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The Journal of Agriculture and Food Environment (JAFE) is a new initiative of the Delta State University, Abraka approved for publication by the Faculty of Agriculture, Abraka. The purpose of the journal is to provide a forum for publishing peer-reviewed scholarly works in the different disciplines of agriculture and food environment.

The areas covered by JAFE include: General Agriculture and Food Policy; Animal Science, Animal Production and Health, Aquaculture, Fisheries, Crop Science, Crop Protection and Horticulture, Soil Science, Agricultural Economics, Agricultural Administration and Farm Management, Agricultural Extension, Agricultural Communication, Agro-Biotechnology, Agricultural Biology, Forestry and Wildlife, Food Science and Technology, Agricultural Ecology, Environmental Management, and any other related disciplines in food production (including food security), processing and marketing, and general agro-environment.

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Original Research Article

Financial Inclusion and its Determinants among Agro-Entrepreneurs in South-South States, Nigeria

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Abstract

Financial Inclusion is an important driver of economic growth. Financial inclusion in the context of this paper involves access to and use of banking services such as ownership of bank accounts, savings, borrowing/credit and use of banking agents at affordable costs by agribusiness entrepreneurs. The major objective of this study was to analyze financial inclusion and its determinants among agro entrepreneurs in South-South States of Nigeria. The study employed a multi-stage random sampling procedure. Data were collected with a well-structured questionnaire. Collected data were analyzed using descriptive statistics (means, percentages and standard deviations) and inferential statistical tools (multiple logistic regression analysis). Some socioeconomic determinants of financial inclusion of agribusiness entrepreneurs in South-South geopolitical zone were found to be statistically significant, namely: gender, education, financial literacy, age, marital status, location and household size. The most significant barriers to involuntary financial inclusion were distance between banks and the home/business premises of agribusiness entrepreneurs, cost of maintaining a bank account and too much paper work, whereas the barriers to voluntary financial inclusion were insufficient income, preference for handling or dealing with cash, and illiteracy. It was recommended among other things that financial literacy workshops that pertain to financial education should be organized for agribusiness entrepreneurs in the South – South geopolitical zone of Nigeria, to enable them gain understanding of financial products, concepts and risks.

Keywords: Financial Inclusion, Determinants, Entrepreneurs

Introduction

The Central Bank of Nigeria explains that financial inclusion (FI) is achieved when adults (persons of 18 years of age and older) have easy access to a broad range of formal financial services that meet their needs and are provided at an affordable cost (CBN, 2018). Allen *et al.* (2012) and Camara *et al.* (2014a) posit that financial inclusion involves access to and use of formal financial services. This is to say that being an account owner with a bank is not sufficient for financial inclusion; it must also involve making use of that account. This is why financial

inclusion is measured by a number of indicators. Use of various banking services such as deposits, credit, savings, payments, use of banking agents, remittance and insurance services are some of the multiple indicators of a formal financial inclusive system.

There is a strong consensus that increased levels of financial inclusion – through the extension of savings, credit, insurance, and payment services – contribute significantly to sustainable economic growth. Access to formal financial services is essential to the ability of individuals and households to manage their lives and build their futures. Access to finance cannot be the privilege of a few, but should be available to all and can be a means to reduce inequalities, particularly for the most vulnerable, including those living in rural areas, women and youths. For businesses to have the ability to invest, employ people and grow, access to finance is very important, and is therefore an essential element of an inclusive growth. It is also tied to the financing for development agenda, especially in relation to mobilization of domestic resources, given the direct links between domestic savings rates and long-term economic growth. Without access to formal financial services, poor families must rely on informal mechanisms: family and friends, rotating savings schemes, pawn-brokers, moneylenders, money under the mattress. These informal mechanisms are insufficient, can be unreliable, and are often very expensive. Thus, financial exclusion imposes large opportunity costs on those who most need opportunity (CGAP, 2014-2018). But exclusion does not just happen as there are a number of factors that determine the admissibility of an individual or business enterprise into the formal financial system.

A number of socioeconomic and demographic variables have been identified to be responsible for the decision to be financially included or excluded. Akudugu *et al.* (2012) employed the logit model and observed that individuals take decision on whether to be included or excluded based on the reaction threshold inherent in them given a number of factors. Beyond the threshold the person will not seek to be included in the formal financial market, while at the critical threshold level the desire to be included in the formal financial market is motivated.

Ewuzie (2018) split the determinants of FI into demand-side determinants and supply-side determinants. The demand-side variables include variables such as literacy, income, employment, household size and years of experience. Through a multiple regression model, these variables which are explanatory were regressed against the Financial Inclusion Index, (FII). Potrich *et al.* (2015) opined that financial inclusion determinants can be modeled using either the logistic model or the probit model. This is because the two models follow the discrete choice models which relate the choice made by each person to the attributes of the person and the attributes of the alternatives available to the person. The models, which are used to forecast how people's choices, will change under changes in demographic characteristics or the attributes of the alternatives. The opposite of financial inclusion is financial exclusion. Exclusion can be effected when the non-users of formal financial services voluntarily or involuntarily exclude themselves from access. The reasons for exclusion constitute the barriers to inclusion in the opinion of end users and as such their responses can provide insights to policy makers on the reasons for none-use and how to build inroads in the expansion of the use of formal financial services.

Objectives of the study

The major objective of the study was to evaluate financial inclusion and its determinants among agro entrepreneurs in the South-South States of Nigeria. The specific objectives were to:

- i. determine the barriers to financial inclusion, and

- ii. evaluate the determinants of financial inclusion

Hypothesis of the study

The following null hypothesis was tested.

HO₁: There is no significant relationship between the socioeconomic characteristics of agribusiness entrepreneurs (the determinants of financial inclusion) and financial inclusion.

Materials and Methods

The South-South geopolitical region of Nigeria is made up of six States namely: Delta; Edo; Bayelsa; Rivers; Cross River and Akwa-Ibom. The study focused on agro-entrepreneurs, specifically crop (yam) farmers/sellers; fresh fish farmers/sellers and poultry farmers/sellers, in the six States of South-South Nigeria. The study employed a multi-stage random sampling procedure. Three States were randomly selected out of the six States that make up the region. A total of 30 agro-entrepreneurs comprising of crop (yam) farmers and marketers, fish farmers and marketers as well as poultry farmers and marketers were randomly drawn from each of the 18 LGAs to give a total sample size of 540 respondents and a corresponding purposive selection of 90 commercial banks. Both primary and secondary data were used in the study. The primary data involved individual level survey by means of well-structured questionnaires, modified from the World Bank's 2014 and 2017 Global Findex database.

Model Specification

The Determinants of Financial Inclusion

This section aims at examining the role of socioeconomic characteristics of agribusiness entrepreneurs in the determination of financial inclusion. Four measures of financial inclusion were used namely; formal savings, formal borrowings, use of banking agents and frequency of use of accounts. Thus the dependent variables comprised of all the four indicators of financial inclusion while the independent variable comprised of the socioeconomic characteristics of agribusiness entrepreneurs. The nature of analysis necessitated the use of a multivariate logistic regression model. Mathematically, the equation takes the form:

$$Y_i = \beta_0 + \beta_i X_i + e_i \dots \dots \dots (1)$$

Where;

Y_i = the financial inclusion variables: account ownership; formal savings; formal borrowings; use of banking agents and frequency of use of accounts, while i is the index for individuals

β_i = parameters to be estimated

X_i = socioeconomic characteristics (age, gender, marital status, education, household size, location, financial literacy, income) for each individual respondent.

Explicitly, the equation is given as:

$$Y_i = \alpha + \beta_1 * \text{Age} + \beta_2 * \text{Gen.} + \beta_3 * \text{MS} + \beta_4 * \text{Educ.} + \beta_5 * \text{HHS} + \beta_6 * \text{Loc.} + \beta_7 * \text{FinL.} + \beta_8 * \text{Income} + \dots + e_i \dots \dots \dots (2)$$

Where;

Y_i = financial inclusion variable index;

Age = Age of agribusiness entrepreneurs, to be measured in years;

Gen = Gender. This was dummy variable which is equal to one if the individual is a male and zero, otherwise;

MS = Marital Status, whether married, divorced, widowed or single. It was a dummy variable: 1 for married; 2 for single; 3 for divorced and 4 for widowed;

Educ = Education, measured as the number of years spent in school;

HHS = Household Size, measured as the number of people living together and feeding from the same pot;

Loc = This is location. It is a dummy variable that takes the value of one if the respondent resides in urban area and zero, otherwise. For the purpose of this study, rural area was referred to as areas outside of cities and towns since this can always easily be perceived;

FinL = Financial literacy, a dummy variable that takes the value of 1 if the individual is financially literate and 0, otherwise. Answers to questions relating to knowledge of interest rates, interest compounding, inflation and risk diversification were collated. Individuals who answered *yes* to three out of the four questions were deemed financially literate. It was measured as a dummy variable equal to 1 for a *Yes* answer and 0 otherwise.

Income = Income was measured in Nigerian naira representing the amount realized by the agribusiness entrepreneur on a monthly basis.

Results and Discussion

Socioeconomic Characteristics of Agro-Entrepreneurs

Table 1 shows that majority (51.3%) of the agribusiness entrepreneurs, crop (yam) farmers/sellers, fresh fish farmers/sellers and poultry farmers/sellers, were within the age bracket of 40-59 years. This age range represents the economically productive age. This has implications on their ability to make informed decisions for or against the use of financial services, formal or informal, and whether to be included in the formal financial services ecosystem or not. Policy development programmes on financial inclusion should focus on this age range for maximum impact. Looking at gender, both male and female were engaged in agribusiness entrepreneurship of the selected enterprises with the majority being females (60.0%).

The study also revealed that 74.5 percent of the sampled agribusiness entrepreneurs were married, with an average household size of 5 persons. This means that there was reasonable family labour available to the agribusiness entrepreneurs. About 49.6 percent of the respondents completed secondary education, which is a relatively good level of education, implying that these people were in a position to take rational decisions concerning finance and its management, and whether to be included in the formal financial system or not.

On the basis of location, 52.6 percent of the sampled respondents resided in urban areas. The study also revealed that years of experience in the respective enterprises was 7 years on the average, and that majority of the respondents (58.1%) earned less than ₦100,000 in a month as income.

