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DRIVERS OF CROP DIVERSIFICATION: EVIDENCE FROM SMALLHOLDER FARMERS IN DELTA STATE NIGERIA

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Abstract

Smallholder farmers in southern Nigeria have relied on the cultivation of cassava, yam, maize and plantain for their livelihood for generations. However, with rising climate variability and soil degradation, many farmers are adopting crop diversification as a viable alternative to improve the productivity of their farmland by growing multiple crops. Therefore, this study was conducted to examine factors that influence crop diversification, and the intensity of crop diversification among small-scale farmers in Delta State. Data for the study were obtained from a random sample of 236 farmers. Crop diversification index (CDI) was used to measure crop diversity, while descriptive statistics, Heckman two-step model and t-test were used to analyse the data. The results showed that 62.3% of the farmers were female; farmers' average age was 51 years, while farm size ranged between 0.08 and 2.2 ha, with a mean of 0.84 ha. Significant differences existed in farming experience ($p < 0.05$), farm income and farm size ($p < 0.01$) between crop diversifiers and non-diversifiers. The Heckman model results indicated that age, farm size, credit access, extension contact and farm income had significant positive ($p < 0.01$) effects on farmers' diversification decision; while farm size, credit access, extension contact and attitude to risk exerted positive and significant influence on intensity of crop diversification by smallholder farmers. Arising from the findings, there is an urgent need for government to chart a new policy direction to revamp the ailing agricultural extension delivery system, a farmer-targeted micro-credit institutions and reforms in land rights to smallholder farmers to enhance timely access to agricultural land to promote crop enterprise diversification among farming households.

Keywords: crop diversification, small-scale farmers, diversification index, Heckman two-step model, marginal effects, Nigeria

INTRODUCTION

Agriculture plays a significant role in the economy of many developing nations because it is a major source of food and income generation as well as a veritable tool for poverty reduction among smallholder farming households. Over the years in Delta State and other parts of Nigeria, small-scale farmers have relied on a subsistence strategy with the use of traditional implements and cultivating major staples such as cassava, yam and maize, particularly in the rain forest agro-climatic zone. Presently, rapid urbanisation, population growth and soil depletion has dwindled output,

reduced income and led to hunger and severe food insecurity among rural households. Due to the myriads of risks and uncertainties that have plagued small-scale agricultural production process, farmers are increasingly embracing crop enterprise diversification as a hedge against risks and to stabilize their income. Agricultural diversification is seen as a cardinal strategy for income generation, poverty and food insecurity reduction and improvement of nutritional status of the rural population (Makate, Wang, Makate and Mango, 2016; Waha *et al*., 2018). Crop diversification refers to a mix of farming systems rather than the shift from one given enterprise to another (Abdullah *et al*., 2019; Dembele, Bett, Kariuki, Le Bars and Ouko, 2018). It is a veritable strategy for mitigating risks in small-scale subsistence agriculture as farmers allocate their resources to diverse sub-units of production areas for sustainable food supply, enhanced food security and poverty reduction among farm families (Makate *et al*., 2016; Aheibam *et al*., 2017). Therefore, crop diversification gives a broader choice in the production of different varieties of crops in a given area of land in order to boost household food production in related farm activities. Moreover, it minimizes production and marketing risks by introducing pest- and disease-tolerant, high value and quick maturing crop varieties and targeting multiple markets (Barbieri *et al*., 2009).

Given the drawback intensification and specialization of agricultural production has caused traditional crops upon which farm households' livelihoods have depended over the years, and the consequent vulnerability and hunger in rural farming communities, many small-scale farmers in Delta State have adopted crop diversification farming system in spite of myriads of constraints (Nguyen, 2017). Apart from being a coping strategy against risk, crop diversity production strategy also reduces the vulnerability of agricultural production to climate variability and change (McCord *et al*., 2015) as well as improving household dietary diversity through consumption of crops of higher nutritional content and quality. Therefore, this study was conceived to address the following research questions: what factors influence farmers' decision to diversify into selected crops?; what is the intensity of crop diversification?; and what factors hinder farmers decision to adopt crop diversification strategy? The major objective of this study was to examine factors that influence the adoption of crop enterprise diversification, as well as factors that determine the intensity of crop diversification among smallholder crop farmers in Delta State, Nigeria. This study contributes to the crop diversification literature because the results of the study will enable policy makers and donor organisations to identify target variables for intervention in order to motivate farmers to adopt crop enterprise diversification, as a strategy to increase output, improve income and enhance farming households' food security. The hypotheses tested in the study are;

