gets interested, constantly evaluates the item, takes a trial of the item and finally acquires it, which in this case is the agricultural information among crop farmers.

## CONCLUSION

Information on fertilizer application was more accessible to crop farmers followed by weed control, while information on loans application, pest control, seed selection, agric marketing, crop rotation, land preparation, disease control and treatment, crop storage methods, farm irrigation, planting methods and farm mechanization were less accessible by them for enhanced food security in the era of COVID-19 in Nigeria. The crops these farmers accessed information on more predominantly were maize, followed by rice, yam and cassava, while information on sorghum, soybean, potato, wheat, beans, guinea corn and millet was least accessed by them for enhanced food security in the COVID-19 era in Nigeria.

The different kinds of information crop farmers accessed on different crops were predominantly through family members followed by fellow farmers and mobile phones, while the radio, television, newspaper, magazine, mobile phones, social media platforms, posters, agriculture extension officers, village leaders, farmers' clubs/associations, Churches/Mosques, and community libraries were the least accessible sources of agricultural information to crop farmers for enhanced food security in the era of COVID-19 in Nigeria. However, radio was adjudged the most credible source of agricultural information followed by agriculture extension officers and television among the sources for enhanced food security in the era.

Crop farmers were satisfied with the agricultural information accessible to them but that satisfaction was to a little extent. The information accessible to crop farmers enabled them to engage in timely fertilizer application and early control of weeds more while their involvement in loans application, pest control, seed selection, agric marketing, crop rotation practices, land preparation, disease control and treatment, crop storage, farm irrigation, planting, and farm mechanization was low.

Further, access to adequate and useful agricultural information by crop farmers is essential for enhanced food production as inadequate access to such information will result to poor application of agricultural innovations capable of preventing a society from attaining food sufficiency and security level.

## RECOMMENDATIONS

- i. Crop farmers in Nigeria should increase their level of access to agricultural information through prioritizing every information beneficial for improving the production of agriculture, if the goal of overcoming the threat to food security due to the COVID-19 in the country is to be overcome.
- ii. Sources of agricultural information adjudged more credible and professional agricultural by crop farmers such as the radio and agriculture extension officers should be made more available for them to access for more in depth knowledge about the innovations in agriculture for more adoption for enhanced food security in the COVID-19 pandemic.
- iii. Farmers should be trained through workshops and seminars (though with strict adherence to COVID-19 guidelines) to enhance their capacity to be a more credible source of information for others to enhance food security in the COVID-19 era in Nigeria.

## REFERENCES

- Abdu`Rahman, B. S. (2018). Review on the Information Needs and Sources of Information for Agricultural Development in Developing Countries. *International Journal of Innovative Research and Development*, 7(12), 73-79, also available at [www.ijird.com](http://www.ijird.com).
- Abdul-Aziz, H. and Baba, D. (2017). An Appraisal of Farmers Internet Use for Sourcing Agricultural Information in NorthWestern Nigeria. *SHS Web of Conferences* 33. Retrieved on June 19, 2020 from <http://creativecommons.org/licenses/by/4.0/>.
- Acheampong, D. L., Frimpong, N. B. Asante, D. M. (2017). Assessing the information seeking behaviour and utilization of rice farmers in the Ejisu-Juaben municipality of Ashanti Region of Ghana. *Business*, DOI:[10.1186/s40066-017-0114-8](https://doi.org/10.1186/s40066-017-0114-8)
- Adegboye, G. A., Oyinbo, O., Owolabi, J. O. & Hassan, O. S. (2013). Analysis of the Sources and Effect of Extension Information on Output of Women Maize Farmers in Soba Local Government Area of Kaduna State, Nigeria. *European Scientific Journal*, 9(9), 210-217.
- Adegebo, A. A. (2016). Knowledge, Attitude and Use of Agricultural Information as Predictors of Increased Productivity among Small Scale Farmers in Southwestern, Nigeria. A Thesis in the Department of Adult Education in fulfillment of the requirements for the Degree of Doctor of Philosophy of the University of Ibadan.
- Adetimehin, D. O., Okunlola, O. J. and Owolabi, E. K. (2018). Utilization of Agricultural Information and Knowledge for Improved Production by Rice Farmers in Ondo State, Nigeria. *Journal of Rural Social Sciences*, 33(1), 76-100.
- Adhiguru, P., Birthal, P. S. & Kumar, B. G. (2009). Strengthen pluralistic agricultural information delivery systems in India, *Agricultural Economics Research Reviews*, 22,71-79. Available at <http://ageconsearch.umn.edu/bitstream/57382/2/5-PAdhiguru.pdf>.
- Adio, E.O; Abu, Y; Yusufu, S. K. and Nansoh, S. (2016). Use of Agricultural Information Sources and Services by Farmers for Improve Productivity in Kwara State. *Library Philosophy and Practice* (e-journal). 1456. Retrieved on June 18, 2020 from <http://digitalcommons.unl.edu/libphilprac/1456>.
- Adomi, E.E., Ogbomo, M. O. and Inoni, M.O. (2003), Gender factor in crop farmers' access to agricultural information in rural areas of Delta State, Nigeria. *Library Review*, 52(8), 388-393.
- AgREN (2000). Agricultural Knowledge and Information Systems in Kenya-implications for technology dissemination and development. *ODI, Agricultural Research and Extension Network Paper Number* 107, 20 Pages.
- Ahmed, M. (2018). Accessibility and Utilization of Agricultural Information: The Role of Communication Media in the Delivery of Information to Farmers in Nigeria. *Information and Knowledge Management*, 8(10). Available at [www.iiste.org](http://www.iiste.org).
- Aina, L. O. (2004). Towards improving information access by semi and non literate groups in Africa: A need for empirical studies of their information seeking and retrieval patterns. In T. J. D. Bothma and A. Kaniki (eds). *ProLISSA 2004: Proceedings of the 3rd Biennial DISSAnet Conference*. Pretoria: Infuse, pp. 11–20.
- Alemna, A. A. and Skouby K. E. (2000). An investigation into the Information Needs and Information- seeking behaviour of members of Ghana's legislature. *Library Management*, 21(5), 235-240.

- Alimi, F. L., Olugbenga, O. A. and Ayoola, O. O. (2017). Elements of Rural Economics: Access to Agricultural Information among Rural Women Farmers in Abuja, Nigeria. *The Journal of Agricultural Sciences*, 12(2), 63-75.
- Alunas, M. M. (2014). Assessment of the factors impacting agricultural extension training programs in Tanzania: A descriptive study. A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the degree of Master of Science, Iowa State University.
- Aminou, A., Guillaume, S., Patricio, M. and Matty, D. (2020). Policy options for mitigating impacts of COVID-19 on domestic rice value chains and food security in West Africa. *Global Food Security*, 26, <https://doi.org/10.1016/j.gfs.2020.100405>.
- Anaeto, G. S., Onabajo, O. S., Osifeso, B. J. (2008). *Models and Theories of Communication*. Maryland: African Renaissance Books Incorporated.
- Anju, D. and Satbir, S. (2017). Sources of Agricultural Information Accessed by Farmers in Haryana, India. *International Journal of Current Microbiology and Applied Sciences*, 6(12), 1559-1565.
- Antidius, F. (2020). Information needs and sources on food and nutrition security among farmers in Chamwino District, Tanzania. *University of Dar es Salaam Library journal*. Retrieved on August 5, 2020 from <https://www.semanticscholar.org/paper/Information-needs-and-sources-on-food-and-nutrition-Fidelis/62b77a37b13f6538d34ad4e451af06b32b85e08b>
- Anunobi, V. C., Ogbonna, A. U. & Osuchukwu, N. P. (2014). Information Needs of Rural Dwellers as a Measure of the Effectiveness of Library and Information Services Provision in Anambra State, Nigeria. *Journal of Applied Information Science and Technology*, 7(1), 35-45.
- Asa, U. A. and Uwem, C. A. (2017). Utilization of Mobile Phones for Agricultural Purposes by Farmers in Itu Area, Nigeria. *European Scientific Journal*, 13(19), 395-402.
- Awili, A. M., White, P. and Kimotho, S. (2016). Factors That Influence Effective Communication of Agricultural Information among Farmers-The Case of Farmers in South West Kisumu Ward, Kisumu County. *Journal of Developing Country Studies*, 1(1), 1-20.
- Ayalew. A. W. (2017). The Effectiveness of Farmers Research Group Approach in Potato Technology Dissemination and Adoption Case Study of Western Part of Ethiopia. *The Journal of Agricultural Extension*, retrieved on August 5, 2020 from <https://www.semanticscholar.org/paper/THE-EFFECTIVENESS-OF-FARMERS-RESEARCH-GROUP-IN-AND-Worku/5925b20490940c2e04475d624ce55cef153d1804>
- Ayubu, J. C., Malongo, R. S. M., Siza, D. T. & Respickius, C. (2012). Understanding Farmers Information Communication Strategies for Managing Climate Risks in Rural Semi-Arid Areas, Tanzania. *International Journal of Information and Communication Technology Research*, 2(11), 838-845.
- Baba, S. A. (2018). Farmers' use of Global System for Mobile for Communication in the Fadama III Project in the Northern Senatorial Zone of Taraba State, Nigeria. *International Journal of Agriculture Innovations and Research*, 7(2), 144-149.
- Babu, C. S., Glendenning, J. C., Kumar, S. & Govindarajan, T. (2012). Farmers' information needs and search behaviors: Case study in Tamil Nadu, India. *Agriculture & Food Security*, DOI:[10.22004/AG.ECON.126226](https://doi.org/10.22004/AG.ECON.126226)