Table 1: Distribution of Respondents According to Socioeconomic Characteristics

Variable	Frequency	Per cent	Mean/mode
Age			
20 – 39 years	180	33.3	
40 – 59 years	277	51.3	46 years
60 – 79 years	82	15.2	
Above 79 years	1	0.2	
Gender			
Male	213	39.4	
Female	327	60.6	Female
Marital status			
Married	402	74.4	Married
Single	106	19.6	
Divorced	15	2.8	
Widowed	17	3.1	
Household size			
1 – 4 persons	177	32.8	
5 – 8 persons	338	62.6	5 persons
9 – 12 persons	22	4.1	
Above 12 persons	3	0.6	
Educational level			
No formal	83	15.4	
Primary	219	40.6	Primary
Secondary	213	39.4	
Tertiary	25	4.6	
Location			
Urban	284	52.6	Urban
Rural	256	47.4	
Occupation			
Crop farmer	106	19.6	Crop farmer
Crop seller	89	16.5	
Fresh fish farmer	86	15.9	
Fresh fish seller	90	16.7	
Poultry farmer	92	17.0	
Poultry seller	77	14.3	
Farming experience			
Less than 5 years	216	40.0	
5 – 8 years	261	48.3	7 years
9 – 12 years	16	3.0	
Above 12 years	47	8.7	
Income (₦)			
Less than ₦100,000	314	58.1	
₦100,000-₦200,000	113	20.9	₦115,185.2
₦201,000-₦300,000	90	16.7	
₦301,000-₦400,000	16	3.0	
Above ₦400,000	7	1.3	

Source: Field Data, 2021

The Determinants of Financial Inclusion in South-South States

Table 2 shows the output of the multivariate logistic regression analysis of the determinants of financial inclusion regressed against some indicators of financial inclusion namely: Formal savings, Formal borrowings, Banking agents and Account usage. Note that the control variables

form part of the assessment that the financial services providers use in granting services to their potential consumers. A useful means for modeling the dependence of a binary response variable on one or more explanatory variable(s) is the logistic regression model, where the predictor variables can be either categorical or continuous. The fit of the resulting model can then be evaluated using a number of methods one of which is the pseudo R squares especially the Cox and Snell and the Nagelkerke R^2 , both of which are methods of calculating the explained variation. However, unlike the linear regression model, the goodness of fit of a logistic model is only an indication of how useful the predictor variables are in predicting the outcome variable and so can be referred to as measures of effective size, (Bewick *et al.*, 2005).

The concern of this work was to find out the extent to which individual-level characteristics influenced formal savings, formal borrowings, use of banking agents and use of accounts generally. These variables constituted the financial inclusion variables. The variable coefficients in Table 2 represent the log-odds of being in a category relative to the base category (with respect to each of the outcome variables), given a one unit increase in the explanatory variables. Thus being a man increases the likelihood of having a savings account by a factor of 20.963, its odds-ratio (Exp (B)) or the exponent of the log odds. In other words, female agribusiness entrepreneurs were less likely to have a savings account in formal financial institutions than their male counterparts. So many reasons were adduced for this; e.g. mobility, inability to meet the requirements for opening accounts with formal financial institutions, inability to have control over their finances, etc. This result is in agreement with the works of Issouf *et al.* (2016), Zins and Weill (2016) and Kairiza *et al.* (2017). For formal borrowing, age was significant, though negative, which is also reflected in an odds-ratio (Exp (B)) that was less than 1 (OR= 0.848). This is to say that younger entrepreneurs were less likely to use formal borrowing services due to lack of wealth accumulation. Older entrepreneurs were therefore more likely to borrow formally from financial institutions but up to a certain age after which they were less likely to use this service. This is implied by the odds ratio of 0.848, meaning that for each year of the life of an agro entrepreneur, the chance of borrowing formally decreased by 15.2% (1-0.848) over the years. This deduction is in agreement with the findings of Mohammed *et al.* (2019) and Zins and Weills (2016).

Other significant variables associated with formal borrowing were household size, location and financial literacy. The odds ratio of 1.232 for household size is an indication that there was a 23.2% chance of agro entrepreneurs formally borrowing or desiring this service with every one unit increase in household size. This makes practical sense because with increase in household size, the propensity to save reduces since there are more mouths to feed. They would rather opt for borrowing services than savings. This can also be traced to why majority of them preferred to borrow from the informal financial services sector.

Those who lived in the rural areas were 47.6 percent (1-0.524) less likely to borrow formally than those in the urban areas (Table 2). This is in agreement with Abel *et al.* (2018)) that the greater the distance away from centers that provide financial products, the less the people will be financially included. For the Use of banking agents, age, marital status, educational level, and household size were all significant. Financial literacy was negative, but significant, while Use of accounts was significantly and positively associated with variables such as age, household size, and income. Financial literacy was negative but significant. There is therefore need for trainings and workshops bordering on financial literacy for more inclusiveness.

The effectiveness of a regression model is evaluated by calculating how strong the relationship between the predictor variables and the outcome variables is. Logistic regression makes use of pseudo-R² statistics to achieve this. They describe the proportion of variance in the outcome that the model successfully explains.

Table 2 indicates that the Cox & Snell R² was 0.355 while the Nagelkerke R² was 0.421.

Table 2: Determinants of Financial Inclusion in South-South States

		B	Std. Error	Wald	Df	Sig.	Exp(B)
Formal Savings	Intercept	-8.174	3413.603	0.000	1.000	0.998	
	AGE	-0.076	0.061	1.533	1.000	0.216	0.927
	GENDER	16.857***	0.000	13.754	1.000	0.000	20.963
	MS	-0.532	0.626	0.720	1.000	0.396	0.588
	EDU	-0.211	0.899	0.055	1.000	0.814	0.810
	HHS	-0.253	0.348	0.527	1.000	0.468	0.777
	LOCATION	-17.819	3413.600	0.000	1.000	0.996	0.000
	FINLIT	-17.951	5417.986	0.000	1.000	0.997	0.000
	INCOME	0.000	0.000	0.131	1.000	0.717	1.000
Formal Borrowing	Intercept	15.277***	2.327	43.112	1.000	0.000	
	AGE	-0.165***	0.029	32.079	1.000	0.000	0.848
	GENDER	-0.502	0.595	0.711	1.000	0.399	0.605
	MS	-0.398	0.250	2.532	1.000	0.112	0.672
	EDU	-0.347	0.265	1.711	1.000	0.191	0.707
	HHS	0.209*	0.124	2.829	1.000	0.093	1.232
	LOCATION	-0.646*	0.368	3.087	1.000	0.079	0.524
	FINLIT	-2.972***	0.587	25.649	1.000	0.000	0.051
	INCOME	0.000	0.000	0.709	1.000	0.400	1.000
Banking Agents	Intercept	11.682***	2.422	23.267	1.000	0.000	
	AGE	-0.173***	0.030	33.235	1.000	0.000	0.841
	GENDER	0.806	0.632	1.628	1.000	0.202	2.240
	MS	-0.756**	0.307	6.051	1.000	0.014	0.469
	EDU	-0.608**	0.292	4.342	1.000	0.037	0.545
	HHS	0.459***	0.132	12.175	1.000	0.000	1.583
	LOCATION	-0.223	0.395	0.317	1.000	0.573	0.800
	FINLIT	-2.669***	0.621	18.475	1.000	0.000	0.069
	INCOME	0.000**	0.000	3.945	1.000	0.047	1.000
Use of Accounts	Intercept	6.052**	2.891	4.384	1.000	0.036	
	AGE	-0.170***	0.034	25.265	1.000	0.000	0.843
	GENDER	1.094	0.803	1.854	1.000	0.173	2.986
	MS	-0.197	0.364	0.291	1.000	0.589	0.822
	EDU	-0.555	0.385	2.074	1.000	0.150	0.574
	HHS	0.828***	0.162	26.122	1.000	0.000	2.289
	LOCATION	0.089	0.518	0.029	1.000	0.864	1.093
	FINLIT	-3.173***	0.825	14.802	1.000	0.000	0.042
	INCOME	0.000*	0.000	3.515	1.000	0.061	1.000
Pseudo R-Square		-2 Log Likelihood		Chi-Square	Df	Sig.	
Cox and Snell	0.355	767.796		236.984	32	0.000	
Nagelkerke	0.421						
McFadden	0.236						

*, **, and *** are statistically significant at the 10%, 5% and 1% alpha levels, respectively.
Source: Field Data 2021

These are not measures of goodness of fit as is the case with linear regression; rather, they are an indication of the usefulness of the explanatory variables in predicting the outcome variable, financial inclusion. This is why they are also referred to as measures of effective size. So from the table, it can be deduced that the explanatory variables in the model were able to predict between 35.5 and 42.1 percent of the outcome variable, and financial inclusiveness of agro

entrepreneurs in the South-South States. This is to say that the null hypothesis of this study was sustained, that there is a significant relationship between the socioeconomic characteristics of agro entrepreneurs and financial inclusion.

Barriers to Financial Inclusion

The reasons for financial exclusion constitute the barriers to financial inclusion in the opinion of end users and as such their responses provide insights to policy makers on the reasons for non-usage and how to build in roads in the expansion of the use of formal financial services. Exclusion can be voluntary or involuntary with the latter being denied access despite their desire to be financially included. Table 3 indicates that reasons for involuntary financial exclusion were: banks are too far, cost of maintaining a bank account, too much paper work, and unsuitable products whereas the reasons for voluntary financial exclusion included insufficient income, preference for handling or dealing with cash, and illiteracy. The most significant barrier to financial inclusion was insufficient income. This result is in line with the works of Zins and Weill (2016), Lanie (2017), and EFINA (2018).

Table 3. Shows the barriers to Financial Inclusion in the South-South States

S/No	Barriers	Mean	Rank	Remarks
Reasons for Voluntary financial exclusion (Voluntary barriers)				
1	Insufficient income	3.7*	1 st	Sig.
2	I prefer dealing with cash	3.4*	2 nd	Sig.
3	Too much paper work	3.1*	3 rd	Sig.
4	Financial illiteracy	2.9*	4 th	Sig.
Reasons for Involuntary financial exclusion (Involuntary barriers)				
5	Banks are too far from my house and business premise	2.8*	5 th	Sig.
6	Cost of maintaining a bank account	2.6*	6 th	Sig.
7	Unsuitable products	2.6*	6 th	Sig.
8	I do not trust Banks	2.4	7 th	Not Sig.
9	A family member already has an account	2.4	7 th	Not Sig.

*Means ≥ 2.5 are significant barriers to financial inclusion
 Source: Field Data 2021

EFINA, (2018) noted categorically that the biggest obstacles to having a bank account in Nigeria were affordability and institutional exclusion. Specifically, affordability captures irregular income, lack of job/joblessness, too much cost and the expensive nature of having a bank account. Institutional exclusion covers such factors as banks being too far, inability of some persons to read, and too much documentation.