i) socio-economic and institutional factors have no significant effects on farmers' diversification decision;
ii) socio-economic and institutional factors have no significant influence on the intensity of crop diversification amongst small-scale crop farmers, in Delta State, Nigeria.

A number of research studies have identified and examined factors that influence crop diversification, as well as its intensity among smallholder farmers in developing countries. Dembele *et al*. (2018) conducted a study on "factors influencing crop diversification strategies among smallholder farmers in cotton production zone in Mali". They obtained data from a cross-sectional survey of 134 farming families across three villages located in different agro-ecological areas in the cotton growing zones by employing a combination of purposive, stratified and simple random sampling procedure. Only men that were involved and registered in cotton production and possessed factors of production were sampled; because they were expected to allocate at least 0.5 ha of land under cotton, and women do not own land in the study area. Structured questionnaire was the research instrument used to collect data on socio-economic variables (gender, age, education level, livestock ownership, land ownership and productive physical assets), and institutional factors (access to agricultural inputs, credit and extension services). Data were analysed using descriptive statistics, and multinomial logistic (MNL) regression to ascertain factors that influence the choice of diversification strategies among smallholder cotton farmers. The results indicated that the age of family head, education level, family size, oxen ownership, farm income and crop pest, significantly determined the likelihood of households' participation in the four diversification strategies. The authors recommended the implementation of policies to promote profit-oriented agribusiness activities through diversification strategies, as well as institutional interventions to increase smallholder farmers' access to inputs and credit.

Kurdyś-Kujawska, Zawadzka and Sompolska-Rzechuła (2018) conducted a study on "The Probability of Farm's Diversification: on the example of Central Pomerania in Poland", using eight year time series data obtained from 256 owners or managers of agricultural holdings, while A logit regression model was used to estimate factors that affect the likelihood of farm diversification, as well as determining variables of income diversification. The results revealed that farmers' demographic characteristics and asset portfolio are major determinants of the decision to engage

in farms diversification. While the propensity for crop diversification increases with the volume of fixed assets, it decreases with the rising level of education. However, farm area exhibited a negative relationship as the likelihood of diversification of income sources increases. The authors concluded that in order to support crop diversification in small-scale farms, policy makers should focus on measures to enhance farmers' access to external funding sources at affordable rates, as this will enable them procure needed inputs to expand production.

Dessie, Abate, Mekie and Liyew (2019) studied 'Crop diversification analysis on red pepper dominated smallholder farming system: evidence from northwest Ethiopia' with the aid of primary data obtained from 385 crop producers using systematic random sampling technique. Data were analysed using a combination of descriptive and inferential statistics such as chi-square test, t-test and Tobit model while crop diversification index (CDI) was determined by Herfindahl Index of concentration deviated from unity (1 – HI). The results revealed a high level of participation in crop diversification strategy of 92.5% among smallholder farmers with an average crop diversification index of 0.77. The results of the Tobit model showed that crop diversification and its intensity were significantly affected by farm size, sex, age, land fragmentation, market distance, and non-/off-farm income opportunities. The authors affirmed that owing to the impact of crop diversification on the income generation and food security of farming households, government and development partners should give special attention to extension service delivery system and infrastructure development in order to improve overall livelihood diversification among rural households.

MATERIALS AND METHODS

Area of Study

The location of the study is Delta North Agricultural zone. It is a major agricultural production belt in Delta State, Nigeria, and it is comprised of 9 (nine) local government areas (LGAs) including, Oshimili North, Oshimili South, Ika Northeast, Ika South, Ndokwa East, Ndokwa West, Aniocha North, Aniocha South and Ukwuani. The total population of the Delta North agricultural zone is one million, two hundred and ninety three thousand and seventy four (1,293,074) people (NPC, 2006).The major occupation of the people is farming and cassava is the major crop cultivated in the area. Other food crops grown include yam, plantain, banana, sweet potato, maize, rice, cocoyam, melon, tomatoes, pepper, okra, and leafy vegetables such as fluted pumpkin, *amaranthus* and water leaf among others.