- Babu, S. C., Glendenning, C. J., Asenso-Okyere, K. & Govindarajan, S. K. (2011). Farmers' Information Needs and Search Behaviors: Case Study in Tamil Nadu, India, Report for International Food Policy Research Institute, Washington, DC.
- Balkrishna, B. B. and Deshmukh, A. A. (2017). A Study on Role of Social Media in Agriculture Marketing and its Scope. *Global Journal of Management and Business Research: E Marketing*, 7(1), 32-36.
- Bankapur, V. M. and Bhavanishankar, N. B. (2018). Information Needs and Seeking Behaviour of Farmers in Bhutaramanahatti Village of Belagavi District in Karnataka State: A Study. *Journal of Emerging Technologies and Innovative Research (JETIR)*, 5(7), 174-1477, also available at [www.jetir.org](http://www.jetir.org).
- Banmeke, T. O. A. and Ajayi, M. T. (2008). Farmers' Perception of the Agricultural Information Resource Centre at Ago-Are, Oyo State, Nigeria. *International Journal of Agricultural Economics & Rural Development*, 1(1), 22-29.
- Banya, M. S. (2014). Dissemination of Agricultural Information to Rural Farmers: A Case Study of the Sustainable Land and Water Management Project in West Mamprusi. Dissertation in the University of Ghana, Legon for the Award of M. A. Communication Studies Degree. Retrieved June 19, 2020 from <http://ugspace.ug.edu.gh>.
- Bello, M. and Obinne, C. P. O. (2012). Problems and Prospects of Agricultural Information Sources Utilization by Small Scale Farmers: A Case from Nasarawa State of Nigeria. *Journal of Communication*, 3(2), 91-98.
- Bozi, I. and Ozcatalbas, O. (2010). Determining information sources used by crop producers: A case study of Gaziantep province in Turkey. *African Journal of Agricultural Research*, 5(10), 980-987.
- Brhane, G., Mammo, Y. and Negusse, G. (2017). Sources of information and information seeking behavior of smallholder farmers of Tanqa Abergelle Wereda, central zone of Tigray, Ethiopia. *Journal of Agricultural Extension and Rural Development*, DOI:10.5897/JAERD2016.0850.
- Byamugisha, H. M., Ikoja-Odongo, R., Nasinyama, G. W. & Lwasa, S. (2008). Information seeking and use among urban farmers in Kampala district, Uganda. Agricultural information and IT proceedings of IAALD AFITA, 24 to 27 August 2008, Tokyo University, Japan.
- CGIAR (2020). Reducing COVID-19 Impact on Agriculture: Nigerian farmers to receive improved seeds. Retrieved on July 26, 2020 from : <https://reliefweb.int/report/nigeria/reducing-covid-19-impact-agriculture-nigerian-farmers-receive-improved-seeds>.
- Charles, L. (2015). Effectiveness of Information Communication Technologies in Dissemination of Agricultural Information to Smallholder Farmers in Kilosa District, Tanzania. Thesis Submitted to the Directorate of Research and Graduate Training in Partial Fulfillment of the Requirements for the Award of a Master of Science in Agricultural Extension Education of Makerere University, Tanzania.
- Chen, Z., Liu, C. & Yang, D. (2011). Information Poverty and Farmers' Information Right in China's Mountainous Rural Areas. *Procedia Engineering*. Retrieved on June 18, 2020, from [www.sciencedirect.com/science/article/pii/S1877705811017371](http://www.sciencedirect.com/science/article/pii/S1877705811017371).
- Cheunwattana, A. (1998). Information for rural development: A multiple-case study of library and information services to the rural communities in Thailand. Unpublished Doctoral Thesis, Indiana University, Indiana.



- Community on World Food Security (2020) Impact of COVID-19 on Food Security and Nutrition (FSN), 1(24), Interim Issues Paper. Retrieved on August 11, 2020 from [www.fao.org/cfs/cfs-hlpe](http://www.fao.org/cfs/cfs-hlpe).
- Correa, A. F. (1995). Training of information providers for the rural context. In E. Johansson (ed) *Seminar on information provision to rural communities in Africa* (92–97). Sweden: Uppasala University Library.
- Daudu, S. Chado, S.S. and Igbashal, A. A. (2009). Agricultural information sources utilized by farmers in Benue state, Nigeria. *Agriculture and Technology*, 5(1), 39-48. Available at <http://patnsukjournal.net/Vol5No1/p5.pdf>.
- Demet, S., Nilay, C., Marco, S., and Tunç, M. (2016). A Comparative Study of Information-Seeking Behavior and Digital Information Needs of Farmers in Turkey and Sweden. *International Journal of eBusiness and eGovernment Studies*, 8(2), 18-33.
- Diemer, N., Atuhaire, A., Fuhrimann, S. & Inauen, J. (2020). Smallholder farmers' information behavior differs for organic versus conventional pest management strategies: A qualitative study in Uganda. *Journal of Cleaner Production*, 257(1). Retrieved on August 1, 2020 from <https://doi.org/10.1016/j.jclepro.2020.120465>
- Ehui, S. (2020). Protecting food security in Africa during COVID-19. Retrieved on August 11, 2020 from <https://www.brookings.edu/blog/africa-in-focus/2020/05/14/protecting-food-security-in-africa-during-covid-19/>
- Ekoja, I. (2003). Farmer's access to agricultural information in Nigeria. *Bulletin of the American Society for Information Science and Technology*, 29(6), 21-23.
- Ezeh, N. A. (2013). Access and application of information and communication technology (ICT) among farming households of south east Nigeria. *Agriculture and Biology Journal of North America*, 4(6), 605-616. Available Online: 2151-7525, doi:10.5251/abjna.2013.4.6.605.616, <http://www.scihub.org/ABJNA>.
- Fahmida, H. (2015). Link Between Nutrition and Agriculture. The *Daily Star News*. Retrieved on June 18, 2020 from <http://www.the-dailystar.net/link-between-nutrition-and-agriculture>.
- Folitse, Y. B., Osei, K. S., Dzandu, P. L. & Obeng-Koranteng, G. (2016). Impact of Agricultural Radio Programmes on Livelihoods of Farmers: The Case of Royal FM in Brong-Ahafo Region, Ghana. *Journal of Sustainable Development in Africa*, 18(5), 100-114.
- Ha, L., Okigbo, R. and Igboaka, P. (2008). Knowledge creation and dissemination in Sub-Saharan Africa. *Management Decision*, 46(3), 392-405.
- Idiako-Ochei, O; Onemolease, E. A. and Erie, G. O. (2016). Information-Seeking Behaviour of Extension Personnel in Edo State, Nigeria. *Scholars Journal of Agriculture and Veterinary Sciences*, 3(4), 318-325.
- Ifejika, P. I. (2016). 2Assessment of Fisherfolk Information Seeking Behaviour with Mobile Phone for Improve Extension and Advisory Services. *Journal of Agricultural Science*, 8(11), 170-178.
- Ijiekhuamhen, O. P. and Omosekejimi, A. F. (2016). Rural Women and their Information Seeking Behavior. *Library Philosophy and Practice (e-journal)*, 4-6. Available at <http://digitalcommons.unl.edu/libphilprac>.
- Isaya, L. E. (2015). Sources of Agricultural Information for Women Farmers in Hai and Kilosa Districts, Tanzania. Presented in Partial Fulfillment of the Requirements for the Degree Master of Science in the Graduate School of the Ohio State University.

- Islam, M. S. and Ahmed, S. M. Z. (2012). The information needs and information-seeking behaviour of rural dwellers: A review of research. *International Federation of Library Associations and Institutions*, 38(2), 137–147.
- Jeffcoat, C., Davis, A. F. & Hu, W. (2012). Willingness to pay for broadband access by Kentucky farmers. *Journal of Agricultural and Applied Economics*, 44(3), 323 -334.
- Kalusopa, T. (2005). The challenges of utilizing Information Communication Technologies (ICTs) for the smallscale farmers in Zambia. *Library Hi Tech* 23, 414-424.
- Kamba, M. A. (2009). Access to information: The dilemma for rural community development in Africa. Paper presented at 7th GLOBELICS Conference, October 6–8, Dakar, Senegal.
- Kari, H. (2007). Availability and accessibility of ICT in the rural communities of Nigeria. *The Electronic Library*, 25(3), 363-372.
- Kleih, U., Okoboi, G. and Janowski, M. (2004). Farmers and traders' sources of market information in Lira District. NARO Conference, 1-4 September 2004, Paper 57-5, 25 Pages. Retrieved on June 18, 2020, 2020 from <http://www.dfid.gov.uk/r4d/PDF/Outputs/R8250s.pdf>.
- Kuria, W. C. (2014). Use of Social Media as a Source of Agricultural Information by SmallHolder Farmers: A Case Study of Lower Kabete, Kiambu County. A Research Project for the Award of the Degree of Master of Arts in Communication Studies, School of Journalism and Mass Communication, University of Nairobi.
- Kursat, D., Huseyin, E., Vedat, C., Savas, A. & Osman, U. (2008). Agricultural information systems and communication networks: the case of dairy farmers in the Samsun province of Turkey. *iRinformationresearch*, 13(2). Retrieved on August 13, 2020 from <http://www.informationr.net/ir/13-2/paper343.html>
- Kusugh, T. (2017). *Mass Communication Research: Methods, Strategies and Procedure*. Makurdi: Obama Publishers.
- Lisa Schlein, L. (2020). COVID-19 is Threatening Food Security in Nigeria. VOA. Retrieved on August 11, 2020 from <https://www.voanews.com/africa/covid-19-threatening-food-security-nigeria>.
- Lughlugh, J. (2020). Information Needs and Information Seeking Behaviour of Farmers for Sustainable Agricultural Development in Benue State, Nigeria. *International Journal of Research and Innovation in Social Science (IJRISS)*, IV(V), 309-312.
- Lwoga, E. T. (2010). Bridging the agricultural knowledge and information divide: the case of selected telecenters and rural radio in Tanzania. *The Electronic Journal on Information Systems in Developing Countries*, 43 (6), 1-14.
- Lwoga, E. T. and Stilwell, C. (2011). Access and use of agricultural information and knowledge in Tanzania. *Library Review*, 60(5).
- Mapiye, O., Makombe, G. & Dzama, K. (2020). Management information sources and communication strategies for commercially oriented smallholder beef cattle producers in Limpopo province, South Africa. *Outlook on Agriculture*, DOI:[10.1177/0030727019860273](https://doi.org/10.1177/0030727019860273)
- Mbagwu, C. F., Benson, O. V. and Onuoha, O. C. (2018). Challenges of meeting information needs of rural farmers through internet-based services: experiences from developing countries in Africa. Retrieved on June 18, 2020 from <http://creativecommons.org/licenses/by/4.0>.
- Mbanda-Obura, A. S., Tabu, M. I. & Obura, R. K. (2017). Determinants of Choice of Agricultural Information Sources and Pathways among Sorghum Farmers in Ndhiwa

- Sub-County, Western Kenya. *The Journal of Agricultural Extension*. Retrieved on August 5, 2020 from <https://www.semanticscholar.org/paper/DETERMINANTS-OF-CHOICE-OF-AGRICULTURAL-INFORMATION-Mbanda-Obura-Tabu/d2e8759e7bcf78d33a54d15989f404ab9fc967c5>
- Mchombu, K. J. (2006). Libraries, literacy and poverty reduction: a key to African Development. A research paper looking at libraries in Africa Commissioned by Book Aid International and sponsored by the Commonwealth Foundation.
- Mehrad, J. and Tajer, P. (2016). Uses and gratification theory in connection with knowledge and information science: A proposed conceptual model. *International Journal of Information Science and Management*, 14(2), 1-14.
- Meitei, L. S. and Devi, T. P. (2009). Farmers information needs in rural Manipur: An assessment. *Annals of Library and Information Studies*, 56, 35–40.
- Meyers, C., Gracey, K., Irlbeck, E. & Akers, C. (2015). Exploring the Uses and Gratifications of Agricultural Blog Readers. *Journal of Applied Communications*, 99, (4), also available on <https://doi.org/10.4148/1051-0834.1064>.
- Moore, N. (2007). Community information and technology centres: Focus on South-East Asia. Bangkok: UNESCO. Retrieved on June 18, 2020 from [http://portal.unesco.org/ci/en/files/25659/11962595511telecentre\\_study\\_en.pdf/telecentre\\_study\\_en.pdf](http://portal.unesco.org/ci/en/files/25659/11962595511telecentre_study_en.pdf/telecentre_study_en.pdf).
- Mtega, W. and Benard, R. (2013). The state of rural information and communication services in Tanzania: a meta-analysis. *International Journal of Information and Communication Technology Research*, 3(2), 64 – 73.
- Mulauzi, F. and Zulu M. (2012). Information and Knowledge: A Panacea for Increased Food Security among Women in Chipata District: The Case of Luangeni. Social Policies and Social Development: OSSREA Zambia Chapter Academic Workshop Proceedings, University of Zambia Senate Chamber, Lusaka, Zambia, 15<sup>th</sup> October, 2012, pp.121-144.
- Mwakaje, A. (2010). Information and Communication Technology for rural farmers market access in Tanzania. *Journal of Information Technology Impact*, 10(2), 111-128.
- Mwangi, M. and Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and Sustainable Development*, 6(5), 208-216.
- Nafiz, Z. S. (2016). The Information Practices of the Fishermen in the Bay of Bengal, Bangladesh. *Open Information Science*, 1, 21-40.
- Obayori, B. J., Nchom, H. and Yusuf, L. O. (2020). Economics of Pandemic in Nigeria: The COVID-19 Experience. *British International Journal of Education and Social Sciences*, 7(4), 1-6.
- Odini, S. (2005). Information seeking and communication behaviour of Kenya Railways Engineers. *University of Dar es Salaam Journal* 7(2).
- Odoemelum, L. E. and Alocha, O. C. (2015). Understanding Farmers Information Network; Implication for Effective Extension Delivery in Akwa Ibom State. *International Journal of Scientific & Technology Research*, 4(1), 98-102.
- Odoemelum, L. E. and Olojede, J. C. (2016). Analysis of Information Needs of Rural Youths on Garden Egg Production (*Solanum melongena*) in Abia State, Nigeria. *European Journal of Physical and Agricultural Sciences*, 4(3), 17-27.