Conclusion

The need to deepen our understanding of financial inclusion in relation to agribusiness performance called for this research investigation. Financial literacy was conspicuously lacking in the respondents and this is a serious determinant factor for financial inclusion. Financial literacy relates to an individual’s knowledge of financial concepts and products. Financial literacy workshops should be organized for agribusiness entrepreneurs in the South – South geopolitical zone of Nigeria. These workshops should be tailored towards their financial education to enable them gain understanding of financial products, concepts and risks. Through

this guided instruction, information and/or objective advice, they will be able to develop the needed skills and confidence to become more aware of financial risks and opportunities so as to be able to make informed choices and to know where to go for help so as to improve their financial wellbeing. Affordability, accessibility and availability of formal financial services were the main reasons why agro-entrepreneurs were under banked or unbanked. These factors relate to fees, Know-Your-Customer (KYC) policies which lead to a cumbersome and expensive paper work, coupled with the fact that traditional banks are mainly located in urban centers with banking hours that make them unavailable for those who work during the day or those who cannot travel to use bank services regularly. There should be increased awareness about the use of Mobile Banking (POS) agents as a means of getting the unbanked and under-banked agro-entrepreneurs to embrace the use of their accounts. Banks on their own part should step up in handling issues relating to unsuccessful transactions via POS as this will instill trust in the financial institutions and therefore encourage patronage on the part of the agro entrepreneurs. This is important because a developed, inclusive and functional financial sector has the capacity to drive a successful entrepreneurial engagement in technological innovation. Inclusiveness in safe, easy and affordable source of finance is a catalyst for accelerating agribusiness growth, and enables economically and socially excluded entrepreneurs to integrate better into the economy and actively contribute to development.

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Original Research Article

The Use of *Moringa oleifera* and *Allium sativum*, and Funding of Poultry Production in Ekiti State, Nigeria

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Abstract

Phytogenic plants contain some chemical substances named phytobiotics which have been investigated and found useful in modulating the gastrointestinal tracts of poultry birds, thereby preventing subclinical infections cause by pathogenic microbes and leading to an improvement in their performance and health status. This study was designed to determine the levels and funding of poultry production, associated with the use of *Moringa oleifera* (MO) and *Allium sativum* (AS) in Ekiti State. A cross-sectional group of 135 farmers were sampled from 9 local government areas (LGAs), (3 LGAs were selected from each of the 3 senatorial districts in Delta State). All data were collected using a well-prepared and structured schedule interview from primary source (questionnaire). The objectives were presented using descriptive statistical tools such as tables, frequencies and percentages. Broiler production was ranked first by 38.5% of the respondents. Levels of poultry production indicated that most of the broiler producers (55.7%), layer producers (47.3%) and cockerel producers (75.0%) were medium scale, medium scale and small scale farms respectively. *Own savings* was observed as being the primary (27.5%) source of funding. The majority (43.3%) of the respondents observed that the percentage of bird's response were from 51 to 75%. It was also discovered that 96.3% of the respondents had "fairly better" performance in the use of "MO" and "AS" in poultry production. The main advantage of feeding these plants was "more activeness" by 53.7% of the respondents. The first procedure suggested was vaccination by 32.2%, followed by medication with 25.7% of the respondents. Conclusively, phytobiotics in phytogenic plants are helpful in improving the overall performance of poultry birds.

Keywords: Broiler, Feed trial, Owing saving, Percentage response, Phytobiotic

Introduction

There are various secondary metabolites known as phytochemical substances (phytobiotics) such as trace metal ions, vitamins, alkaloids, carotenoids, polyphenols, fats, carbohydrates, and

proteins that are contained in phytogetic plants. These unique substances were involved in the promotion of health benefits in humans and animals (Sravanthi and Rao, 2014). There is a broad range of plant materials that produce these phytochemical substances. The majority of them have a long history in human nutrition, where they have been used as flavours, food preservatives, colour pigments and medicines (Elagib *et al.*, 2013). The biologically active properties in phytogetic plant materials are advantageous in modern poultry production where they produce anti-oxidative, anti-inflammatory, anti-microbial and digestion-enhancing effects. Anti-microbial effects probably rank first among the reasons for the use of phytogetic plants in the poultry industry, followed, perhaps, by their digestion-enhancing effects (Vinus *et al.*, 2018). They are therefore useful as growth promoters within the alternative growth promoters (AGP) replacement strategy framework (Agbetuyi and Oloruntola, 2020).

A few of the phytogetic plants and plant extracts that have attracted research interests recently include shea butter (Agbetuyi and Oloruntola, 2020), *Moringa oleifera* and *Allium sativum* Sugiharto *et al.*, 2018; Agbetuyi *et al.*, 2023).

Allium sativum (garlic) is traditionally one of the major spices and herbs used for medicinal purposes (Puvaca *et al.*, 2013). It is rich in sulphur-containing substances, and belongs to the family *Liliaceae*. The plant is widely distributed globally, with over 81% of world output produced in China (Lewis, 2012). Recent research findings on the use of *Allium sativum* as a phytogetic feed additive showed improvements in weight gain, feed efficiency, livability, and reduced mortality in broiler chickens. Oleforuh-Okoleh *et al.*, 2014; Karangiya *et al.*, 2016). The plant is also known for its strong stimulating effect on the immune and digestive systems of broiler chickens (Al-Shuwaili *et al.*, 2015). Hanieh *et al.* (2010) and Mansoub (2011) listed the beneficial effects of their phytobiotics to include antimicrobial, hypolipidemic, antihypertensive, anti-atherosclerosis, antioxidant, antiviral, antifungal and vasodilatory characteristics. In addition, *Allium sativum*, according to Toyhyani *et al.* (2011), is also capable of reducing intestinal pathogenic bacteria loads, and improving digestion and absorption in broiler chickens. *Moringa oleifera* leaf and *Allium sativum* bulb have potential usefulness as feed additives that promote broiler chicken production (Agbetuyi *et al.*, 2023).

Moringa oleifera is a tiny, drought-resistant deciduous tree with a height of 5-12 cm. It is also called drumstick tree with outstanding capacity to provide adequate nutritional, medicinal (Oyeyinka and Oyeyinka, 2018), and industrial values with some useful minerals, vitamins and amino acids (Leone *et al.*, 2018). The various part of *Moringa oleifera* has been used as medication for treating many infections due to its exceptional therapeutic and medicinal properties. The treatment ranges from inflammation, infectious diseases with cardiovascular, gastrointestinal, haematological and hepatorenal disorders (Alnidawi *et al.*, 2016). It is also potentiated as a good source of growth stimulant, antioxidant compounds such as ascorbic acid, flavonoids, phenolics and carotenoids, and anti-microbial agent (Mbikay, 2012; Teixeira *et al.*, 2014). The ease of propagation of *Moringa oleifera* with relatively low soil nutrients and water requirement, ensure the ease of its production and friendliness in most environment (Paliwal *et al.*, 2011). The plant often trapped carbon dioxide at a higher rate of about 20 times more than king of bitter and some other plants (Potadar and Patil, 2017). According to Donkor *et al.* (2013), supplementation of *Moringa oleifera* in poultry diet could improve growth performance and increases the serum level of biochemical minerals. Hence, this study was designed to determine the levels and funding of poultry production, associated with the use of *Moringa oleifera* and *Allium sativum* in Ekiti State, Nigeria.

Materials and Methods

The Study Area

The research was carried out in Ekiti State, Nigeria. Ekiti State has a total land area of about 6,353 km². The State lies within the following: 7°40'N 5°15'E/7.667°N 5.250°E and enjoys a tropical climate with two distinct seasons. These are the rainy season (April – October) and the dry season (November – March). The temperature ranges between 21 °C and 28 °C, with high humidity. The people of the State are mainly of the Yoruba ethnic group, although other Nigerians and foreigners co-exist peacefully in the State. The major occupation of the people is farming, which includes rearing of animals and cultivation of crop plants, especially arable crops such as maize, yam, rice, cassava, plantains, vegetables, and pepper.

Sampling Technique

The respondents for this study (135) were selected from three local government areas (LGAs) in each of the three Senatorial districts of the State by random sampling, with 15 copies of the questionnaire administered per LGA. The LGAs which were randomly sampled were: Ado, Irepodun Ifelodun, Ekiti West, Ikere, Ekiti South West, Gbonyin, Ikole, Oye and Ido/osi. The administrative map the LGAs is shown of Ekiti State showing in figure 1:

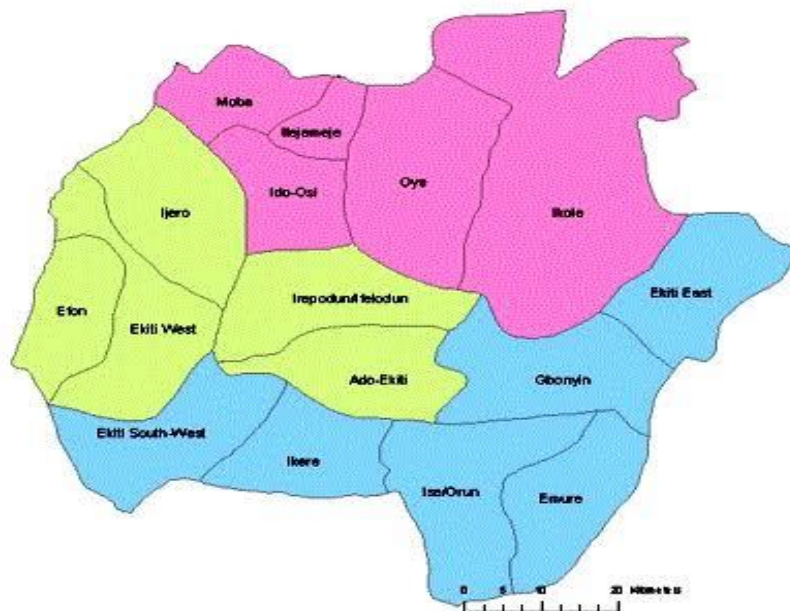


Figure 1: Administrative Map of Ekiti State showing the LGAs

Source: (ekitistategov.com, 2014)

Sources of Moringa oleifera and Allium sativum

Moringa oleifera was sourced from available moringa plants (stands) in their respective communities, while *Allium sativum* was obtained from the local markets and garlic hawkers in their communities.

Levels of Poultry production

The levels of poultry production in Ekiti State were determined using a three scale index (small, medium and large). The small scales were the farmers who had less than 100 birds at a time on their farms. Farmers with the categories of medium scale, kept 101 – 500 birds, while the large scales are those with more than 500 birds in production.

Data Collection

Data were collected using a well-prepared and structured interview schedule. Data were collected from a primary source (questionnaire) which sought information on the farmers' type of poultry enterprise, levels of poultry production and funding, birds' responses to feed given, farmers' experience in using *Moringa oleifera* and *Allium sativum* for poultry production and the procedures for improving birds' health.

Statistical Analysis

All data collected were analyzed using the Statistical Packages for Social Sciences (SPSS) to determine the use of *Moringa oleifera* and *Allium sativum* by farmers for poultry production in Ekiti State, Nigeria. Descriptive statistical tools such as tables, frequencies, and percentages were used for the analysis.