Sampling Procedure and Data Collection

Multistage sampling procedure was used to draw samples for the study. Firstly, five (5) local government areas (LGAs) were randomly drawn from the 9 (nine) LGAs that comprised the Delta North Agricultural zone. The LGAs are; Oshimili North, Ika North-East, Aniocha North, Ndokwa East and Ukwuani. At the second stage, five (5) farming communities were selected from each of the five (5) LGAs to give a total of twenty five (25) farming communities that were surveyed. The third stage involved the random selection of eleven (11) crop farmers from each of the twenty five (25) farming communities to give a total of two hundred and seventy-five (275) farmers to whom the research instrument was administered.

Primary data for this study were obtained from a cross section of crop farmers with the use of structured questionnaire that was randomly administered to 275 respondents. The research instrument was self-administered by the researchers with assistance of trained enumerators that were fluent in both English Language and *Igbo*, the local dialect of the people. Data collected included social characteristics of households such as educational status, gender of household head, marital status, household size and farm income. Others are farm size, input and output data, crops cultivated, access to credit, access to extension services. However, due to inadequate information supplied by some farmers and non-response, 39 copies of the questionnaire were discarded and data analysis was based on the responses of 236 crop farmers. The survey was conducted between November, 2018 and March, 2019.

Methods of Data Analysis

Descriptive and inferential statistics were used to analyse the data generated from the survey. Descriptive analysis involved the use of frequency counts, means, mode and percentages; while students'-test was employed to check whether there were significant differences between adopters and non-adopters of crop diversity. In order to analyse factors that influence crop diversification and its intensity, the Heckman Two-Step model was applied. The first stage involved determining the probability that a farmer diversify his crop enterprise, which is a positive outcome, while the second stage estimates the extent of participation, which is conditional upon observing positive values. A four point likert-type scale was employed in order to determine factors that hinder the adoption of crop diversification strategy in the study area. The scale ranged from very insignificant (1), insignificant (2), significant (3), and very significant (4). Farmers' responses to the statements of constraint were analysed using one sample t-test.

A number of indices have been developed to determine the level of crop diversification

including; Simpson's Index (SI), Margalef index (MI), Herfindahl Index (HI), and Entropy Index (EI) and their modifications (Basavaraj, Gajanana and Satishkumar, 2016; Asante, Villano, Patrick, Battese, 2018). However, this study used HI because it has been widely used in the crop diversification literature (Aheibam *et al*., 2017; Dembele *et al*., 2018). In order to compute crop diversification index (CDI), the HI (which is actually a measure of concentration) is deviated from unity (1);

$$CDI = 1 - \sum_{i-1}^{n}\left(\frac{A_i}{\sum_{i=1}^{n} A_i}\right)^2, \quad (1)$$

$$HI = \sum_{i=1}^{n} P_i^2. \quad (2)$$

But,

$$P_i = \frac{A_i}{\sum_{i=1}^{n} A_i}. \quad (3)$$

Thus,

$$HI = \sum_{i-1}^{n}\left(\frac{A_i}{\sum_{i=1}^{n} A_i}\right)^2. \quad (4)$$

Where,
P_i.....Proportion of ith crop;
A_i.....area under ith crop;
$\sum_{i-1}^{n} A_i$..Total land cropped cultivated;
i.....1, 2, 3 ..., n;
n..... number of crop enterprises.

Model Specification

The decision of small-scale farmers to diversify their crop enterprises is based on the theory of random utility maximization (Rahm and Huffman, 1984). Farmers will diversify their crop production if the utility of existing farm operation (U_0) is less than that of introducing additional crop enterprises (U_1). Therefore, the i^{th} farmer will diversify (D_i) if the utility derived from diversification is greater than not diversifying; if $U_{1i} > U_{0i}$ or if the non-observable (latent) random variable $D_i^* = U_{1i} - U_{0i} > 0$.

$$D_i = \begin{cases} U_{1i} > U_{0i}, \text{ if the farmer diversifies,} \\ \text{or} \\ U_{1i} \le U_{0i}, \text{ if the farmer doesn't diversify,} \end{cases} \quad (5)$$

where,
U_{1i}..... utility that the ith farmer participate in crop diversification,
U_{0i}.....uility that the ith farmer does participate in crop diversification.