- Odoi, N. (2017). The information behaviour of Ugandan banana farmers in the context of participatory development communication. *Information Research*, 22(3). Retrieved on August 1, 2020 from <http://www.informationr.net/ir/22-3/paper759.html>
- Ogar, E. C., Dika, I. S. and Atanda, A. L. (2018). Challenges and Prospects of Information Service Delivery to Rural People of Nigeria. *Research Journal of Library and Information Science*, 2(3), 14-28.
- Ogboma, M. U. (2010). Access to agricultural information by fish farmers in the Niger delta region of Nigeria. *Journal of Library Philosophy and Practice*. Retrieved on June 18, 2020 from Available at <http://www.faqs.org/periodicals/201009/2166597671.htm>.
- Ogunniyi, D. M. and Ojebuyi, B. R. (2020). Mobile Phone Use for Agribusiness by Farmers in Southwest Nigeria. *Journal of Agricultural Extension*, XX(X), 172-187. Available at <http://dx.doi.org/10.4314/jae.v20i2.13>.
- Ogunsola, J.O., Ogunsola, A. J., Alarape, A. B., Oloba, O. G. and Osalusi, C. S. (2019). Effectiveness of broadcast Agricultural Programmes on Agricultural Development among Farmers in Akoko South West Local Government Area of Ondo state, Nigeria. *International Journal of Environment, Agriculture and Biotechnology (IJEAB)*, 4(5), 1392-1399. Available at <https://dx.doi.org/10.22161/ijeab.45.16>.
- Oladimeji, I. O. (2006). Multilinguality of Farm Broadcast and Agricultural Information Access in Nigeria. *Nordic Journal of African Studies*, 15(2), 199-205.
- Olajide B. R. (2015). Crop farmers' level of utilization of agricultural information from Agbe afokosoro radio farm broadcast in Ogun state, Nigeria. *International Journal of Agricultural Economics and Rural Development*, 7(1), 32-37.
- Olajide, B. R. (2011). Assessment of Farmers' Access to Agricultural Information on Selected Food Crops in Iddo District of Oyo State, Nigeria. *Journal of Agricultural & Food Information*. Retrieved on August 5, 2020 from <https://www.semanticscholar.org/paper/Assessment-of-Farmers>.
- Olaniyi, O. A. and Ogunkunle, T. (2018). Agricultural and Nutritional Information Needs of Arable Crop farmers in Ondo State Nigeria. *Journal of Agricultural Extension*, 22(3), 9-21. Also available at <https://dx.doi.org/10.4314/jae.v22i3.2>.
- Olaniyi, O.A., Adebayo, O. O. and Akintola, S. (2011). Rural youth's perception and utilization of agricultural information in Oyo State, Nigeria. *J. Agric. Soc. Sci.*, 7, 117–123.
- Olumuyiwa, A. O. and Tajudeen, O. (2018). Agricultural and nutritional information needs of arable crop farmers in Ondo State Nigeria. *The Journal of Agricultural Extension*. Retrieved on August 5, 2020 from <https://www.semanticscholar.org/paper/Agricultural-and-nutritional-information-needs-of-Olaniyi-Ogunkunle/7a7fc37bb19d05b31fd07202e8469d0279a32f5e>
- Oluwatoyin, S. S. (2016). Analysis of Agricultural Communication for Improving Productivity among Rural Farmers in Odeda Local Government Area of Ogun State, Nigeria. A Dissertation Submitted to the School of Postgraduate Studies, Ahmadu Bello University, Zaria in Partial Fulfillment of the Requirements for the Award of Master of Science Degree in Mass Communication.
- Omekwe, S., Omiekuma, P. and Obayori, B. J. (2020). The Effect of Coronavirus on Agriculture and Education in Nigeria. *Economics and Social Sciences Academic Journal*, 2(5), 31-38.
- Omotayo, O. F. (2018). Information Behaviour of Nigerian Women Living in Rural Areas towards Socio Economic Empowerment-What do Women Want, What Should Women

- Want? *JORIND*, 16(1). Also available at [www.transcampus.org/journal;www.ajol.info/journals/jorind](http://www.transcampus.org/journal;www.ajol.info/journals/jorind).
- Opara, U. N. (2008). Agricultural information sources used by farmers in Imo State, Nigeria. *Information Development*, 24(4), 289-295.
- Oriakhi, H. and Okoedo-Okojie, D. U. (2013). Arable Crop Farmers Preference for Agricultural Information Sources and Adoption of Technology in Edo State, Nigeria. *Journal of Agriculture and Veterinary Science*, 3(1), 31-35. Also available at [www.iosrjournals.org](http://www.iosrjournals.org).
- Owolade, E. O. and Kayode, A. (2012). Information-Seeking Behavior and Utilization among Snail Farmers in Oyo State, Nigeria: Implications for Sustainable Animal Production. doi: 10.5191/jiaee.2012.19304, 19(3).
- Oyeniya, A. D. and Olofinsawe, A. A. (2015). Access and use of Agricultural Information Resources by Rural Women of Akure North and South Local Government areas of Ondo State Nigeria. *International Journal of Academic Library and Information Science*, 3(4), 132-138.
- Padam, B. P., Mukti, R. P., Aasish, G., Samiksha, P., Chiran, K. T., Nisha, B. and Shila, B. (2020). COVID-19 and its Global Impact on Food and Agriculture. *Journal of Biology and Today's World*, 9(5), 1-4.
- Pamphily, M., Harrison, B. and Emily, B. (2017). The means of access to agricultural information among farmers in Samia Sub-County, Kenya. *International Journal of Advanced Scientific Research*, 2(5), 12-18. Also available at [www.allscientificjournal.com](http://www.allscientificjournal.com).
- Riesenberg, L. E and Gor, C. O. (1999). Farmers' Preferences for Methods of receiving information on new or innovative farming practices. Graduate Student University of Idaho 5th April 2007. <http://pubs.aged.tamu.edu/jae/pdf/vol30/30-03-07.pdf>.
- Salau, E. S., Saingbe, N. and Garba, M. (2014). Agricultural Information Needs of Small Holder Farmers in Central Agricultural Zone of Nasarawa State. retrieved on August 5, 2020 from <https://www.semanticscholar.org/paper/Agricultural-Information-Needs-of-Small-Holder-in-Salau-Saingbe/c500adc11afb91185b51002b8c886e929fdde67d>
- Saleh, R. A., Burabe, I. B., Mustapha, S. B. and Nuhu, H. S. (2018). Utilization of Mass Media in Agricultural Extension Service Delivery in Nigeria: A Review. *International Journal of Scientific Studies*, 6(1), 43-52.
- Sani, L. (2014). The generation and dissemination of agricultural information to Farmers in Nigeria: a review. *Journal of Agriculture and Veterinary Science*, 7(2), 102-111.
- Sasakawa Africa Association (2020). Assessment of the Impact of COVID-19 on Food Systems in Africa and Recommended Mitigation Measures: Summary Findings. Sasakawa Africa Association, April-May, 2020.
- Schmidhuber, J., Pound, J. and Qiao, B. (2020). COVID-19: Channels of transmission to food and agriculture. Food and Agricultural Organisation of the United Nations.
- Shrama, A. K. and Fatima, N. (2004). Information-seeking behaviour and sharing pattern among the rural people of Gwalior district of Madhya Pradesh. In A. Chatterjee et al. (eds) *Information support for rural development*. Kolkata: IASLIC, 217-222.
- Siatiri, R. (1999). Evolution of user studies. *Libri*, 49, 132-141.
- Singh K. P. and Satija M. P. (2006). A review of Research on Information Seeking Behaviour of Agricultural Scientists: International Perspectives. *DESIDOC Bulletin of Information Technology*, 26(2). P30.



- Starasts, A. M. (2004). Battling the Knowledge factor: A Study of Farmers' Information Seeking Learning and Knowledge Process with an online environment in Queensland. Unpublished Ph.D Thesis.
- Stienon, J., Bruinsma, W. and Neuman, F. (2017). How ICT can make a difference in agricultural livelihoods. Retrieved on June 18, 2020, from [www.bibalex.org/Search4Dev/files/287913/118796.pdf](http://www.bibalex.org/Search4Dev/files/287913/118796.pdf).
- Stringer, A. P., Robert, C. and Pinchbeck, G. L. (2019). Associations between sources of information and animal health knowledge of rural farmers in central Ethiopia. *The Journal of Agricultural Extension*, DOI:[10.33687/IJAE.007.02.2857](https://doi.org/10.33687/IJAE.007.02.2857)
- Suleiman, M. M., Ogakason, R. O. & Faruk N. B. (2018). Influence of Social Media in Promoting Farmers' Participation in Agriculture. *Nigerian Journal of Agricultural Extension*, 19(1), 56-62.
- Sunil, K., Sangeetha, V. and Shaik, N. M. (2018). Stakeholders' Information needs, Information Searching and Sharing Behaviour about Rice related Information through Rice Knowledge Management Portal. *International Journal of Current Microbiology and Applied Sciences*, 7(1) DOI:[10.20546/ijcmas.2018.701.357](https://doi.org/10.20546/ijcmas.2018.701.357)
- Tadesse, D. (2008). Access and Utilization of Agricultural Information by Resettler Farming Households: The Case of Metema Woreda, North Gondar, Ethiopia. A Thesis in The School of Graduate Studies, Department of Rural Development and Agricultural Extension, Haramaya University for The Degree of Master of Science in Agriculture (Rural Development And Agricultural Extension).
- Thuo, W. M. (2018). Access and Use of Dairy Agricultural Information by Small Scale young Farmers in Murang'a County, Kenya. A Research Project Submitted in Partial/Fulfillment of the Degree of Master of Library and Information Science of Kenyatta University, Kenya.
- Tologbonse, D., Fashola, O. & Obadijah, M (2008). Policy Issues in Meeting Rice Farmers Agricultural Information needs in Niger state. *Journal of agriculture extension*, 12(2). Also available at [ajol.info/index.php/jae/article/view/47053/33437](http://ajol.info/index.php/jae/article/view/47053/33437).
- Toluwase S. O. W. and Apata O. M. (2017). Use of ICTs as a Source of Information for Improving Agricultural Productivity in South-West, Nigeria. *International Journal of Agricultural Economics*, 2(3), 50-54. doi: 10.11648/j.ijae.20170203.11.
- Ugwoke, B. U. (2013). Promoting Nigerian Agriculture through Library and Information Services. *International Journal of Information Management*, 33, 564-566. Also available at [www.sciencedirect.com/science/article/pii/S0268401213000352](http://www.sciencedirect.com/science/article/pii/S0268401213000352).
- Ukachi, N. B. (2007). Information needs, Sources and Information Seeking Behaviour of Rural Women in Badagry, Lagos, Nigeria. *Information Trends*, 4 & 5.
- Ukachi, N. B. (2015). Exploration of information literacy skills status and impacts on the quality of life of artisans in Lagos, Nigeria. *New Library World*, 116(9/10), 578-587. Available at <http://dx.doi.org/10.1108/NLW-01-2015-0006>.
- Ukachi, N. B. and Ayiah, E. M. (2017). Exploration of Appropriate Media for Satisfying the Information Needs of Future Community of African Farmers. *Library Philosophy and Practice* (e-journal), 1513. Available at <http://digitalcommons.unl.edu/libphilprac/1513>.
- Umunakwe, P. C., Nnadi, F. N., Chikaire, J. and Nnadi, C. D. (2014). Information Needs for Climate Change Adaptation among Rural Farmers in Owerri West Local Area of Imo State, Nigeria. *Agrotechnol*, 3, 118. doi:10.4172/2168-9881.1000118.