Results and Discussion

Poultry farmers' enterprises

Multiple responses were obtained from the farmers and sampled for the determination of *Moringa oleifera* and *Allium sativum* usage in Ekiti State. The result strongly suggested that broiler production was ranked first by 38.5% of the respondents. Those engaged in Layer production alone were 21.1% of the respondents, while 30.1% of them combined broiler production with layers. Cockerel production was the least by 10.2% of the respondents (Table 1). From the result, broiler production was the most preferred among the poultry farmers in Ekiti State. The rationale behind this could be attributed to its short production cycle and, consequently, its quick returns on investment.

Table 1: Poultry enterprises engaged in by the respondents

Enterprises	Responses			Total	Percent
	1st	2ⁿ d	3rd		
Broiler production	60	-	-	60	38.5
Layer production	29	2	2	33	21.2
Broiler and layer production	44	3	-	47	30.1
Cockerel production	2	14	-	16	10.2
Total				156*	100.0

Source: Computation from Field Survey Data, 2021; *Multiple responses

Levels of poultry production

Different scales were used to assess the levels of poultry production in Ekiti State. The scale was based on the farmer's farm size, which is in terms of the number of birds in production. The majority (55.7%) of the respondents who were into broiler production were medium scale

farmers (Table 2). This was followed by the small scale with 36.1% of the respondents, and the least (8.2%) were into large scale production. In layer production, medium scale had the majority (47.3%), while small scale had 34.5% of the respondents. Only 18.2% of the farmers were into large scale production.

Table 2: Scale of poultry production

Scale of Poultry Production	Broiler production		Layer Production		Cockerel Production	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Small	35	36.1	19	34.5	18	75.0
Medium	54	55.7	26	47.3	4	16.7
Large	8	8.2	10	18.2	2	8.3
Total	97	100.0	55	100.0	24	100.0

Source: Computation from Field Survey Data, 2021; Small scale: less than 100 birds, Medium scale: 100 – 500 birds, Large scale: more than 500 birds

The cockerel production showed that small scale producers were the highest (75.0%) among its farmers, who were followed by medium scale with 16.7% of the respondents, and the large scale had 8.3% of the respondents (Table 2). The scale of poultry production enterprises in the State revealed that most of the broiler producers have average (medium scale) farm size, and were the majority in poultry business. Most of the layer producers also operate an average farm size (medium scale), but have more of its farmers keeping large scale farms compared to other enterprises. Moreover, the cockerel was rarely produced since the majority of its producers operate in the least (small scale) of production. The least production of cockerel might be attributed to an extended/prolong production cycle of the birds.

Table 3 shows the respondents classified according to engagement (part-time or full-time) in poultry production, and their sources of funding in Ekiti State, Nigeria. The study observed that most of the respondents were part-time rearers of broilers (65.2%), layers (55.8%) and cockerels (71.4%), while those that reared broilers, layers and cockerels on full-time basis constituted 34.8%, 44.2% and 28.6% respectively. This finding indicates that poultry production is operated as part-time business, and this explains why large-scale poultry farms are few in Ekiti State. The result on sources of fund indicate that *Own savings* was the major (27.5%) way in which poultry production was funded in Ekiti State. This was closely followed by both *borrowed fund and own savings* with 23.7% of the respondents. The least source of fund (9.2%) was obtained from the *cooperatives* (figure 2). The highest level (26-50%) of “own savings” involvement had 23.1% of the respondents, followed by 51-75% with 22.9% of the respondents (figure 3). It was also revealed that “Friends and Family” was the main source of borrowed fund by 26.6% of the respondents. It is obvious that many of the poultry farmers fund their farm businesses from personal or own savings, while a few of them make use of other sources of fund (table 3). This is the reason for low level of poultry production as seen in Ekiti State. It was reported by Osei *et al.* (2018), that personal savings limit the financial ability of farmers to meet certain shortfalls in capital involvement in poultry businesses.

Table 3: Poultry production and its funding in Ekiti State

Characteristics	Responses	Frequency	Percent	Cumulative Percent
Broiler	Part time	88	65.2	65.2
	Full time	47	34.8	100.0
	Total	135	100.0	
Layer	Part time	29	55.8	55.8
	Full time	23	44.2	100.0
	Missing responses	83	0.0	
	Total	135	100.0	
Cockerel	Part time	15	71.4	71.4
	Full time	6	28.6	28.6
	Missing responses	114	0.0	
	Total	135	100.0	
Borrowed fund	10 - 15%	3	7.9	7.9
	16 - 25%	12	31.6	39.5
	26 - 50%	11	28.9	68.4
	51 - 75%	9	23.7	92.1
	76 - 100%	3	7.9	100.0
	Missing responses	97	0.0	
	Total	135	100.0	
Co-operative	10 - 15%	3	7.9	7.9
	16 - 25%	9	23.7	31.6
	26 - 50%	10	26.3	57.9
	51 - 75%	14	36.8	94.7
	76 - 100%	2	5.3	100.0
	Missing responses	97	0.0	
Total	135	100.0		
Source of borrowed fund	Commercial banks	13	20.3	20.3
	Money lenders	13	20.3	40.6
	Agric bank	11	17.2	57.8
	Friends and family	17	26.6	84.4
	Others	10	15.6	100.0
	Missing responses	71	0.0	
	Total	135	100.0	

Source: Computation from Field Survey Data, 2021

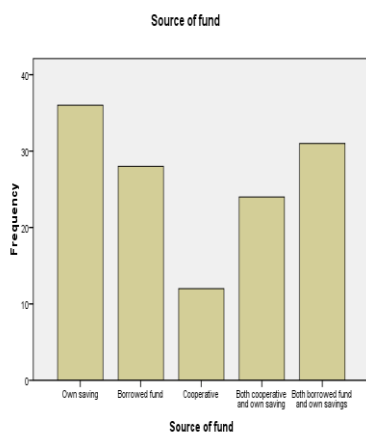


Figure 2

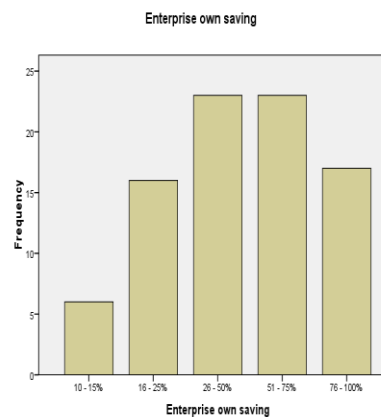


Figure 3

Response of poultry birds to the feed given

The bird’s response to the nutrient requirements supplied in the feed given showed that the majority (37.6%) were at 51-75% level of improvement, followed by above 75% with 31.2% of the respondents (Table 4). Only a total of 31.2% of the respondents reported that the response of their birds was below 50%. The birds’ responses were commensurate with the feed cost by 89.3% of the respondents. Most (43.3%) of the respondents also observed that the percentage responses were between 51–75%, the next being 76-100% by 24.2% of the respondents. The least percentage response (32.5%) was observed in the 10-50% category. The present study observed a better utilization of the nutrient supplied in the feed fed poultry birds, which ensured a greater improvement in their performance. Majority (75.2%) of the respondents had below 10 years of experience in the poultry business, while those in the 11-15 years category were 15.0%. Those with 16-20 years’ experience were 8.3% while those with over 20 years in experience were 1.5%. This is in line with Salami *et al.* (2021) who reported that the majority of the farmers in Abuja municipal area had more than 5 years’ experience in poultry production. Other categories of animals that were being reared along with poultry birds by farmers in Ekiti State were goats, sheep, rabbits, fish and snails, with goats being the most popular (47.2%)

Table 4. Response of poultry birds to the feed given

Characteristics	Response	Frequency	Percent	Cumulative Percent
Birds response to nutrient requirement	10 - 15%	1	0.8	0.8
	16 - 25%	12	9.6	10.4
	26 - 50%	26	20.8	31.2
	51 - 75%	47	37.6	68.8
	Above 75%	39	31.2	100.0
	Missing responses	10	0.0	
	Total	135	100.0	
Does the response commensurate with feed cost	Yes	117	89.3	89.3
	No	14	10.7	100.0
	Missing responses	4	0.0	
	Total	135	100.0	
Percentage of bird’s response to feed cost	10 - 15%	4	3.3	3.3
	16 - 25%	15	12.5	15.8
	26 - 50%	20	16.7	32.5
	51 - 75%	52	43.3	75.8
	76 - 100%	29	24.2	100.0
	Missing responses	15	0.0	
	Total	135	100.0	
Farmer’s years of experience in poultry production	5 years or less	48	36.1	36.1
	6-10 years	52	39.1	75.2
	11-15 years	20	15.0	90.2
	16-20 years	11	8.3	98.5
	above 20 years	2	1.5	100.0
	Missing responses	2	0.0	
	Total	135	100.0	
Other animals reared by poultry farmers	Goat	35	47.2	47.2
	Sheep	11	14.9	62.1
	Rabbit	11	14.9	77.0
	Fish	14	18.9	95.9
	Snail	3	4.1	100.0
	Missing responses	61	0.0	
	Total	135	100.0	

Source: Computation from Field Survey Data, 2021

Farmers' experience in the use of Moringa oleifera and Allium sativum for poultry production in Ekiti State

Moringa oleifera and *Allium sativum* are plant materials with certain secondary metabolites that are capable of improving the performance and promoting the health status of poultry birds. In this study, broiler chickens were observed among the respondents to have been the major (35.2%) chicken type considered to be fed *Moringa oleifera* or *Allium sativum* (Table 5). In the same vein, cockerels (29.6%) and layers (27.8%) were also prioritized. Dietary feeding of *Moringa oleifera* or *Allium sativum* to poultry birds, especially broiler chicken, is done because of the presence of phytochemicals in the plants toward promoting effective growth and wellness among the birds. The powdery and liquid forms of the supplements were equally popular (47.3% each) among the respondents, while other forms of feeding were preferred by 5.5%. In this study, the seed was the plant part mostly used (37.7%), followed by the leaf (35.8%) and bark (22.8%). The least considered part was the root (3.8%). It was observed that farmers' and producers' inadequate knowledge were responsible for the low levels of usage of *Moringa oleifera* in poultry diets (Mahfuz and Piao, 2019). It was shown that 54.4% of the respondents had the expertise or knowledge required to determine the additive value, while 45.6% had no knowledge. Sources of information about the determination procedure showed that 27.1% of the respondents got the information through their friends and relatives, followed by *farmer to farmer* (22.9%) and radio (14.6%). Others were extension agents (12.5%) and research institutions such as universities (12.5%).

The feed trial was ranked first (87.2%) above chemical analysis (12.8%). The reduced response to chemical analysis is an indication of the technicality involved in the process, which attests to the fact that the method requires a special skill that most farmers may not have. Therefore, there is a need to provide extension education for the farmers that will help them to understand the various additive components (secondary metabolites) in *Moringa oleifera* and *Allium sativum*. The small number of extension workers limits the circulation of such innovation. This study is in line with the finding of Ezeh *et al.* (2012) that productivity in poultry is low in Nigeria due to technical inefficiency, inadequate extension personnel and training facilities.