Therefore, the first stage of the Heckman Two-Stage model (Heckman, 1979), is the selection equation, a probit model which estimates the probability of the farmer diversifying (1) or not (0). Thus,

$$D_i^* = \delta_1 + \delta_2 X_{1i} + e_{1i}, \quad (6)$$

where,
D_i^*..... latent variable denoting farmers decision to participate in crop diversification;
δ_1.....intercept;
δ_2.....parameters to be estimated;
X_{1i}.....vector of variables that affect crop diversification decision. The variables are: X_1 = Sex; X_2 = Farmer's Age; X_3 = Marital status; X_4 = Years of formal education; X_5 = Years of cultivating selected crops; X_6 = Average farm income; X_7 = Access to credit; X_8 = Attitude to risk; X_9 = Access to extension services; X_{10} = Household size; X_{11} = Farm size;
e_{1i}..... error term. The probit model (first stage) could be specified explicitly as;

$$D_i = \delta_0 + \delta_1 X_1 + \delta_2 X_2 + \delta_3 X_3 + \delta_4 X_4 + \delta_5 X_5 + \delta_6 X_6 + \\ + \delta_7 X_7 + \delta_8 X_8 + \delta_9 X_9 + \delta_{10} X_{10} + \delta_{11} X_{11} + e. \quad (7)$$

The second stage of the two-step procedure is the estimation of the intensity of crop diversification (outcome equation) and the dependent variable is the crop diversification index, CDI, computed from equation (1);

$$CDI = \psi_1 + \psi_2 X_{2i} + e_{2i}, \quad (8)$$

where,
CDI..... observable random variable;
ψ_1.....intercept;
ψ_2.....regression parameters to be estimated;
X_{2i}.....vector of independent variables that explain the intensity of diversification (X_1–X_{11}) as defined earlier;
e_{2i}..... error term.

In order to correct for selectivity bias in the outcome equation, an Inverse Mills Ratio (IMR) estimated from the probit model was included in the outcome model as a regressor, denoted as (λ);

$$CDI = \psi_1 + \psi_2 X_{2i} + \psi_\lambda \lambda_i + e_{3i}, \quad (9)$$

$$\lambda_i = \frac{\phi(\delta_1 + \delta_2 X_{1i})}{\Phi(\delta_1 + \delta_2 X_{1i})}, \quad (10)$$

where,
λ.....IMR;
ϕ (·).....the standard normal probability density function and
Φ (·) .....the cumulative density function of the standard normal random variable (Greene, 2008). If the term (λ) is not statistically significant, it means that there is no problem of sample selection bias in the model (Heckman, 1979). The descriptive statistics of variables that influence farmers' participation in crop enterprise diversification, as well as its extent are

shown in Tab. I. The outcome (OLS) equation is expressed explicitly as follows:

$$CDI = \psi_0 + \psi_1 X_1 + \psi_2 X_2 + \psi_3 X_3 + \psi_4 X_4 + \psi_5 X_5 + \psi_6 X_6 + \\ + \psi_7 X_7 + \psi_8 X_8 + \psi_9 X_9 + \psi_{10} X_{10} + \psi_{11} X_{11} + \psi_{12} IMR. \quad (11)$$