- United Nations (2020). Policy Brief: The Impact of COVID-19 on Food Security and Nutrition. Retrieved on August 11, 2020 from <http://www.fao.org/documents/card/en/c/ca8657en>
- Uzuegbu, P. C. and Naga, M. M. (2016). Information Communication to Rural Cassava Farmers in Nigeria: A Pilot Study. *Journal of Applied Information Science and Technology*, 9(2), 120-132.
- Verdier-Chouchane, A. and Karagueuzian, C. (2016). Moving towards a green productive agriculture in Africa: the role of ICTs. *Africa Economic Brief*, 7(7), 1-12.
- Weiss, A., Van Crowder, L. and Bernard, M. (2000). Communicating agrometeorological information to farming communities. *Agriculture and Forest Meteorology*, 103, 185-196.
- World Bank (2006) World development indicators. Washington, DC: World Bank. Retrieved on June 18, 2020 from <http://data.worldbank.org/sites/default/files/wdi06.pdf>.
- World Farmers' Organisation (2020). COVID-19 Pandemic Outbreak: Overview of the Impact on the Agricultural Sector. A Technical Assessment of the Undergoing Situation. Retrieved on July 27, 2020 from [www.wfo-oma.org/covid-19-agri-information-hub](http://www.wfo-oma.org/covid-19-agri-information-hub).
- World Food Programme (2020). Update on the impact of Covid-19 on food and nutrition security in West and Central Africa. WFP Regional Bureau Dakar, Research, Assessments and Monitoring, Emergency Preparedness, Nutrition and Supply Chain Units, April, 17 2020.
- World Food Programme (April 21, 2020). COVID-19 will double number of people facing food crises unless swift action is taken. Retrieved on August 19, 2020 from <https://www.wfp.org/news/covid-19-will-double-number-people-facing-food-crises-unless-swift-action-taken>.
- Wulystan, M. P. (2018). The usage of radio and television as agricultural knowledge sources: The case of farmers in Morogoro region of Tanzania. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, 14(3), 252-266.
- Yaseen, M., Xu, S.W., Yu, W. & Hassan, S. (2016). Farmers' Access to Agricultural Information Sources: Evidence from Rural Pakistan. *Journal of Agricultural Chemistry and Environment*, 5, 12-19.
- Yohanna, I., Ndaghu, A. A. & Barnabas, B. P. (2014). Sources of Information on Climate Change among Arable Crop Farmers in Adamawa State, Nigeria. *Journal of Agriculture and Veterinary Science*, 7(8), 32-36. Also available at [www.iosrjournals.org](http://www.iosrjournals.org).
- Zijp, W. (1994). *Improving the transfer and use of agricultural information: A guide to information technology*. Washington, DC: World Bank.

## **Rainfall Harvesting as Panacea for Domestic Water Supply in Maiduguri**

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**Abstract:** The paper “Rainfall harvesting as panacea for domestic water supply in Maiduguri” examines water supply in Maiduguri with a view to identifying problems associated with it and showcasing rainwater harvesting as a panacea for domestic water supply. This was achieved through examining the various sources of domestic water supply in Maiduguri; explaining the idea of rainfall harvesting, discussing the practice and contribution of rainfall harvesting and suggesting ways of harvesting rainfall for solving problem of domestic water supply in Maiduguri. The study concentrated on literature research that involved consulting written texts such as seminar and conference papers, journals, magazines, books, internet materials among others. The major finding was that water supply in Maiduguri is inadequate in quantity and quality, time and energy consuming in respect to , expensive and unreliable. The paper recommended participation stakeholders that involved the communities, the local government, the state government, community based organizations, other non-governmental organization to work together harmoniously in the provision infrastructure for rainfall harvesting in various communities within and around Maiduguri, Engage of relevant professional in the operation and maintenance of the infrastructure. Regular training and retraining of personnel to enable them handle to update them on modern issues regarding rainfall harvesting. Explore international sources of finance for urban development project for adequate funding in order to make rainfall harvesting effective and efficient in addressing the problem of domestic water supply in Maiduguri.

**Keywords:** Domestic water, Harvesting, Panacea, Rainfall, Water supply

### **1.0 INTRODUCTION**

Water maintains life, water sustains life and water is life: these are popular slogans in water industries depicting the importance of water in human life. Water is the most important liquid substance in human life, it constitute more than 90% of the human body and essential in physical, social , economic, cultural and psychological development of human society (Yobe water 1992 in Adamu, 2008).



Water can be obtained from the surface (rivers, lakes, oceans), underground (well, boreholes) and from the sky (rain, snow and other forms of precipitation). (Microsoft Encarta, 2009)

Maiduguri town has problem with domestic water supply being a state capital with increasing population and rapid expansion of settlements without water connections. Several efforts made in addressing the problem have been inadequate (Adamu, 2008). These calls for more alternatives in meeting the domestic water supply which is what this paper is trying to do by looking at rainfall harvesting.

According to Wikipedia (2016) Rainfall harvesting is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. Rainwater can be collected from rivers or roofs, and in many places the water collected is redirected to a deep pit (well, shaft, or borehole), a reservoir with percolation, or collected from dew or fog with nets or other tools.” Oluwasanya (2006) described Rainfall or Rainwater harvesting (RWH) as the collection of rainwater where it falls or capturing the runoff in one’s village or town. In other words it is defined as gathering and storing of rainwater (Akoh and Oyeyemi, 2009). Rainwater harvesting has been used to provide drinking water, water for livestock and water for irrigation or to fill aquifers through ground water recharge process.

Rainwater collection is one of the oldest means of getting water for domestic purposes that is growing in popularity due to interest in reducing the problems of water supply in our communities. The history of the use of rainwater as a source of water supply date back to 400years (Agarwal and Narrain 1997, Srinivas 2013).

According to Guebaili *et-al* (2011) Rainwater harvesting is an old method used almost anywhere in the world. It is applied in a traditional way in some parts of the world. It attracts more and more attention in several countries as an excellent practice of sustainable water management. In most cases rainwater is stored in a reservoir or a tank constructed using various materials such as concrete, polypropylene, polyethylene, fiberglass, or metal.

Rainwater harvesting has been undertaken successfully throughout Africa and can be implemented cost effectively by residents of high, medium and low income areas. Rainwater harvesting essentially involves the collection, storage and continuous use of captured rainwater, as either a main or alternative source of water (Gebhardt, 2013) . At present in china and Brazil rooftop rainwater harvesting is in practice for providing water for drinking, livestock, irrigation and for replenish of ground water level. Gansu province in china and semi-arid north east brazil have the largest rooftop harvesting project in progress. In Rajasthan, India rainfall harvesting has traditionally been practiced by people of the Thar desert ( Agarwal and Narrain, 1997).

Rainwater harvesting system primarily consists of collection and subsequent use of captured rainwater as either the principal or supplementary source of water. All rainwater harvesting systems share a number of common components: a) A catchment’s surface from which runoff is collected e.g. roof surface. b) A system for transporting water from the catchment’s surface to a storage reservoir, known as the delivery systems. c) A reservoir where water is stored until needed (storage system). d) A device for extracting water from the reservoir (Olaoye, Coker, Sridhar and Adewole, 2013). Various technologies to harvest rainwater have been in use for millennia and new ones are being developed all the time. They include macro-catchment technologies that handle large runoff flows diverted from surfaces such as roads, hillsides, pastures, as well as micro-catchment technologies that collect runoff close to the

growing crop and replenish the soil moisture. Rooftop harvesting structures have the advantage to collect relatively clean water, while weirs and dams on ephemeral watercourses can store relatively larger volumes and for longer periods (RELMA, 2005). Advantages and benefits of rainwater harvesting are numerous. The water is free; the only cost is for collection and use. The end use of harvested water is located close to the source, eliminating the need for complex and costly distribution systems. Rainwater provides a water source when groundwater is unacceptable or unavailable, or it can augment limited groundwater supplies. The zero hardness of rainwater helps prevent scale on appliances, extending their use; rainwater eliminates the need for a water softener and the salts added during the softening process. Rainwater is sodium-free, important for persons on low-sodium diets. Rainwater is superior for landscape irrigation. Rainwater harvesting reduces flow to stormwater drains and also reduces non-point source pollution. Rainwater harvesting helps utilities reduce the summer demand peak and delay expansion of existing water treatment plants. Rainwater harvesting reduces consumers' utility bills. (Krishna, 2003 and Ishaku *et al* 2011).

Due to pollution of both groundwater and surface waters, and the overall increased demand for water resources due to population growth, many communities all over the world are approaching the limits of their traditional water resources. Therefore they have to turn to alternative or 'new' resources like rainwater harvesting (RWH). Rainwater harvesting has regained importance as a valuable alternative or supplementary water resource. Utilization of rainwater is now an option along with more 'conventional' water supply technologies, particularly in rural areas, but increasingly in urban areas as well (Worm and Hattum, 2006). Rainwater harvesting yields numerous social and economic benefits, and contributes to poverty alleviation and sustainable development (Bancy, Mati and Oduor, 2006). RWH can augment water supply in all sectors. Rainwater harvesting increases food production and hence forms the foundation of many development projects that promote agriculture and land management (Rigasira *et al* 2002, Lundgren, 1993; Hurni and Tato, 1992; WOCAT, 1997). For instance, according to studies carried out, maize yield can be tripled with RWH through Conservation agriculture. RWH minimizes the risk of crop failure during droughts, intra seasonal droughts and floods (Baron and Rockstrom, 2003); RWH reduces women's burden of collecting water for domestic use, leaving time for other productive activities. RWH gives opportunity for the girl child to attend school and provides a relatively safe and clean source of drinking water, minimizing incidences of water borne diseases. When applied at watershed level, it improves the environment and minimizes the effects of drought and floods. RWH is a decentralized water supply system encouraging community participation and self-reliance. Local communities who have an enormous capacity to invest labour and time can do it; the systems are varied and can therefore be built according to the ecological characteristics of the particular region or locality (Oweis *et al*, 2001; SIWI, 2001). Hatibu and Mahoo (2000) also demonstrated the importance of Rain Water Harvesting to domestic water supplies, livestock watering and crop production using examples and data from Tanzania.