The farmers' experience about the choice of *Moringa oleifera* and *Allium sativum* revealed that their uses were *better* (31.5%), *improved* (20.4%), *good* (16.7%), *excellent* (9.3%) and *no difference* (3.7%). This finding showed that 96.3% of the respondents observed a "fairly better" performance in poultry production. Its feeding advantages showed that *more activeness* was ranked first (53.7%), and *increased weight gain* was ranked second (24.1%). Furthermore, *improve meat taste* was 11.1% and *increase resistance to infestation* was 9.3%. The responses of farmers to the *effect of the test materials*, showed a significant improvement on their production outputs. This positive effect of *Moringa oleifera* or *Allium sativum* as feed additives in feed formulation might be attributed to the presence of bioactive components that improve the performance of birds. This is in line with the finding of Mountzouris *et al.* (2011) that active maintenance of regular digestive function can be achieved by feeding phytochemical plants. *Moringa oleifera* leaf and *Allium sativum* bulb have potential usefulness as feed additives which improve the digestive system of broiler chicken with resultant increase in productivity (Agbetuyi *et al.*, 2023).

Result on farmers' years of experience in using *Moringa oleifera* and *Allium sativum* revealed that 59.2% of the respondents had less than 5 years' experience, followed by those who had been

Table 5. Farmers' experience in using *Moringa oleifera* and *Allium sativum* for poultry production in Ekiti State

Characteristics	Responses	Frequency	Percent	Cumulative Percent
Poultry birds fed with <i>Moringa oleifera</i> or <i>Allium sativum</i>	Broilers	19	35.2	35.2
	Layers	15	27.8	63.0
	Cockerels	16	29.6	92.6
	Noilers	2	3.7	96.3
	Turkey	2	3.7	100.0
	Total		135	100.0
Feeding form of processed <i>Moringa oleifera</i>	Powder	26	47.3	47.3
	Liquid	26	47.3	94.5
	Other	3	5.5	100.0
	Total		135	100.0
Part of <i>Moringa oleifera</i> tree used in feeding animals	Leaf	19	35.8	35.8
	Seed	20	37.7	73.6
	Bark	12	22.6	96.2
	Root	2	3.8	100.0
	Total		135	100.0
Expertise to determine the additive values of <i>Moringa oleifera</i> and <i>Allium sativum</i>	Yes	43	54.4	54.4
	No	36	45.6	100.0
	Total		135	100.0
Determination of additive values of <i>Moringa oleifera</i> and <i>Allium sativum</i>	Feed trial	41	87.2	87.2
	Chemical analysis	6	12.8	100.0
	Total		135	100.0
Sources of information about the determination	Extension agent	6	12.5	12.5
	Institution (such as university)	6	12.5	25.0
	Farmer to farmer	11	22.9	47.9
	Friends and relatives	13	27.1	75.0
	Radio	7	14.6	89.6
	Television	3	6.2	95.8
	Others	2	4.2	100.0
	Total		135	100.0
Farmer's experience in using <i>Moringa oleifera</i> and <i>Allium sativum</i>	No difference	2	3.7	3.7
	Fairly better	10	18.5	22.2
	Better	17	31.5	53.7
	Improved	11	20.4	74.1
	Good	9	16.7	90.7
	Excellent	5	9.3	100.0
	Total		135	100.0
Advantages of feeding <i>Moringa oleifera</i> or <i>Allium sativum</i> to birds	Increase weight gain	13	24.1	24.1
	More activeness	29	53.7	77.8
	Resistance to infestation	5	9.3	87.0
	Improve meat taste	6	11.1	98.1
	Others	1	1.9	100.0
	Total		135	100.0
Years of using <i>Moringa oleifera</i> or <i>Allium sativum</i> to raise birds	Less than 5 years	29	59.2	59.2
	6-10 years	13	26.5	85.7
	11-15 years	5	10.2	95.9
	16-20 years	2	4.1	100.0
	Total		135	100.0
Other ways to use <i>Moringa oleifera</i>	Human food	56	76.7	76.7
	Confectionary making	10	13.7	90.4
	Cream making	6	8.2	98.6
	Others	1	1.4	100.0
	Total		135	100.0
Other materials used as feed additives	Ginger	35	61.4	61.4
	Tumeric	9	15.8	77.2
	Organic acid	5	8.8	86.0
	Probiotics	4	7.0	93
	Prebiotics	1	1.8	94.8
	Exogenous enzymes	1	1.8	96.6
	Others	2	3.4	100.0
	Total		135	100.0

Source: Computation from Field Survey Data, 2021

applying the additives for 6-10 years (26.5%). The reduction in the number of respondents as the years of experience increased strongly suggests that the use of *Moringa oleifera* or *Allium*

sativum in the poultry industry is entirely a new concept. Gobezie (2021) reported little information on the use of *Moringa oleifera* in poultry feeding, as was observed in this study. Other ways of using *Moringa oleifera* include human (food) consumption (76.7%), confectionary making (13.7%) and cream making (8.2%). It means that the additive values is not only beneficial to poultry birds, but also provides some other human uses. This is in line with a study by Popoola and Obembe (2013), who reported that *Moringa oleifera* leaf is often used for its medicinal and human nutritional properties due to its high level of antioxidants and other components.

The respondents also indicated that among other materials that can be used as feed additive in poultry, “ginger” is the most common (61.4%), followed by turmeric (15.8%), organic acids (8.8%), probiotics (7.0%), prebiotics (1.8%) and exogenous enzymes (1.8%). The study clarifies that farmers have knowledge of some other materials that can be used as feed additives in livestock feeds.

Procedures for improving birds’ health

The result of the multiple responses on the procedures for improving birds’ health by the respondent farmers is presented in Table 6. The major procedure suggested was vaccination (32.2%), then medication which was ranked second (25.7%) and biosecurity (16.5%). Other procedures are: good hygiene (15.3 %), adequate management (6.5%) and *ad libitum* (3.8%). The least use of *ad libitum* feeding as a procedure for improving birds’ health is probably attributable to the high costs of feed ingredients used for feed formulation. Moreover, the use of vaccination and medication (drugs) was much prominent among the farmers for livestock production in Ekiti State, owing to a low level of awareness of the value of plant materials a additives in livestock feeds. Supplementation of phytogenic plants in poultry feed is low as a result of poor knowledge of the farmers about their inclusion (Mahfuz and Piao, 2019).

Table 6: Procedures for improving bird’s health

Procedures	1st responses	2nd responses	3rd responses	Total responses	Percent
Medication	67	-	-	67	25.7
Vaccination	31	53	-	84	32.2
Biosecurity	11	5	27	43	16.5
<i>Ad libitum</i> feeding	3	3	4	10	3.8
Good hygiene	14	5	21	40	15.3
Adequate management	7	5	5	17	6.5
Total				261*	100.0

Source: Computation from Field Survey Data, 2021; *Multiple responses

Conclusion and Recommendations

The use of *Moringa oleifera* and *Allium sativum* is quite new among poultry farmers in Ekiti State, Nigeria. However, their use has been gaining recognition as alternative feed materials with secondary metabolites (phytobiotics) that can help to improve the overall performance of poultry birds. The low level of farmers’ knowledge about the nutritive value of these plant products makes the farmers to depend heavily on the use of synthetic materials as medication (drugs) in their production processes. Furthermore, there are no established doses for *Moringa oleifera* and *Allium sativum* used in raising poultry birds among the farmers in Ekiti State. It can therefore be

concluded that there is a great prospect in the poultry industry with the use of *Moringa oleifera* and *Allium sativum*.

To maximize the potentials of these plant materials, it is recommended that:

1. Extension agents should be strengthened to provide correct information about the importance of phyto-genic plant materials to the farmers.
2. Government should partner with research institutes in the area of training and re-training of these extension workers on innovations that involve the use of phyto-genic plants in the poultry industry.
3. Further study should be conducted to seek for adequate/acceptable level of *Moringa oleifera* and *Allium sativum* use that will enhance an improved performance of birds in the State.

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Original Research Article

Climate Change Adaptation Measures of Aquaculture Enterprises in Delta State, Nigeria

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Abstract

As the population of the world is increasing, so is the demand for food, especially protein, which is necessary for growth. Production from fisheries is crucial for food security in the face of current population increases. Despite the reliability on fisheries and aquaculture to supply the animal protein needed by the world's population, climate change has significantly reduced production and increase instability in the sector. In order to achieve food security and achieve fisheries development goals, climate change adaptation measures are needed to lower greenhouse gas emission intensities with output. This study therefore discusses adaptation measures employed by aquaculture practitioners in Delta State, Nigeria. Accordingly, 480 copies of a structured questionnaire were shared across the three senatorial districts in Delta state using the multi-stage sampling technique. The study used simple percentages to present the results obtained from descriptive analysis of the sourced data. The study found out that, a little over half of the respondents (50.42%) were aware of climate adaptation measures. Household income diversification, disaster risk management, building response capacity were the top three measures adopted by 81.67%, 75.83% and 71.67% of the respondents respectively. With as many as 49.58% of the respondents ignorant of climate change adaptation measures, it was recommended that the government should step up its farmers' enlightenment programmes through effective extension services, and provide training and financial support to the farmers.

Keyword: Climate Change, Aquaculture, Adaptation Measures

Introduction

The continual burning of fossil fuel, and changes in land use by man have continued to emit increasing quantities of greenhouse gases into the Earth's atmosphere. These greenhouse gases include carbon dioxide (CO₂), methane (CH₄) and nitrogen dioxide (NO₂), and a rise in these gases has caused a rise in the amount of heat from the sun withheld in the Earth's atmosphere, heat that would normally have been radiated back into space. This increase in heat has led to the greenhouse effect, resulting in climate change. The main characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and

precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity – due to seawater absorbing heat and carbon dioxide from the atmosphere (UNFCCC, 2021). It is now widely accepted that climate change is no longer simply a potential threat, but a consequence of 200 years of excessive greenhouse gas (GHG) emissions from fossil fuel combustion in energy generation, transport and industry, deforestation and intensive agriculture as noted by Inter-governmental Policy on Climate Change (IPCC, 2007; Onada and Ogunola, 2017).