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Respondents

The results of the socio-demographic analysis of the data revealed that 147 respondents representing 62.3% of the farmers were women, while 89 (38.7%) of them were men (Tab. II). Most smallholder crop diversity production systems are dominated by women in the rainforest agricultural zone of Nigeria due to the several challenges women farmers face to access land for agricultural production. Thus, many women farmers grow multiple species of crops on their little parcels of farmland not only for cash income, but particularly to meet the nutritional needs of the household. The age of the farmers ranged between 29 and 73 years, with an average age of 51 years. Older farmers are likely to have larger household sizes which are a source of labour required to diversify into other productive activities (Asante *et al.*, 2018). Furthermore, large families require more resources for sustenance than small-sized households, thus they will venture into several livelihood activities in order to obtain the resources to cater for their families (Albore, 2018). However about 60% of farmers are within the economically active working age and can withstand the arduous task of labour-intensive and low-capital input small-scale crop farming. Furthermore, about 63% of the crop farmers were married; 90% of them have had some form of formal education. With a mean age of 51 years and an average farming experience of 19 years, the farmers are more likely to adopt crop diversification strategy in the face increasing land and labour scarcity. The average household size was found to be 6 persons. Though this appeared somewhat low, the continual emigration of able-bodied youths to urban centres in search of white collar jobs may be implicated for this, with serious consequences in the scarcity of farm labour. Farm sizes ranged between 0.08 and 2.2 ha, with an average farm size of 0.84. However, about 78% of all the sampled farmers had farm sizes that ranged between 0.08 and 1.09 ha. The prevailing cultural practices and indigenous land tenure system by inheritance which has vested authority in males, has resulted in agricultural land fragmentation and hindered women access to land (Chigbu, 2019; Ajadi, Oladele, Ikegami and Tsuruta, 2019).

Test of Differences of Means of Socio-Economic Variables Among Participants and Non-participants in Crop Diversification

The results of the t-test of mean difference of socio-economic characteristics of crop diversifiers and non-diversifiers are presented in Tab. III. The 236 smallholder crop farmers comprised 125 crop diversifiers and 111 non-diversifiers. The results indicated that there is significant mean difference

I: *Description and Summary Statistics of Variables used in the Heckman Two-Step Model*

Variable	Variable Description	Mean (Mode)	Std. Deviation	Minimum	Maximum
CROPDIV	Participation in diversifying into the selected crops	(1)	0.50018	0.00	1.00
SEX	Sex of farmer (1 if male, 0 otherwise)	(0)	0.49644	0.00	1.00
FARMAGE	Number of years since birth	51.1907	11.51916	29.00	73.00
MRLSTA	Marital status (1 if married, 0 if not married)	(1)	0.48460	0.00	1.00
EDUC	Years of formal education	10.0763	4.44667	.00	21.00
FARMEXP	Number of years the farmer has been growing the selected crops	19.2331	11.00100	2.00	45.00
FARMINCOM	Average farm income (₦)	45477.79	17217.70	3568.92	84031.68
CREDITACES	Access to credit; 1 if the farmer had access, 0 otherwise	(1)	0.48346	0.00	1.00
ATDRSK	Attitude to risk (1 if a risk taker, 0 otherwise)	(0)	0.51526	0.00	1.00
EXTENACES	Access to production and marketing information; 1 = yes, 0 otherwise	(0)	0.50104	0.00	1.00
HHSIZE	The number of persons in farmer household	6.1441	2.14486	3.00	13.00
FARMSIZE	Total size of the farm owned by a farmer (hectares)	0.8365	0.44013	0.08	2.14
CDI	Index of intensity of crop diversification	0.5383	0.14475	0.21	0.72

Source: Computed from survey data, 2019

II: *Distribution of Socio-economic Characteristics of Respondents*

Variable	Frequency	Percentage (%)	Mean (mode)
Sex			
Male	89	37.7	
Female	147	62.3	(Female)
Age (years)			
29–37	36	15.3	
38–46	47	19.9	
47–55	64	27.1	51 years
56–64	52	22.0	
65–73	37	15.7	
Marital Status			
Not married	88	37.3	
Married	148	62.7	(Married)
Household Size			
3–5	107	45.8	
6–8	90	37.7	6 persons
9–11	35	14.8	
12–14	4	1.7	
Farm Experience (years)			
2–12	88	37.3	
13–23	59	25.0	
24–34	65	27.5	19 years
35–45	24	10.2	
Farm Size (hectares)			
0.08–0.58	90	38.1	
0.59–1.09	95	40.3	
1.1–1.6	45	19.1	0.84 ha
1.7–2.2	6	2.5	
Years of Formal Education			
No formal education	14	5.9	
Primary education	79	33.5	
Secondary education	76	32.2	(Primary school)
Tertiary education	66	28.0	
Postgraduate education	1	0.4	
Farm Income (*)			
28,453.00–188,853.00	34	14.4	
188,854.00–349,254.00	73	30.9	
349,255.00–509,655.00	89	37.7	362,576.86
509,656.00–670,056.00	40	17.0	