From the above is not out of place to say that rainwater collected from roofs of houses, tents and local institutions or from specifically prepared areas of ground can make an important contribution to domestic water supply in Maiduguri.

### **1.1 Aim and Objectives**

The aim of this paper is to examine water supply in Maiduguri with a view to identifying problems associated with it and showcasing rainwater harvesting as a panacea for domestic water supply.

The Specific objectives are to:

- Examine the various sources of domestic water supply in Maiduguri.
- Explain the idea of rainfall harvesting
- Discuss the practice and contribution of rainfall harvesting.
- Suggest ways of harvesting rainfall for solving problem of domestic water supply in Maiduguri.

**1.2 Methodology:** the study will concentrate on literature research that will involves consulting written texts such as seminar and conference papers, journals, magazines, books, internet materials among others.

### **1.3 The study area**

Maiduguri town is the capital of Borno state located in the northeastern corner of Nigeria on latitude 11 51' north and longitude 13 05' east based on the fertile soil of the bank of Lake Chad area. It laid strategically on Kano/Jos road as well as Mubi and Port Lome roads. The town covered a total land area of 543 Sqkm, which make it the largest city in the northeastern region of the country.

The city comprises of two (2) local governments; Maiduguri Metropolitan Council (MMC) and Jere, engulfs parts of Konduga and Mafa local governments. It comprised of twenty seven (27) Political wards, fifteen in MMC twelve in Jere. The city is directly administered by the state government with the two municipal local governments and directly supported by the traditional leaders comprising of the Emir (Shehu), the district head (Lawan) and traditional representative of the ward head (Bulama) to execute their constitutional responsibilities.

The projected population of Maiduguri town for 2007 was 1,019,902 with a density of 1878 persons per Sqkm, which makes it the most densely populated city in the northeastern Nigeria. There is rapid increase in population with a growth rate of 3.5 in resent time in the town. This partly accredited to the serious influx of people from Cameroun, Chad, and Niger that the state share international boundary with, from Adamawa, Gombe and Yobe state that the state share national boundary with, from various local government in the state and other state of the nation in lesser degree. The people that move into the state continuously move into Maiduguri town thereby increasing the population and make it the fastest growing city in the region.

With the above situation in the town, the present domestic water supply is inadequate and therefore welcome rainfall harvesting to contribute in bringing remedy.

## **2.0 SOURCES OF DOMESTIC WATER SUPPLY IN MAIDUGURI**

In Maiduguri, drinking water is obtained from boreholes. The annual rainfall range from 500mm to 1000mm and relative humidity of about 49% with evaporation 293mm per year

and temperature range of 38 to 40°C during the hottest month of March and April. These factors together with persistent draught, very short rainfall period and desertification had made the water table very difficult to reach. In addition, the cost of drilling new boreholes and maintenance of the old ones had been on the increase. (Dakwa and Abu, 2004)

The Borno state government in an effort to solve the problem of water in Maiduguri sought the assistance of the World Bank and that led to the initiation of a water project in 1986 to channel water from lake Alau to treatment plant located in Maiduguri for purification and subsequent distribution to the metropolis (Dakwa and Abu, 2004). With the construction of the dam and channeling of the water to the treatment plant, Dammo and Sangodoyin (2014) observed that provision of portable water had proved difficult because of the socioeconomic activities around the dam. There is evidence of improper sanitary management, inadequate proper education on irrigation, indiscriminate waste disposal and some farming practices.

The popular sources of water supply in Maiduguri include the following: Alau dam – completed in 1988 by the federal government of Nigeria managed by Chad basin development. It provides water for human and animal consumption and agricultural purposes ((Dakwa and Abu, 2004). Alau dam is the main source of water supply to Maiduguri which is supported and complemented with some boreholes. At present the alau dam supplies about 10million gallons daily. Generators were provided for the treatment plant and submersible pumps of various capacities for the boreholes (FMHD, 2006).

Boreholes – a number of boreholes were constructed in various settlements within Maiduguri town with the aim of providing domestic water to the people to compliment the Alau dam

Tube wells – Several tube wells have been dug by private individual for commercial, private or both.

However in recent times with the increasing population and human activities the water supply is has become inadequate.

Several Studies have shown that Maiduguri town has a history of water supply problem for long. According to a study conducted by Odihi (1988) Maiduguri's water supply services are both inadequate and unreliable. The water rate irony of higher cost burdens for the low income households generates an inequality pattern of water supply, namely low and relatively insecure supply condition for low income households and wards.

Water supply in Maiduguri is generally inadequate, time and energy consuming, expensive and unreliable. Hence the need of rainfall harvesting to complement the present sources

### **3.0 THE IDEA OF RAINFALL HARVESTING**

Rainwater harvesting is an old method used almost anywhere in the world. It attracts more and more attention in several countries as an excellent practice of sustainable water management (Guebaili et al, 2011). Rainfall harvesting is a technology use for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple technique such as jars and pots as well as more complex techniques such as underground check dams (srinivas, 2013). It is a simple low-cost technique that requires minimum specific expertise or knowledge and offers many benefits. Collected rainwater can supplement other water sources when they become scarce or are of low quality like brackish groundwater or polluted surface water in the rainy season. It also provides a good alternative and replacement in times of

drought or when the water table drops and wells go dry. One should, however, realize that rainfall itself cannot be managed. Particularly in arid or semi-arid areas, the prevailing climatic conditions make it of crucial importance to use the limited amount of rainfall as efficiently as possible. The collected rainwater is a valuable supplement that would otherwise be lost by surface run-off or evaporation.

Rain Water Harvesting has proven to be of great value for arid and semi-arid countries or regions, small coral and volcanic islands, and remote and scattered human settlements.

Rainwater harvesting has been used for ages and examples can be found in all the great civilizations throughout history. The technology can be very simple or complex depending on the specific local circumstances. Traditionally, in Uganda and in Sri Lanka rainwater is collected from trees, using banana leaves or stems as gutters; up to 200 litres may be collected from a large tree in a single rain storm. With the increasing availability of corrugated iron roofing in many developing countries, people often place a small container under their eaves to collect rainwater

The reasons for collecting and using rainwater for domestic use are plentiful and varied the following are among others:

1. Increasing water needs/demands

The increased need for water results in lower groundwater tables and depleted reservoirs. Many piped water supply systems fail. The use of rainwater is a useful alternative.

2. Variations in water availability

The availability of water from sources such as lakes, rivers and shallow groundwater can fluctuate strongly. Collecting and storing rainwater can provide water for domestic use in periods of water shortage. Rainwater may also provide a solution when the water quality is low or varies during the rainy season in rivers and other surface water resources (for example in Bangladesh).

3. Advantageous collection and storage near the place of use

Traditional sources are located at some distance from the community. Collecting and storing water close to households improves the accessibility and convenience of water supplies and has a positive impact on health. It can also strengthen a sense of ownership.

4. Quality of water supplies

Water supplies can become polluted either through industrial or human wastes or by intrusion of minerals such as arsenic, salt (coastal area) or fluoride. Rainwater is generally of good quality.

Broadly there are two ways of harvesting rainfall which are surface runoff harvesting and roof top rain water harvesting (The Constructor 2015) Rainfall harvesting system comes in various shapes and sizes, from simple catchment system under a downspout to large above and or underground cisterns with complex filtration system that can store thousands of gallons of water. Most rainfall harvesting system comprised the same basic components as follows:

- i) Catchment surface – hard smooth surface such as metal roofs or concrete areas with reasonable size and good slope.
- ii) Distribution system - Gutters and downspouts that channel water from the catchment area to a holding container.
- iii) Leaf screens – are panels of shields that remove or catch debris.
- iv) Roof washers – a device that diverts the first flush of rain before it enters the storage tank.
- v) Storage tanks – they are of numerous types and styles which can be above ground or underground. Made from galvanized steel, wood, concrete, clay plastic, fiberglass, masonry etc.
- vi) Delivery systems – pumped or gravity fed to landscape or other end use areas.
- vii) Purification or treatment system – filtration to make the water safe for human consumption.

Table 1: The table below shows the advantages and disadvantage of rain water harvesting:

Advantages	Disadvantages
Simple construction: Construction of RWH systems is simple and local people can easily be trained to build these themselves. This reduces costs and encourages more participation, ownership and sustainability at Community level.	High investment costs: The cost of rainwater catchment systems is almost fully Incurred during initial construction. Costs can be reduced by simple construction and the use of local materials.
Good Maintenance: Operation and maintenance of a household catchment system are controlled solely by the tank owner's Family. As such, this is a good alternative to poor maintenance and monitoring of a centralized Piped water supply.	Usage and maintenance: Proper operation and regular maintenance is a very important Factor that is often neglected. Regular inspection, cleaning, and occasional repairs are essential for the success of a system.
Relatively good water quality: Rainwater is better than other available or traditional sources (groundwater may be unusable due to fluoride, salinity or arsenic).	Water quality is vulnerable: Rainwater quality may be affected by air pollution, animal or bird droppings, insects, dirt and organic matter.
Low environmental impact: Rainwater is a renewable resource and no damage is done to the environment.	Supply is sensitive to droughts: Occurrence of long dry spells and droughts can cause water supply problems.
Convenience at household level: It provides water at the point of consumption.	Limited supply: The supply is limited by the amount of rainfall and the size of the catchment area and storage reservoir.
Not affected by local geology or topography: Rainwater collection always provides an alternative wherever rain falls.	
Flexibility and adaptability of systems to suit local circumstances and budgets, including the increased availability of low-cost tanks (e.g. made of Ferro cement, plastics	

or stone/bricks).	
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Source: Adopted from Worm and Hattum (2006)

#### **4.0 PRACTICE AND CONTRIBUTION OF RAINFALL HARVESTING**

Today many countries in the world engage in large scale rainfall harvesting, particularly in rural areas where the people use it for activities such as farming, fishing, mining etc. The technology is flexible and adaptable to a very wide variety of conditions. It is used in the richest and the poorest societies, as well as in the wettest and the driest regions on our planet (Worm and Hattum 2006). Rainwater harvesting is practiced at individual, household, commercial and occasionally at local or state government level to augment dwindling water supplies to urban centres (Sridhar, Coker and Adegbuyi, (undated), Lade and Oloke, 2015).

In China seventeen provinces have adopted the rainwater utilization technique, building 5.6 million tanks with a total capacity of 1.8 billion m<sup>3</sup>, supplying drinking water for approximately 15 million people and supplemental irrigation for 1.2 million ha of land.