In Nigeria, climate change has significant effects on Nigeria's freshwater and marine aquatic systems and, consequently, on the country's fisheries and aquaculture (FDF, 2007). The effects of these changes have resulted in elevated water temperatures (IPCC, 2007) which affect fish physiological processes, thereby affecting spawning, survival of the juveniles, development into the exploitable phases of the population, population size, production and yield (Tubiello and Fischer, 2007). The negative impacts of increased flooding of the freshwater bodies are erosion of watersheds, destruction of fish feeding and breeding habitats, decrease in primary productivity and alteration of the normal resilience of the aquatic systems, while the positive impact includes expansion of aquatic habitats for primary and secondary fish production, especially during the dry season (Tubiello and Fischer, 2007). In the event of drought, water reservoirs in lakes and streams are diminished (Jamieson *et al.*, 2004), and give rise to insufficient water flow in the river basins for spawning and primary production thereby affecting fish production. The implications of this are low output of fish and other aquatic products for family consumption, as well as for sale, which in turn, affects market prices of fish especially when demand is high and supply is low.

Considering the importance of fish to Nigeria's economy through provision of food supplies, enhancement of food security, creation of employment opportunities and income generation, the sector has contributed 3-4% of Gross Domestic Product to the national, and provided employment for over a million people (FDF, 2008), and contributed about 50% of the animal protein intake of the population (IFC, 2003). It is important, therefore, to protect the sector from the adverse effects of climate change, whose impacts are already being felt by small-scale fisheries investors.

This study set out to examine the various climate change adaptation measures which the government of Delta State, Nigeria has provided for use in order to combat and reduce the negative impact caused of climate change. In view of the above, this paper focused on the climate change adaptation measures of aquaculture enterprises in Delta State of Nigeria.

Materials and Methods

Study Area

The study was conducted in Delta State, located in the South-South geopolitical zone of Nigeria. The State consists of 3 Senatorial districts, and 25 local government areas (LGAs).

Data Collection and Analysis

The study adopted the multistage sampling technique. From each of Delta State's three (3) senatorial districts, which are: Delta North (DN), Delta Central (DC) and Delta South (DS) senatorial districts, two (2) local government areas (LGAs) were selected as follows: Ukwuani and Aniocha South LGAs for DN senatorial district; Ethiope East and Isoko South LGAs for DC senatorial district, and Burutu and Warri South LGAs for senatorial district. The last stage involved the selection of two (2) rural and one (1) major urban centre in each zone as shown in

Table 1 below. The sourced data were descriptively analyzed and presented as simple percentages.

Table 1: Sampling Frame

Senatorial Districts	LGAs	Rural Settlements	Urban settlements
Delta North	Ukwuani	Ezionum and Obiaruku	Asaba
	Aniocha	Idumujunor and Ewulu	
Delta Central	Ethiophe East	Isiokolo and Okpara Inland	Ughelli
	Isoko South	Igbide and Uzere	
Delta South	Burutu	Okpokunu and Odimodi	Warri
	Warri South	Obodo and Ubeji	
Total Distributed		240	240

Source: Field Survey (2022)

Results and Discussion

Socio-economic Characteristics of the Respondents

This section presents the socio-economic characteristics of the respondents (Table 2). The result indicates that majority of the respondents (36.04%) fell in the age brackets of 31-40. Those aged 41 to 50 years (20.42%) followed closely while those aged above 60 years constituted 18.96%;

Table 2: Socio-economic Characteristics of the Respondents from the State

Characteristic	Frequency (F)	Percentage (%)
Age Group		
≤ 25	54	11.25
26-30	64	13.33
31-40	173	36.04
41-50	98	20.42
>60	91	18.96
Total	480	100.00
Gender		
Male	218	45.42
Female	262	54.58
Total	480	100.00
Education		
No Formal	55	11.46
Primary	131	27.29
Secondary	143	29.79
Tertiary	151	31.46
Total	480	100.00
Occupation		
Civil servants	61	12.71
Business	75	15.63
Farming	101	21.04
Artisan	53	11.04
Students	56	11.67
Unemployed	98	20.42
Housewife	36	7.50
Total	480	100.00

Source: Field Survey (2022)

those aged 26-30 years were 13.33% while those aged 60 years ≤ 25 constituted 11.25% of the respondents. This indicates that about 55 of the respondents were above 30 years old, and were therefore old enough to assess environmental changes in the study area.

It terms of gender representativeness, females were more than male respondents (54.58% vs 45.42%). Again, most (>88%) of the respondents had some form of formal education. Meanwhile, most of the respondents (21.04%) identified farming as their primary occupation, while the rest of the respondents followed the following sequence: Unemployed (20.42%), Business men/women (15.63%), Civil servants (12.71%), Students (11.67%), Artisan (11.04%), and Housewives (7.50%).

Awareness of Climate Adaptation Measures

Table 3 evidenced that, 50.42% of our respondents were aware of Climate Adaption Measures while the remaining 49.58% were not. This reveals that, there is still much to be done in this regard.

Table 3: Awareness of Climate Adaptation Measures

Response	Frequency	Percentage
Yes	242	50.42
No	238	49.58

Source: Field Survey (2022)

The climate risk response measures adopted by farmers in the Delta State are presented in Table 4. Household income diversification was an important adaptation effort of fish farmers in Delta state. About 81.67% of the respondents stated that they responded by integrating fish farming with other aquaculture activities such as fish processing, fish gear production and cultivation of aquatic vegetables. Diversifying into other means of livelihoods is an important strategy for building resilience and managing climate risks (FAO, 2014). By implication, pursuing a single form of livelihood puts fish farmers at great risk when a shock occurs and, to overcome this, many fish farmers in Nigeria combine fish farming with other livelihood activities including petty trading, crop and poultry farming and artisan works. This is in line with the findings of Adeleke and Omoboyeje (2016).

In like manner, adoption/introduction of income stabilization programmes is also critical as it contributed 50.83%. Evidently, it reduces the level of variability in farm income over the investigated periods. More so, social protection consists of policies and programs designed to reduce poverty and vulnerability by promoting efficient labour markets, diminishing people's exposure to risks, and enhancing their capacity to manage economic and social risks, such as unemployment, exclusion, sickness, disability, and old age. *However*, innovative risk financing instruments and insurance schemes was adopted by only 15% of the farmers to manage climate risks in fish farming. By implication, most aqua-farmers in the study area are yet appreciate the protection that insurance provides. A study by Isife and Ekeremor (2015) in Bayelsa state found that aquaculture insurance was the climate change adaptation measure least used by fish farmers.

The table shows that the most common adaptation practice was building response capacity, conservation of genetic resources; implement co-management systems, and managing climatic risks. Approximately, 75.83%, 39.17%, 65.00% and 67.50% of the farmers, respectively, adopted this strategy. Again, other two (2) common strategies were managing climate risk and

disaster risk management. Approximately, 67.50% and 71.67% of the farmers adopted these strategies, respectively.

Flood represents a major threat to fish farming in Nigeria and in other developing countries (Oyebola *et al.*, 2018).

Table 3: Climate Adaptation strategies Adopted by Aquaculturists in Delta State

Adaptation strategy	Frequency (N)	Percentages (%)
Household Income Diversification	392	81.67
Adoption of income stabilization programmes	244	50.83
Social protection initiatives	300	62.50
Community-based risk management	208	43.33
Innovative risk financing instruments and insurance schemes	72	15.00
Building response capacity	364	75.83
Conservation of genetic resources	188	39.17
Implement co-management systems	312	65.00
Managing climate risk	324	67.50
Disaster risk management	344	71.67

Source: Field Survey (2022)

Conclusion and Recommendations

Adapting to climate change will entail adjustments and changes at every level – from community to national and international. For instance, communities must build their resilience, including adopting appropriate technologies while making the most of traditional knowledge, and diversifying their livelihoods to cope with current and future climate stress. The study concludes that a little over half of our respondents were aware of climate adaptation measures, and that household income diversification, disaster risk management and building response capacity, topped the list of climate adaptation measures adopted by most of the respondents. As such, local coping strategies and traditional knowledge need to be used in synergy with government and local interventions. The choice of adaptation interventions depends on national circumstances. To enable workable and effective adaptation measures, ministries and governments, as well as institutions and non-government organizations, must consider integrating climate change in their planning and budgeting in all levels of decision making.

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Original Research Article

Knowledge and Utilisation of Forest Products among Rural Dwellers: Implication for Forest Conservation in Delta State, Nigeria

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Abstract

This study assessed the knowledge of forest products utilization among 240 rural dwellers across 6 Local Government Areas with forest reserves in Delta State, Nigeria. A multistage sampling procedure was employed to select the respondents from 5 villages in each of the LGA. Descriptive statistics and knowledge index analysis were used for analysis of the data obtained. The results indicated that 85% of the respondents had strong knowledge of plant species; 66% had relatively weaker knowledge of timber, while 60.4% had high knowledge of animal species. The ANOVA test showed significant zonal differences ($p < 0.05$), in knowledge, with Delta South having the lowest mean knowledge score (57.18%) compared to Delta North (67.49%) and Delta Central (66.52%). The extensive use of non-timber forest products (NTFPs) like *Uziza*, *Utazi*, bitter kola and avocado pear highlights dependence on diverse forest resources for nutrition, health and income. Overexploited timber species such as West Indies mahogany and threatened bushmeat species signify areas needing sustainable management. Targeted educational programs, agroforestry initiatives and participatory forest management can enhance local expertise and engagement in balancing utilization and conservation needs across various forest products in the different zones of Delta State.

Keywords: Forest products, Non-timber forest products, Knowledge, Utilization, Rural dwellers

Introduction

The world for long has recognized the importance of the environment and the need for man to live harmoniously with it. However, significant efforts ensuring adequate care for the environment began to manifest in the 1990's through international conferences dedicated to the environment. Reports of these international conferences culminated in the adoption of environmental issues as one of the eight goals of the Millennium Development Goals (MDGs) (Oyetunji *et al.*, 2020). Goal 7 of the MDGs was to ensure environmental sustainability. The

focus of this goal, according to Adekola and Mbalisi (2015), was to integrate the principles of sustainable development into the country's policies and programmes and to reverse the loss of environmental resources. The focus of this goal on reversing loss of environmental resources confirms that there had been serious damages and loss of environmental resources which include the forests.

Forests are often referred to as natural capital, and are considered as a stock of capital or assets of given quantities and qualities (Ezenwaka and Graves, 2014). They are also identified as one of the livelihood assets (capitals) in the Sustainable Livelihood Framework (Adams, 2019). Natural capital supports a number of interrelated ecosystem functions in order to provide capacity to produce a variety of ecosystem goods and services that have value for humans (Marais *et al.*, 2019).

Nigeria is endowed with abundant natural resources, both renewable and non-renewable. Oil and gas, which account for about 95% of Nigeria's export earnings and about 80% of the total annual income, has over the years become a cause of many conflicts in Nigeria (Ezenwaka and Graves, 2014). Apart from crude oil, Nigeria is also rich in forest resources that are important in the livelihoods of local people.

Millions of people, especially those living in the rural areas of developing countries, gather forest products on daily basis for their livelihoods. About 80% of rural dwellers in developing countries depend on forest products for their food and income needs (Martin, 2017). For instance, Suleiman *et al.* (2017) observed that forest products contribute significantly to households' food security, income, and medicine in African countries such as Nigeria, Kenya, and Cameroon. However, despite the significant contribution of forest products to the local and national economies, the forestry master plan for Nigeria gives little attention to the important role played by forest products in rural livelihoods. This can be primarily attributed to the lack of quantitative information to justify the role of forest products in local and national economies.

This knowledge gap partly explains the government's little attention to conservation of forest ecosystems in different parts of the country, in spite of their protection status. As indicated by Otum *et al.* (2017), most resource users as economic agents rarely decide on how much natural resources to conserve, but rather how much to use. Therefore, knowledge of the forest proximate communities on exploitation of natural resources should be of concern to conservationists. As a result, the prerequisite for sustainable conservation of forest products and biodiversity is to improve rural dwellers' knowledge toward exploitation and utilization of environmental resources (Posner *et al.*, 2016). In order to ensure sustainable conservation of forest products in Delta State, empirical evidence on the knowledge and utilization pattern by the rural dwellers is imperative. It is against this background that this study was conducted. This study is therefore expected to provide a better understanding and knowledge of the selected forest products, and their utilization. In addition, the findings of these study are expected to stimulate interest for further research on forest products in the study area.

Objectives of the study

The main objective was to ascertain the knowledge and utilisation of forest products among rural dwellers: implication for forest conservation in Delta State, Nigeria

The specific objectives of this study were to;

- i. determine the socioeconomic characteristics of the respondents,
- ii. identify the various forest products utilized by rural dwellers in the study area; and
- iii. assess the level of knowledge of forest products utilization among the three agricultural zones of Delta State, Nigeria.

Hypothesis of the study

The following hypothesis stated in the null forms, guided the study;

HO₁: There is no significant difference in the level of knowledge of forest products utilization among rural dwellers in the three agricultural zones of Delta State, Nigeria.

Methodology

The study was carried out in Delta State, Nigeria. A multistage sampling procedure was used in the selection of respondents. First, from each of the three (3) agricultural zones in the State, two (2) local government areas with 2 forest reserves, and an abundance of forest species were purposively selected, giving a total of six (6) Local Government Areas (LGAs). Thereafter, five (5) villages with high number of forest-dependent rural dwellers within their territories were randomly selected from each of the LGAs. Finally, eight (8) rural households were randomly selected from each of the five (5) villages making a total of two hundred and forty (240) respondents used for this study. Data on the socioeconomic characteristics and the various forest products utilized by rural dwellers in the study area were descriptively analysed, and presented as means, frequencies and percentages, while objective (iii) was achieved using the Knowledge Index. The hypothesis HO₁ was tested using analysis of variance.

Model Specification

(i) Level of knowledge of forest products utility

All the forest products available in the study area were identified and presented to seek responses from the respondents on their level of knowledge of utilization. A correct response was scored 1 and incorrect response scored 0. The grand score for each respondent was calculated by adding up the scores on all the knowledge items. The maximum and minimum scores were obtainable for each of the respondents on level of knowledge. Using the total scores obtained, the Knowledge Index according to Rizwana and Paris (2009) and Ebewore and Isiorhovoja (2019) was calculated as follows:

$$\text{Knowledge Index} = \frac{\text{Number of correct responses}}{\text{Total Number of Knowledge item}} \times 100 \dots \dots \dots (1)$$

The average score was taken to be 50%. Any respondent that scored 50% or more fell into the high knowledge level category, while any respondent that scored below the average fell into low knowledge group.

(ii) Analysis of Variance (ANOVA)

The One-way ANOVA was used to test the hypothesis of no significant differences among the three agricultural zones of Delta State in terms of level of knowledge of forest products utilization among rural dwellers.

Significantly different means were separated using the Duncan’s Multiple Range Test.

Results and Discussion

Socioeconomic characteristics of rural dwellers

The socioeconomic characteristics of rural dwellers, as illuminated Table 1, unveil significant insights into the dynamics of forest resource utilization in Delta State. The gender distribution among forest product users highlights a predominant male representation, with 69.2% of respondents being male and 30.8% female. This disparity suggests gender-specific roles that are deeply entrenched in the utilization of forest resources, likely stemming from cultural and traditional practices. Such insights emphasize the importance of understanding and addressing gender dynamics for promoting equitable access to forest resources, and fostering sustainable forest management practices. The study's findings echo similar observations by Kabir *et al.* (2020) in Oyo State, emphasizing the prevalent gender division of labour and responsibilities in forest-related activities.

Table 1: Socioeconomic characteristics of rural dwellers in Delta State, Nigeria

Variable	Frequency	Percent	Mean/Mode
Sex			
Male	166	69.2	Male
Female	74	30.8	
Age			
20 – 35 years	67	27.9	41 years
36 – 51 years	133	55.4	
52 – 67 years	37	15.4	
Above 67 years	3	1.3	
Marital status			
Single	54	22.5	Married
Married	146	60.8	
Divorced	14	5.8	
Widowed	26	10.8	
Educational level			
No formal	9	3.8	Secondary
Primary	72	30.0	
Secondary	95	39.6	
Tertiary	64	26.7	
Household size			
1 – 4 persons	107	44.6	5 persons
5 – 8 persons	119	49.6	
9 – 12 persons	12	5.0	
Above 12 persons	2	0.8	
Monthly income from forest products			
Less than ₦50,000	44	18.3	₦88,205.42
₦50,000 – ₦100,000	111	46.3	
₦101,000 – ₦150,000	43	17.9	
₦151,000 - ₦200,000	30	12.5	
Above ₦200,000	12	5.0	

The age distribution of forest product users highlights a middle-aged population, with 55.4% of respondents falling within the 36 to 51 years age bracket. Individuals in their middle years, as observed in these respondents, are likely to be more actively engaged in forest-related activities,

possibly due to their accumulated experience and responsibilities within their households. However, the declining representation of older individuals above 67 years (1.3%) implies a waning interest or participation in forest-based activities among the elderly, potentially signalling broader socioeconomic shifts within rural communities. A study by Amoga (2022) further corroborates these findings, highlighting age-specific trends in non-timber forest product trade and rural migration patterns.

Marital status, educational level, household size, and monthly income from forest products collectively depict the intricate nexus between socioeconomic factors and forest resource utilization. The high prevalence of married respondents (60.8%) underscores the pivotal role of family units in forest resource utilization, while the educational profile revealed a substantial portion of individuals with secondary schooling (39.6%). The mean household size of 5 persons underscores the significance of forest resources in supporting larger dependents, albeit with heightened pressures for higher incomes. Furthermore, the distribution of monthly income underscores the economic importance of forest products for rural livelihoods, while simultaneously highlighting challenges such as income vulnerability and limited earning potential. Insights from Soaga *et al.* (2010) and Ingutia and Sumelius (2022) accentuate the need for holistic interventions aimed at enhancing market access, entrepreneurial skills, and diversifying non-farm opportunities to bolster sustainable forest incomes and rural livelihoods.

Forest products utilized by rural dwellers in the study area

Table 2 shows the diversity of forest products utilized by rural dwellers in Delta State, Nigeria. The high frequency of many plant species highlights the importance of non-timber forest products (NTFPs) for livelihoods.

Plant Species: The table documents extensive use of non-timber forest products (NTFPs) by rural communities in Delta State. The most frequently harvested species were multi-purpose plants used for food, medicine, and as spices, oils, dyes and crafts. *Uziza* (87.1%), *Utazi* (88.3%), *Uchi* (88.3%) and *Ujuju* (83.3%) provide important culinary, medicinal and income benefits. As documented across Nigeria, these leafy green vegetables are crucial for flavouring soups and stews (Lawal *et al.*, 2018). *Uziza* and *Utazi* also have antimicrobial properties effective in treating coughs, intestinal issues and malaria (Anyanwu and Okoye, 2017). *Uchi* and *Ujuju* fruits are rich in vitamins and sold fresh or processed into juices and wine (Lawal *et al.* 2018). Sustainable harvesting and cultivation can support continued availability.

Alligator pepper (82.9%), grains of Selim (58.3%) and *Ichaku* (87.9%) provide flavoured spices. Alligator pepper is widely used in Nigerian cuisine and serves as a cash crop (Adefegha *et al.* 2016). Grains of Selim add a peppery taste to soups and meats. *Ichaku* fruits produce a fragrant seed spice. These spices supply income through local and international trade. Domestication can reduce wild harvesting pressure.

Bitter kola (80.8%), kola nut (50%) and avocado pear (79.2%) have cultural significance and health benefits. Bitter kola is valued in ceremonies and consumed as a stimulant, while processing kola nut employs many rural workers (Adefegha *et al.* 2016). Avocado pears provide nutritious fruits. Sustainably integrating these species into agroforestry systems can maintain availability.

Table 2: Forest products utilized by rural dwellers in the study area

Common name	Botanical name	Frequency	Percent
Plant species			
Achi	<i>Brachystega Eurycoma</i>	212	88.3
Alligator pepper	<i>Aframomum meleguata</i>	177	73.8
Bitter kola	<i>Garcina kola</i>	194	80.8
Breadfruit	<i>Treculia africana</i>	127	52.9
Bush mango	<i>Irvingia gabonensis</i>	57	23.8
Kolanut	<i>Cola nitida</i>	120	50.0
Mushroom	<i>Agaricus bisporus</i>	84	35.0
Cashew	<i>Anacardim occidentale</i>	99	41.3
Icheku	<i>Dalium guinese</i>	211	87.9
African star apple(udara)	<i>Chrysophyllum Albidium</i>	217	90.4
Avocado pear	<i>Persea Americana</i>	190	79.2
African bush pear	<i>Dacryodes edulis</i>	179	74.5
Oilbean	<i>Pentacletha macrophyla</i>	61	25.4
<i>Akpalata</i>	<i>Afzelia Africana</i>	174	72.5
<i>Mmimmi</i>	<i>Denntia Tripetala</i>	182	75.8
<i>Uda</i>	<i>Xylopia spp</i>	94	39.2
<i>Uziza</i>	<i>Piper guinense</i>	209	87.1
<i>Utazi</i>	<i>Gongromeme latifolaim</i>	212	88.3
<i>Ujuju</i>	<i>Myrianthus arboreus</i>	200	83.3
<i>Okpa</i>	<i>Tetracarpidum Conophorum</i>	196	81.7
<i>Ogbono</i>	<i>Iruingia gabonensis</i>	141	58.8
Grains of selium (Urhirhie)	<i>Xylopia aethiopica</i>	140	58.3
Alligator pepper (Erhiè)	<i>Aframomum melegueta</i>	199	82.9
<i>Èvéwe</i>	<i>Tetrapluera tetraptera</i>	42	17.5
Timber species			
<i>Ucar</i>	<i>Bucida bucerash</i>	134	55.8
<i>Maria, maria</i>	<i>Calophyllum Calaba L.</i>	101	42.1
<i>Capa Prieto</i>	<i>Cordia alliodora</i>	187	77.9
<i>Deglupta</i>	<i>Eucalyptus deglupta blume</i>	181	75.4
American Muskwood, Guaragua O.	<i>Guarea guidonia L.</i>	165	68.8
<i>Mahoe, majo</i>	<i>Hibiscus elatussio</i>	117	48.8
Caribbean pine	<i>Pinus caribaeae moreleyt</i>	223	92.9
West indies mahogany	<i>Swieenia mahogany</i>	198	82.5
Hybrid mahogany	<i>Swieteria mahogany</i>	186	77.5
Teak tech	<i>Techona grandis L.</i>	83	34.6
Animal species			
Snail	<i>Achatina achatina</i>	212	88.3
Bee products	<i>Apis mellifera</i>	40	16.7
Grasscutter	<i>Thronomys Swinderianus</i>	146	60.8
Flying termites/Swarmer/Alate(Aku)	<i>Reticulitermes flavipes</i>	44	18.3
Fish	<i>Ictalurus punctatus</i>	209	87.1
Palm weevil larva	<i>Rhynchophorus species</i>	84	35.0
Bush rat	<i>Ratus fuscipes</i>	120	50.0

Oil bean (25.4%), bush mango (23.8%) and African bush pear (74.5%) provide edible oils and fruits. Large-scale processing and marketing of these nutritious NTFPs can boost food security and incomes (Asamoah, *et al.*, 2023).