In South Africa there is a number of rainwater harvesting projects namely: Botlhabela Village Project in Alexandra, Johannesburg; the Cato Manor Green Initiative in Durban and the Indlovu Centre in Khayelitsha, Cape Town. Collectively, these projects assist in supplementing water supply and management in low income communities, as well as improving their quality of life.

In Senegal and Guinea Bissau the houses of Diola people are normally fitted with local brew rainwater harvesters made from local organic material. In Bermuda the law requires that all new construction to include rain water harvesting adequate for the residents. The United States Virgin Island also has similar law. Elephanta and Kalahari caves in Mumbai of indus valley civilization rainwater harvesting alone has been used to supply their requirement.

In Botswana thousands of roof catchment and tank systems have been constructed at a number of primary schools, health clinics and government houses throughout Botswana by the town and district councils under the Ministry of Local Government, Land and Housing (MLGLH)

In Tanzania the principles for the operation of rainfall harvesting system are: (i) only one underground tank should be filled at a time; (ii) while one tank is being filled, water can be consumed from the other tank, (iii) rainwater should not be mixed with tap water; (iv) underground storage tanks must be cleaned thoroughly when they are empty; (v) in order to conserve water, water should only be used from one distribution tank per day. (Hatibu and Mahoo 1999)

In Tokyo Japan rainwater harvesting and utilization is promoted to mitigate water shortages, control floods, and secure water for emergencies.

In Bangladesh, rainwater collection is seen as a viable alternative for providing safe drinking water in arsenic affected areas. About 1000 rainwater harvesting systems have been installed in the country, primarily in rural areas.

In Berlin, Germany rainwater utilization systems were introduced as part of a large scale urban re-development, to control urban flooding, save city water and create a better micro climate.

In Central Texas, more than 400 full scale rainwater harvesting systems have been installed by professional companies, and more than 6,000 rainbarrels have been installed through the City of Austin's incentive program in the past decade. Countless "do-it yourselves" have installed systems over the same time period (Texas Water Development Board, 2005).

## **5.0 CONCLUSION AND RECOMMENDATION**

### **5.1 Conclusion**

Potable, fresh and reliable water is very essential in most human activities in life, its availability determines location and development of human settlement. In Maiduguri the supply of water is inadequate, time and energy consuming, expensive and less reliable. For these reasons there is need for rainfall harvesting to address the situation. For it to be effective the following is highly recommended

### **5.2 Recommendation**

- All stakeholders that involved the communities, the local government, the state government, community based organizations, other non-governmental organization to work together harmoniously in the provision of infrastructure for rainfall harvesting in various communities within and around Maiduguri.
- Engagement of relevant professional in the operation and maintenance of the infrastructure.
- Regular training and retraining of personnel to enable them handle and to update them on modern issues regarding rainfall harvesting.
- Exploration of international sources of finance for urban development project for adequate funding.

## **REFERENCES**

- Adamu, M.M. (2008) Planning for the Integration of Informal Economic Activities into Land uses in Maiduguri. MURP Thesis Department of Urban and Regional Planning School of Environmental Sciences Federal University of Technology Yola Adamawa State.
- Agarwal, A and Narrain, S. (1997) Dying Wisdom Rise, Fall and Potential of India's Traditional Water Systems, State of Indian's Environment, a Citizen's Report, Centre for Science and Environment in India.
- Akoh, S. A. (2014) Rainfall Harvesting: Panacea for Domestic Water Supply in the Peri-Urban Area of Kaduna Metropolis, Nigeria in the Journal of Nigeria Institute of Town Planners. Volume xxiii number one.
- Akoh, S.O and Oyeyemi, S. M. (2009). Rainfall Harvesting in Nigeria. Paper presented at



- the 19th Annual Conference/AGM of Nigerian Environmental Society, NICON Luxury Hotel Abuja.
- Bancy, M, Mati, M. M and Oduor, A. (2006) Promoting Rainwater Harvesting in Eastern and Southern Africa. Published by the World Agroforestry Centre United Nations Avenue PO Box 30677, GPO 00100 Nairobi, Kenya.
- Baron, J. and Rockstrom, J. (2003) Water harvesting to upgrade smallholder farming: Experiences from on-farm research in Kenya and Burkina Faso. RELMA, Nairobi. 20pp.
- Dakwa, P.Y. and Abu G.O.(2004) Distribution and Statistical Analysis of bacteria in Lake Alau in the arid northern Nigeria in journal of applied science and environmental management volume 8 number 1 pages 5-9.
- Dammo, M.N. and Sangodoyin O.(2014) Socioeconomic activities around Alau dam and the quality of raw water supply to Maiduguri treatment plant Nigeria .at <https://www.researchgate.net/>.
- Federal Ministry of Housing and Urban Development, (2006). Sustainable Urbanization and Urban Development in Nigeria: Challenges and Response. Abuja Nigeria.
- Gebhardt, Z. (2013) Rainwater Harvesting. Why What and How.
- Guebaili , A. Djebbar , Y. Guedri , A and Boukhari S. (2011) Rainwater Harvesting in North Africa: A novel method for reservoir sizing. Colloque International « Journées des Géosciences de l'Environnement » Oujda, 21, 22 et 23 Juin 2011 « Environnement et développement durable ». [www.jmaterenvironsci.com](http://www.jmaterenvironsci.com)
- Hatibu, N. and Mahoo H. (1999) Rainwater harvesting technologies for agricultural production: A case for Dodoma, Tanzania in: Kaumbutho P G and Simalenga T E (eds), 1999. Conservation tillage with animal traction. A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Harare. Zimbabwe. 173p. A publication supported by French Cooperation, Namibia. At <http://www.atnesa.org>
- Hatibu, N. and Mahoo, H. F, (2000) Rainwater harvesting for natural resources management. A Planning guide for Tanzania. Technical Handbook No. 22. RELMA, Nairobi.
- Hurni, H. and Tato, K. (eds). (1992) Erosion, Conservation and small-scale farming. Geographica Bernesia, Walsworth Publishing Company, Missouri, USA.

- Ishaku H.T, Majid, M.R and Johar, F. (2011). Rainwater Harvesting: An Alternative to safe water supply in Nigeria Rural Communities. In Water Resources Management Volume 26 issue 2. At <http://activatejavascript.org>.
- Krishna H. (2003) An Overview of Rainwater Harvesting Systems and Guidelines in the United States.Proceedings of the First American Rainwater Harvesting Conference; 2003 Aug 21-23; Austin (TX).
- Lade, O and Oloke, D. (2015) Rainwater Harvesting in Ibadan City , Nigeria: socioeconomic survey and commercial water supply practices. In American Journal of Water Resources Volume 3 Number 3.
- Lundgren, L. (1993) Twenty years of soil conservation in eastern Africa.  
RSCU/Sida. Report No. 9. Nairobi, Kenya.
- Odihi, J. O. (1988) Urban water supply response to droughts in Maiduguri, Nigeria in the context of the recent sudano- sahelian droughts 1960-8  
5. unpublished dissertation for doctor of philosophy PhD Pennsylvania State university.
- Olaoye, R. A.1, Coker, A.O.1, Sridhar, M. K.1 and Adewole, M. (2013) Examining the Effectiveness of Rainwater Collection Systems in a Nigerian Leper Colony using the Behavioural Model in Asian Research Publishing Network (ARPN).Journal of Engineering and Applied Sciences VOL. 8, NO. 1, At [www.arpnjournals.com](http://www.arpnjournals.com)
- Oluwasanya, G. O. (2006) Assessment of Rainwater Harvesting in RuralHouseholds Water Supply.A case of Olofure Village, Edo state.Journal of the Nigerian Meteorological Society Volume 6 number1.
- Oweis, T., Prinz, P. and Hachum, A. (2001) Water harvesting. Indigenous knowledge for the future of the drier environments. International Centre for Agricultural Research in the Dry Areas (ICARDA). Aleppo, Syria.
- RELMA, (2005) Potential for Rainwater Harvesting in Africa: A GIS Overview  
Volume I. In ICRAF & UNEP
- Rigasira,J, Abaru, M. and Winberg,R. (2002). Empowering rural communities; Rainwater

harvesting by women groups in Rakai, Uganda. Technical Report No.29. RELMA, Nairobi.

SIWI. (2001). Water harvesting for upgrading of rain-fed agriculture: Problem analysis and research needs. Report II. Stockholm International Water Institute. Stockholm, Sweden: Stockholm International Water Institute.

Sridhar, M. K. C. Coker A. O. and Adegbuyi S. A. (2011) Rainwater Harvesting in Nigeria: Prospects and Problems. Division of Environmental Health, College of Medicine, Nigeria, email: mkcsridhar@skannet.com

Sriniva, H. (2013) An Introduction to Rainwater Harvesting. At <http://www.gdrc.org>.

Texas Water Development Board, (2005). The Texas Manual on Rainwater Harvesting. Third edition. Austin USA.

The Constructor, (2015) Methods of Rainwater Harvesting. Civil engineering Home. At <http://theconstructor.org/waterresource>.

Wikipedia Encyclopedia (2016) Rainwater capture and storage system at the Monterrey Institute of Technology and Higher Education, Mexico City.

WOCAT, (1997). WOCAT, World Overview of Conservation Approaches and Technologies – A Programme overview. May 1997. Bern, Switzerland.

Worm, J. and Hattum, T.V. (2006) Rainwater Harvesting for Domestic Use. First edition Agrodok 43 Agromisa Foundation and CTA, Wageningen.

## **An Appraisal of Ground Water Management System in Chad Basin Area of Borno State Nigeria**

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**Abstract:** This paper on “Appraisal of Ground water management systems in chad basin area of Borno state”. Studied the ground water system in Chad Basin with a view to identifying problems associated with the management techniques. It described the nature of ground water in the chad basin area, examined the ground water management system in the area, identified problems associated with the management system and Proposed future management perspective for improvement. The study adopted qualitative research method that focused on literature, consulted written texts namely seminar and conference papers, journals, magazines, books, internet materials among others. The paper identified general over exploitation of the aquifer, falling water level in the area, reduction in borehole yield, expensive pumping of water and some shallow wells and boreholes are put out of the system as problems associated with the management system. Proposed future perspective that involved: Proper definition of a framework for ground water resources management, ground water conservation measures, demand management, source enhancement, provision of adequate legislations, stakeholder inclusion, increased investment and funding in the water sector and institutional integration for the improvement in ground water management system in Borno state.

**Keywords:** Aquifer, Appraisal, Chad Basin, Ground water, Management System

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### **1.0 INTRODUCTION**

Groundwater plays a vital role in the socio-economic development of urban and rural areas in Nigeria. Out of the current population of about 168 million, more than half depend directly on this natural resource for their daily water needs (Bakari *etal*, 2014). With a rapid population growth of about 2.5% per annum, the demand for water supply in chad basin area has progressively increased over the last three decades. The provision of safe drinking water has actually deteriorated; access in urban areas fell from 55 million people to 27 million people in 2002 alone largely due to poor management, inadequate technical capabilities, lack of investment and insufficient manpower and their training. Furthermore, the institutions responsible for water supply are both ineffective and fragmented, thus a transition is needed

to bring about a thorough and holistic change to the current system. This change requires a long period of time to be effective, and into the future it can only be achieved by empowering and engaging the relevant stakeholders in groundwater management issues.

However, rapid population growth and uncontrolled urbanization further aggravates the increasing trend of above ground human activities that potentially affect the quality and quantity of the underlying groundwater by radically changing both recharge and abstraction, thus adversely affecting groundwater quality (Foster, 2001). Urbanization, dense population concentrations and human activities all severely affect groundwater quality especially in developing countries of sub-Saharan Africa where the urban expansion is poorly planned (Chilton 1999, Wakida and Lerner 2005, Naik *et al* 2008, Putra and Baier 2008 and Eni *et-al* 2011).

These problems pose a significant threat to the upper unconfined system of the Chad Basin around Maiduguri in Northern Nigeria. The aquifer in the Chad Basin is the major water supply source for the city and it is hydraulically connected to the Ngadda River which drains the city. River Ngadda – groundwater system is threatened by incessant waste disposal in recharge areas by residents and local businesses, uncontrolled pit latrine construction and other non-point sources of contamination across the city.

The negative impact is most significant in some of the areas in Maiduguri where tons of residential and commercial solid wastes are inappropriately dumped into the River Ngadda. The hydraulic connectivity that exists between the river and the upper aquifer serves as a pathway of groundwater contamination. This consequently poses unacceptable health risks to the local population, most especially the urban poor who largely depend on the groundwater without any form of treatment.

According to Bunu (1999), Dami *et-al* (2011) and Adkins (2007), the Lake Chad basin extends over areas in the countries of Niger, Chad, Cameroun and Nigeria. Total area extent within Nigeria is about 200,000 km<sup>2</sup>, out of which Borno and Yobe States cover about 58 percent. Groundwater is the predominant source of water supply for domestic and other uses, while surface water is used mainly for irrigation purposes. Groundwater abstraction from boreholes for water supply has a long history. As many as 100 boreholes have been drilled and operated in Maiduguri town alone for water supply and over 2,000 boreholes have been drilled and operated within the two states. Many more are still being drilled and operated by many agencies.

There is generally a high rate of abstraction without matching recharge. A general decline in rainfall for the area has led to the over-exploitation of groundwater and the available groundwater resource is on the decline. Water levels in boreholes have fallen and borehole yields have drastically declined over the years. Groundwater resource management must be approached systematically (Bunu 1999).

### **1.2 Aim and Objectives**

The aim of the study is to examine ground water in Chad Basin area with a view to identifying problems associated with the management system and propose future management perspective for improvement.

The specific objectives are to:

- Describe the nature of ground water in the chad basin area.
- Examine the ground water management system in the area
- Identify problems associated with the management system.
- Propose future management perspective.

## **2.0 NATURE OF GROUND WATER IN THE CHAD BASIN AREA**

The area has many small rivers and streams and most of them are ephemeral, flowing for about three to four months a year. Some of them rise locally, while others have their tributaries outside the area. The climate is semi-arid with a long dry season and a short rainy season lasting for 2 – 3 months. Temperature value of about 32 C. Rainfall is generally low with a mean annual value of about 625mm, while the mean annual evaporation rate is about 1600mm (Marte1986,Bonsor and Macdonald 2010,Vassolo 2012 and Lake Chad-HYCOS 2015).

The hydrology of the area is dominated by the Chad formation, Exploitable aquifers occur at depths of up to 650m and comprise the upper, middle and lower zones which correspond to the phreatic, lower Pliocene and terminal continental aquifers described by the Lake Chad Basin Commission (LCBC) for the entire basin. Potential deep aquifers at depths greater than 700m are unlikely ever to become economically feasible in the study area or elsewhere in the basin. For all practical purposes the development of groundwater resources is limited to the currently exploited aquifers to depths of about 650m. The upper zone is termed the upper aquifer system because it is a heterogeneous body comprising more than one aquifer intercalated with less permeable beds. The middle and lower zones are termed separate aquifers since each is sufficiently isotropic as to be considered an individual hydro-geological unit. The geometry, lithology and hydrogeology of the aquifers are fairly well known due to the greater number of boreholes drilled in and around Maiduguri (Bumba *et al.*, 1985, Vassolo et al 2009, Vassolo, 2012and Lake Chad-HYCOS 2015).

The groundwater resources of the area come from the three aquifers of the Chad formation and to a lesser extent are supplemented by the basement complex and the Fikashales.

### **The upper aquifer system**

The upper aquifer system consists of at least three zones in and around Maiduguri. These zones referred to as A, B and C are found at depths of 10-40m, 40-70m and 78-99m, respectively. They are usually screened under a multiple screening arrangement in the borehole where they are found to exist together. The yields from these boreholes range from 2-5 litres per second (l/sec). recharge to this aquifer system occurs through vertical infiltration of rainfall as well as seepage along rivers and streams. (Bunu1999 ,Vassoloetal 2009,Global Water Partnership 2013,Yusuf 2015 and Usman *etal* ,2016)

### **The Middle aquifer system**

This is the most widespread and best exploited confined aquifer in the Nigerian sector of the Chad Basin with a surface area in excess of 50,000kmsq. Its depth ranges from about 200 to 350m. Lithologically, it is the most varied aquifer, consisting mainly of sand and gravels with silt and clay intercalations. Recharge to this aquifer is reported to occur by horizontal inflow around the ridge of the rocky areas fringing the Chad basin and also by vertical percolation from a ridge popularly referred to as the Bama ridge. Yields of boreholes tapping this aquifer range between 5 and 10 l/sec (Bunu 1999,Bonsor and Macdonald 2010, Global Water Partnership 2013 and Yusuf 2015).

### **The Lower Aquifer System**

The lower aquifer system is found at depths of 420-650m, with varying yields according to location ranging from about 15 l/sec to as high as 30 l/sec. Initially, it was thought that the aquifer was mainly confined to the Maiduguri area but a recent geophysical survey indicates its presence beyond Maiduguri. Not much is known about the recharge to

this aquifer but it is believed to be far from this area (Bunu 1999 , Global Water Partnership 2013 and Yusuf 2015 ).

The rate of abstraction of groundwater in the area has been analyzed by Ndubuisi (1990). Although, many new boreholes have been drilled and added to the system, the total may not have changed greatly. This is mainly due to the implementation of a surface water supply scheme for Maiduguri in 1992 and the closing down of many of the operational boreholes. (Bunu, 1999)

The boreholes are designed with diameters of 150mm or more with pump chambers up to 130 m deep in the case where a tapered design is used. The piezometric levels are below 50m deep in some of the boreholes tapping the middle and lower aquifers for which the average setting depth of the pumps are between 80 and 90m.

### **3.0 GROUND WATER MANAGEMENT SYSTEM IN THE AREA**

Realizing dangers posed by over exploitation and the imposed operational difficulties, some form of informal management practice has evolved. It consists of isolated uncoordinated efforts by individuals trying to understand the system through research on a personal level, mainly for academic purposes. No well documented policies on water resources management are in place. However, the efforts have somehow become a way of managing the groundwater resources of the area. Borehole siting criteria, pumping tests of completed boreholes, selection of appropriate pumping equipment for boreholes, though not properly documented are being used systematically by the staff of the Borno and Yobe State Water Boards, the organizations responsible for the development, operation and maintenance of water supplies (Bunu 1999 ,Yusuf 2015 and Ngamdu, 2015).

Due to the frequent loss of submersible pumps in boreholes, especially during the 1980s and the associated difficulty of fishing the pumps due to the small size of the boreholes, the diameters of the boreholes have been standardized to 150mm. With this design concept, it is easy to fish out pumps when they fall into the boreholes. Again, on the advice of experts in the late 1970s, a surface water supply scheme for the town of Maiduguri has been implemented. Similarly, other surface water supply schemes have been recommended for some of the major towns in the area. Researchers in this part of the world and elsewhere have made valuable contributions. However, in spite of these many contributions, the majority of findings have not been implemented and there do not seem to be concrete plans for implementing them in the future. Worst of all, even those involved in the actual exploitation of water resources of the area do not seem to be fully aware of the issues involved. In short, water resources management is neither scientific nor systematic (Hanidu 1990, Bunu 1999, and Yusuf 2015).

### **4.0 PROBLEMS ASSOCIATED WITH THE MANAGEMENT SYSTEM**

According to Bunu (1999) , Jacobsen *et-al* (2012) and Idu (2015) with more than 2,000 boreholes tapping the various aquifers in the area, further water level decline is expected. Groundwater resources have been and are still the main source of potable water supply for domestic, livestock and industrial use in this area. The largest demand is for domestic and livestock consumption which account for over 80 percent of the groundwater use. There is general over exploitation of the aquifers as indicated by the falling water levels and the reduction in boreholes yields.

Economic implications

Generally, the decline in groundwater level caused by over exploitation has produced high pumping heads necessary to abstract water from these aquifers. This has steadily and increasingly made pumping more expensive in the area (Ndubuisi1990,Bunu 1999 and Idu 2015).

#### Environmental implications

The environmental implications of over abstraction are many. Some shallow wells and boreholes have dried up and have been abandoned and put out of the system. There is a need to take precautions in order to safeguard the effects on the whole aquifer and Maiduguri has already been designated as one of the subsidence prone areas of the country (Bunu 1999 and Jacobsen *et al* 2012).

From the above it can be deduced that problems associated with ground water management include the following:

- General over exploitation of the aquifer.
- Falling water level in the area.
- Reduction in borehole yield.
- Expensive pumping of water.
- Some shallow wells and boreholes are put out of the system.

### **5.0 FUTURE MANAGEMENT PERSPECTIVE FOR IMPROVEMENT**

Groundwater resources have played and will continue to play an important role in meeting the water requirements, especially for domestic and livestock consumption in this area. The scientific management of groundwater resources of the area is absolutely essential for sustainable groundwater development and economic advancement. The following measures are suggested as a basis for a proper groundwater management strategy:

- Proper definition of a framework for water resources management: Water resources management involves a sequence of activities and decisions including needs assessment, problem analysis, resource allocation, planning and design, implementation, operation and maintenance, all of which are interrelated in a complex way. These activities are also based on other sub activities, which provide the basic information for decision making. Each decision is based on information on available alternatives and their anticipated outcomes and effectiveness. For proper management, well-coordinated water resources studies need to be undertaken. It is necessary to quantify all aspects of demand and relate it to available resources. Where the demand exceeds available resources, steps should be taken to either cut the demand to match the available resources or increase the supply. This will maintain a favourable balance between water demand and water supply while satisfying the various constraints of quality, technology, availability, sustainability and environmental and economic factors.

Rigorous quantitative hydrogeological studies, geophysical investigations, assessment of aquifer parameters, evaluation of well and aquifer hydraulics to determine safe yields, optimum borehole spacings, water quality testing and economic analysis to determine optimum yields are important prerequisites for scientific management of groundwater resources.