Overall, the wide variety of NTFPs illustrates the strong reliance of rural communities on forest resources for nutritional, health and income support. Environmental education and agroforestry initiatives can promote continued access while reducing unsustainable harvesting from the wild.

Timber Species: The most frequently used timber species are Caribbean pine (92.9%), West Indies mahogany (82.5%) and *deglupta* (75.4%). Caribbean pine thrives in Nigeria's climate and environment providing construction wood, poles and pulp (Riki *et al.*, 2019). However, extensive harvesting for lumber and fuel-wood has led to deforestation in some areas. West Indies mahogany is overexploited for its high-value timber, but remains illegally traded (Dewanjee and Maiti, 2011). The introduced *deglupta* is a fast-growing softwood used for pulp, particle board and fuel-wood to reduce logging pressure on native species (Dewanjee and Maiti, 2011). Sustainable forestry policies, agroforestry and community forestry initiatives are needed to balance timber production with conservation. Reforestation programs can also help recover depleted forests, sequester carbon and maintain future wood supplies. Education and alternative livelihood programs can reduce overreliance on timber and fuel-wood extraction.

Animal Species: Snail gathering (88.3%), fish harvesting (87.1%), grasscutter hunting (60.8%) and bush rat trapping (50%) provide essential proteins for rural communities in Delta State. Snail collection is primarily done by women as a source of food and income (Babatunde *et al.*, 2019). But habitat loss threatens snail species. Grasscutters and bush rats are important bush-meat species, but unregulated hunting for subsistence and commercial sale can threaten wildlife populations (Babatunde *et al.*, 2019). Overall, the diverse forest products confirm the high dependence of rural livelihoods on forest resources in Delta State. Well-managed participatory forest management, agroforestry integration and sustainable harvesting initiatives can help balance utilization and conservation needs. More equitably valuing women's roles is also key.

Level of knowledge of forest products utilization in the study area

Table 3 shows levels of knowledge about forest product utilization among rural dwellers in Delta State, Nigeria.

Knowledge of Plant Species: The majority of respondents (85%) demonstrated high knowledge of plant species by recognizing over 50% of the species listed. This extensive knowledge reflects the vital dependence on plants for nourishment, medicine, and income. Leafy vegetables like *Uziza*, *Utazi* and *Uchi* are crucial for flavouring soups and stews in the local cuisine (Weber *et al.*, 2001). Fruits like avocado pear, bush mango and African bush pear provide nutritional and market benefits. Medicinal plants like alligator pepper, *Ujuju* and *Utazi* treat common ailments. The ubiquitous use of these plants in daily life generates knowledge of their properties and values. However, a Niger Delta study found younger generations had declining plant knowledge, indicating a need for environmental education (Ansah *et al.*, 2022).

Knowledge of Timber Species: Timber species knowledge was lower, with 66.3% demonstrating high knowledge. Local communities may not directly utilize many timbers for subsistence, but may, instead, rely on external loggers and wood traders. However, some timbers like Caribbean pine are used for local construction and fuel-wood. Other studies in Nigeria have also found weaker community knowledge of timber trees compared to other flora (Ansah *et al.*, 2022). This gap limits community participation in sustainable forest management. Building local timber expertise through training programs can provide income options and empower communities to better regulate external logging.

Knowledge of Animal Species: About 60.4% showed high knowledge of animal species. Wildlife hunting practices tend to be specialized skills. A study by Odunlami and Nkata (2021) found that grasscutter farmers had good knowledge but other bush-meat hunters showed poor

identification abilities. Rural women may also have weaker animal expertise if not involved in hunting. Overall, the relatively lower knowledge of timber and animal species compared to plants indicates specific areas needing improvement to support local participation in managing all forest resources.

While respondents demonstrated relatively strong plant knowledge, gaps existed for timber and animal species. Targeted education programs building local knowledge across diverse forest products can empower communities for more engaged roles in sustainable forest management. Higher indigenous expertise also enables communities to better regulate external resource exploitation. Integrating local forest knowledge with scientific principles is key for equitable, effective policies.

Table 3: Level of knowledge of forest products utilization in the study area

Forest products	Level of knowledge	Frequency	Percent
Plant species	Low knowledge (0 - 49%)	36	15.0
	High knowledge (50 - 100%)	204	85.0
Timber species	Low knowledge (0 - 49%)	81	33.8
	High knowledge (50 - 100%)	159	66.3
Animal species	Low knowledge (0 - 49%)	95	39.6
	High knowledge (50 - 100%)	145	60.4
All species	Low knowledge (0 - 49%)	71	29.6
	High knowledge (50 - 100%)	169	70.4

Differences in the level of knowledge of forest products utilization in the three agricultural zones of Delta State

The result in Table 4 compares mean knowledge scores as percentages across the three agricultural zones of Delta State, Nigeria. The ANOVA results again show statistically significant differences between the zones ($p < 0.05$). Respondents in Delta South had the lowest mean score (57.18%), indicating relatively poor knowledge compared to Delta North (67.49%) and Delta Central (66.52%). The post-hoc Duncan tests confirm Delta South's knowledge level was significantly lower than the other two zones, which did not significantly differ. The knowledge gap in Delta South is quite substantial at around 10 percentage points below the other zones. This highlights much weaker understanding and utilization of diverse forest products in Delta South. Several factors may contribute to this regional disparity such as; Greater emphasis on fishing in riverine areas of Delta South may orient livelihoods away from forests. More advanced palm oil production in Delta South could focus labour and expertise more on palm species over diverse NTFPs. Proximity to urban centres like Warri may accelerate migration from rural forest-based activities in Delta South.

Regardless of reasons, strengthening capacity around forest products through education, training programs and agroforestry initiatives is critical in Delta South zone. This can provide communities with greater opportunities to sustainably utilize and conserve forest resources. Closing the knowledge gap will also promote more equitable rural development across the state. Targeted measures suited to the ecology and livelihoods of Delta South are needed, while retaining traditional knowledge. A coordinated policy approach can help ensure balanced advancement across regions.

Test of hypothesis: Since the ANOVA results showed statistically significant differences among the three agricultural zones ($p < 0.05$), the null hypothesis which stated that there is no significant difference in the level of knowledge of forest products utilization among rural dwellers in the three agricultural zones of Delta State was rejected.

Table 4: Difference in the level of knowledge of forest products utilization in the three agricultural zones of Delta State

Agricultural zones	N	Mean	Std. Deviation		
Delta North	80	67.4909	10.72794		
Delta Central	80	66.5213	9.60518		
Delta South	80	57.1783	14.90003		
Total	240	63.6013	12.85765		
ANOVA					
Forest products	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5271.171	2	2635.586	18.243	0.000
Within Groups	34240.138	237	144.473		
Total	39511.310	239			
Duncan (Post Hoc Tests)				Subset for alpha = 0.05	
Agricultural zones	N	1	2		
Delta South	80	57.1783			
Delta Central	80		66.5213		
Delta North	80		67.4909		
Sig.		1.000		0.611	

Conclusion and Recommendations

The study on the knowledge of forest product utilization among rural dwellers in Delta State, Nigeria, unveiled critical insights into the socioeconomic dynamics, forest resources utilized, and levels of knowledge across agricultural zones. Gender-specific roles are deeply entrenched in forest resource utilization, with males predominantly engaged in activities such as logging and hunting, signalling the need for gender-sensitive approaches in promoting equitable access to resources. Middle-aged individuals demonstrated heightened participation in forest-related activities, while older demographics showed declining engagement, reflecting broader socioeconomic shifts and rural-to-urban migration trends. The diversity of non-timber forest products underscores their multifaceted role in supporting livelihoods, nutritional needs, and cultural practices, but challenges such as habitat loss and declining knowledge of timber and animal species threaten sustainable forest management. Regional disparities in knowledge levels, particularly in Delta South, highlight the need for targeted interventions to strengthen capacity-building efforts and promote sustainable forest utilization practices, ensuring equitable rural development and the long-term resilience of forest ecosystems across the State.

Based on the findings of the study several recommendations can be proposed to promote sustainable forest management and enhance rural livelihoods:

- i. Government agencies at the local, regional, and national levels play a crucial role in developing and implementing gender-sensitive programs. They should provide resources, policy support, and regulatory frameworks to promote equitable access to forest resources and ensure the inclusion of women in decision-making processes related to forest management.

- ii. NGOs specializing in community development, environmental conservation, and gender equality should collaborate with local communities to implement community-based education and awareness campaigns. They should facilitate workshops, training sessions, and awareness programs aimed at enhancing knowledge of forest resources and promoting sustainable harvesting practices.
- iii. Research institutions should conduct studies and assessments to identify best practices in sustainable forest management and livelihood diversification. They should also provide technical expertise and support for capacity-building initiatives, knowledge sharing platforms, and policy development processes.
- iv. Local communities are key stakeholders in sustainable forest management efforts. They should actively participate in decision-making processes, establish community-based forest management committees, and implement sustainable harvesting practices. Communities should also diversify their livelihoods by engaging in alternative income-generating activities such as agroforestry, eco-tourism, and small-scale enterprises.
- v. International organizations should provide funding support, technical assistance, and capacity-building initiatives to strengthen institutional capacity and promote sustainable forest management practices. They should also facilitate knowledge exchange and collaboration among diverse stakeholders to address common challenges and promote collective action towards sustainable forest management goals.

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