Extensive need exists for adequate and reliable data for water resources planning and management. In order to obtain such data, deliberate policies need to be put in place by the concerned authorities to provide the necessary financial backing and a conducive atmosphere to enable water experts and operators to become responsive



and responsible to these tasks. The studies and activities that need to be carried out should consist of, but are not limited to the following:

- Groundwater monitoring and establishment of a groundwater database: These activities mainly consist of collecting data on boreholes (an inventory), abstraction rates (quantity), water quality, water demand, water level monitoring etc. One simple method of doing this is through the establishment of a groundwater monitoring network from which data on the occurrence, movement, quantity and quality of the groundwater could be obtained and analyzed (Oluboye, 1995).
  - Understanding the aquifer characteristics of the groundwater system: Another related issue is understanding the aquifer characteristics of the groundwater system. Although the aquifer characteristics have been fairly well known, their practical application to estimate recharge has not been defined. It is necessary to understand the aquifer behaviour and interactions with infiltrating and deeply percolating water. There is also a need to investigate further and establish areas of possible recharge to the aquifers and recharge capacity.
  - Creation of a forum for dissemination of research findings on groundwater: The history of water resources planning and development in this area in general has been characterized by ad-hoc solutions. It is unfortunate that since the first free flowing (artesian) boreholes were sunk during the colonial era in the late 1950s, no concrete plans
  - For the management of the Chad Basin aquifers has emerged. Many have failed to understand the importance of proper groundwater resources management. It is the responsibility of water resources professionals to emphasize to public policy makers the importance of groundwater resources management. As a first step, the water industry operators themselves need to be properly educated on these issues. The improved management of the state water agencies should be precisely targeted so that staff can appreciate their position in relation to the need for the combined development and conservation of water resources.
- Ground water conservation measures: groundwater conservation is of paramount importance. Non-structural measures of water resources conservation are a real alternative in water resources management and should be considered and evaluated alongside the structural measures. The following water wastage reduction measure can be considered.
- i) Leakage detection and repairs: The repair of visible leakages on water mains, at well heads, consumer connections, taps, etc. and detection and repair of invisible leaks will greatly enhance the water availability.
  - ii) Rationing of water supplies: Water rationing is another way of augmenting the water supply for a given area. Water rationing involves the imposition of water cut off to some selected areas on a rotational basis (the process is referred to as shifting). This practice is aimed at forcing consumers to collect and conserve water until their next turn to get the supply.
  - ii) Creation of water scarcity awareness: A campaign strategy needs to be initiated to create awareness among consumers regarding the scarce nature of water resources and the need for its quality protection and quantity conservation.
  - iii) Control of free flow (artesian) boreholes in the area: There are many artesian boreholes in the area, which waste water continuously. This is a serious situation that need to be address with immediate effect.

- Demand management: One way of augmenting water supplies is to reduce the pressure on water demand through restriction of water use. There are a variety of ways through which this can be achieved.
- 5. Metering of consumers: Water metering of consumers can reduce water usage greatly. A metered system can save water more than unmetered one. As much as a 50 percent reduction in water demand can be achieved by metering consumers in large cities. Only major consumers are being metered now while the metering of small consumers is not cost-effective. However, with increasing awareness of the water scarcity situation and increased cost of water, the economic viability of metering small consumers can also be considered.
- 6. Improvement of water use effectiveness: Improvement of water use effectiveness can be achieved through the imposition of high prices for water for domestic use as well as other purpose. Water rates should be such as to convey the scarcity value of the resource to the users and to foster the motivation for economic use of water. Regular leak detection and repairs of faulty pipe and plumbing facilities in pipe distribution systems and at houses could become routine conservation practices of consumers are made to pay for water equitably.
- Source enhancement: Source enhancement comprises structural measures aimed at improving the source of water. These may consist of rehabilitation of existing facilities or the provision of entirely new facilities, or their combination.
  - i) Rain water harvesting: rainwater harvesting comprises not only the collection and storage of rainwater in surface and subsurface reservoirs for future use but prevention of water so store from evaporation and in other artificial storage structures.
  - ii) Artificial recharge: Artificial recharge of ground water through surplus water resources is achieved by induced recharge, spreading and injection methods.
  - iii) Internal inter-basin water transfer: This refer to the inter-basin water transfer schemes where the source and the receiving basins are within the same country, in this case Nigeria. They are relatively of lesser scope and hence cost. Likewise, political and environmental considerations are less complex and their related problems are easier to solve than the external ones. Two such transfer schemes have so far been identified which are the Hawul-Ngadda and the Dindima transfer schemes. Government report on these are available and need to be pursued to their logical conclusions.
  - iv) External inter-basin transfer: This refer to the inter-basin water transfer schemes for which the source of water to be transferred does not originate or lie within the country to which the water will be transferred. Such transfer schemes are usually of higher dimensions involving long distances and possibly repairing various large structures to facilitate transfer and they have higher costs.
- Provision of adequate legislations: current legislations require more robust laws that will ensure sustainability of water resources. Some interviewees are of the opinion that even if the current legislations are adequate, their enforcement will be a daunting task for the authorities concerned as this will require the cooperation of the citizens.
- Stakeholder inclusion: involving local communities in water projects will address many problems from the onset. The exclusion of stakeholders in water management was evidenced by the unsustainability of most water projects under the auspices of the

rural water supply programme and host of other previous water projects initiated various past governments across the state.

- Increased investment and funding in the water sector: adequate investments in physical infrastructure and human capital will greatly contribute in the management.
- Institutional integration: Most institutions have different programmes and are independent of one another in tackling a particular societal issue. Contrastingly, coordination among the local communities is moderate to strong depending on a particular community. This is because of the traditional alignment of addressing vital issues among key members of the community.

## **6.0 CONCLUSION**

The study has essentially examined ground water management system in the study area and identified problems associated with the management system that included; general over exploitation of the aquifer, falling water level, reduction in borehole yield, expensive pumping of water as well as some shallow wells and boreholes are put out of the system. The study suggested proper definition of a framework for ground water resources management, ground water conservation measures, demand management, source enhancement, provision of adequate legislations, stakeholder inclusion, increase investment and funding in the water sector and institutional integration to improve management system.

## **REFERENCES**

- Adkins, C. (2007) Groundwater Recharge History and Modern Recharge in the Lake Chad Basin: Sources of Salinity and Fluid Flow in a Disappearing Lake, Lake Chad, Africa ([cadkins@hwr.arizona.edu](mailto:cadkins@hwr.arizona.edu)).
- Bakari, A., Akunna J. and Jefferies, C. (2014) Towards Sustainable Groundwater Management in the South-Western Part of the Chad Basin, Nigeria: A Stakeholder Perspective. In British Journal of Applied Science & Technology. SCIENCE DOMAIN international. At [www.sciencedomain.org](http://www.sciencedomain.org)
- Bonsor, H. C and Macdonald A. M. (2010) Groundwater and Climate Change in Africa: Review of Recharge Studies. Groundwater Science Programme. British Geological Survey Internal Report, IR/10/075.
- Bumba, J.H., M. Kida and Z. Bunu (1985). Exploitation of underground water in the Chad formation. Maiduguri as a case study in N.M. Gadzama, F.A. Adeniji, W.S. Richards and G.G.R. Thambiyahpillay (ed) Arid Zone Hydrology and Water Resources, Ibadan: University of Maiduguri, Nigeria, pp. 89-98
- Bunu, M.Z. (1999) Groundwater Management Perspectives for Borno and Yobe states, Nigeria. In the Journal of Environmental Hydrology Volume 7 Paper 19. The Electronic Journal of the International Association for Environmental Hydrology. On the World Wide Web at <http://www.hydroweb.com>
- Chilton J. (1999) Groundwater in the urban environment- selected city profiles. Balkema, Rotterdam.
- Dami A, Adesina F. A and Garba S. S. (2011) Adaptation Strategies to Environmental Change in the Nigeria's Section of the Chad Basin in Journal of Geography and Geology Vol. 3, No. 1 [www.ccsenet.org/jgg](http://www.ccsenet.org/jgg);
- Eni, D.I, Obiefuna, J.N, Oko, C and Ekwole, J. (2011) Impact of Urbanization on Subsurface water Quality in Calabar Municipality, Nigeria. International Journal of Humanities and Social Science. Volume 1 number 10 : Page 167-173.

- Foster, S.S.D. (2001). The interdependence of groundwater and urbanisation in rapidly developing cities. In *Urban water* volume 3 number 3 page:185-192.
- Global Water Partnership (2013) Trans boundary Groundwater Factsheet .the lake chad basin aquifer system. Global Secretariat ,Drottningatan, Stockholm Sweden. At [www.gwp.org](http://www.gwp.org).
- Jacobsen, M, Webster, M., and Vairavamoorthy, K. (2012).The future of water in African cities. Why waste water? *Direction in Development*, Washington, DC, World Bank.
- Hanidu, J.A. (1990). National growth, water resources and supply strategies in Nigeria in the 1990s. *Water resources J. Nigeria Association of Hydro geologists*, 1:1-6
- Idu A. J (2015) Threats to Water Resources Development in Nigeria. *Geology and Geophysics*. At <http://dx.doi.org/10.4172/jgg.1000205>.
- Lake Chad-HYCOS (Hydrological Cycle Observing System) 2015.Project document.Annex 5
- Marte, M.A. (1986). Groundwater exploitation and drilling technology in Arid areas of Nigeria, Borno as a case study. *Proceedings of the First annual Symposium and Training workshop on Groundwater resources in Nigeria*, University of Lagos, Nigeria pp. 141-173
- Naik, P.K, Tambe, J.A, Dehury, B.N and Tiwari, A.N (2008) Impact of urbanization on the groundwater regime in a fast growing city in central India. *Environmental monitoring and assessment*.
- Ndubuisi, O.L. (1990). Managing groundwater resources of the Lake Chad Basin in Nigeria. *Proc, of the First Biennial National Hydrology Symposium*, Maiduguri, Nigeria pp. 429-440.
- Ngamdu, M. B. (2015) Challenges of Adaptive Water Management in the LakeChad Basin. *International Journal in Management and Social Science (IJMSS)* Volume.03 Issue-09. <http://www.ijmr.net.in>
- Oluboye, M.O. (1995). Groundwater monitoring network as an aid to averting some ecological disaster: The Case for Chad basin area. *Water Resources (Journal of Nigerian Association of Hydrogeologists)*, 6, 57-60.
- Putra, D and Baier, K. (2008) Impact of Urbanization on Groundwater Recharge – The Example of the Indonesian Million City Yogyakarta , In: *UN Habitat- United Nations Settlement Programs: Fourth session of the World Urban Forum*, Nanjing, China, Documentations of Germany's Contribution to a Sustainable Urban Future.
- Usman, Y. M., Mohammed A., Ibrahim, B. and Saleh1, B. A. (2016) Assessment of Groundwater Quality status along River Ngadda in Maiduguri, Nigeria. In *The International Journal Of Engineering And Science (IJES)* Volume 5 Issue 1 [www.theijes.com](http://www.theijes.com)
- Vassolo, S.Bila, M and Hamit, A. (2009) Sustainable Water Management: A Review of the Groundwater Situation in the Lake Chad Basin.Project Activities -Report N° 2.
- Vassolo, S. (2012) Groundwater Need Assessment Lake Chad Basin. BY Bundesanstaltfür Geowissenschaften und Rohstoffe (BGR).
- Wakida, F.T and Lerner, D.N. (2005) Non-agricultural sources of groundwater nitrate: a review and case study. *Water research*.
- Yusuf, A.K. (2015) Groundwater Resource Management Strategy in the Nigerian Sector of the Chad Basin. In *Journal of Natural Sciences Research*.Volume.5, No.14.[www.iiste.org](http://www.iiste.org)