* 1US Dollar = 365 Nigerian Naira
Source: Computed from survey data, 2019

III: *Results of Test of Differences of Means of Socioeconomic Variables among Participants and Non-participants in Crop Diversification*

Variables	Diversifiers	Non-diversifiers	Mean diff.	t-statistic (2-tailed)
Age	51.50	50.8378	0.67	0.44
Years of education	10.2	9.95	0.25	0.42
Farming experience	20.8	17.5	3.25	2.29**
Farm income	39,7918.66	32,2777.54	75141.12	4.36***
Household size	6.21	6.04	0.17	0.61
Farm size	0.9387	0.7214	0.217	3.925***

*** ($p < 0.01$); ** ($p < 0.05$)
Source: Computed from survey data, 2019

in farming experience, farm income and farm size cultivated by farmers who adopted crop diversification and non- diversifiers. The significance of these variables indirectly implied their importance as determining factors in crop diversity adoption decision among small-scale farmers in Delta State, Nigeria.

Probit Estimate of Determinants of Crop Enterprise Diversification

The results of the Heckman two-step model for the determinants of crop diversification, and its extent are presented in Tabs. IV and V. Tab. IV shows the results of the probit model (selection equation) of factors that influence the decision to diversify or otherwise. The model had a good fit with a highly significant Wald chi-square, 43.73 ($p < 0.001$) and McFadden R^2 of 0.39 implying that 39% variation in the dependent variable, crop enterprise diversification, was jointly explained by all the independent variables included in the model. The variance inflation factor (VIF), an indicator of multicollinearity showed that the independent variables are not collinear as all the VIF values range between 1.023 and 1.176, far below the threshold of 10 (Hair, Black, Babin and Anderson, 2014). Furthermore, the results indicated that age, farm income, farm size, credit access and extension

IV: *Estimates of Heckman Selection model of Determinants of Crop Diversification*

Variable	Coefficient	Std, error	z-stat	Marginal effect	Variance Inflation Factor
Sex	0.03300	0.2144	0.15	0.013	1.033
Age	0.04451	0.01097	4.06***	0.018	1.096
Marital status	0.31735	0.22036	1.44	0.126	1.057
Years of education	-0.03802	0.02470	-1.54	-0.015	1.176
Farming experience	0.00815	0.00844	0.97	0.003	1.042
Farm income	0.000021	6.50e-05	3.17***	0.0000081	1.068
Credit access	0.64218	0.22628	2.84***	0.252	1.147
Attitude to risk	-0.16540	0.21018	-0.79	-0.066	1.072
Extension contact	1.4013	0.20669	6.78***	0.514	1.153
House hold size	0.03743	0.04441	0.84	0.015	1.023
Farm size	0.6830	0.24708	2.76***	0.271	1.080
Constant	-4.6913	0.80127	-5.85		
Number of obs = 236					
Censored obs = 111					
Uncensored obs = 125					
Wald $chi^2(11) = 43.73$					
Prob > $chi^2 = 0.0000$					
McFadden $R^2 = 0.39$					

*** ($p < 0.01$)
Source: Computed from survey data, 2019

contact had positive and statistically significant influence on crop diversification decision.

Age is a major determinant of crop diversification participation decision. Older farmers who have acquired experience over the years have a better understanding of the need to diversify production to mitigate unwarranted climatic variability, price shocks and total crop failure, in order to protect the wellbeing of the farm household. The results further implied that a 10% increase in age will result in a 0.18% increase in the likelihood of participating in crop diversification. This finding is in consonance with those of Meraner, Heijman, Kuhlman and Finger (2015), Asfaw, Pallante and Palma (2018) and Dembele *et al*., 2018 who reported that farmer's adoption of crop diversification strategy significantly increases with age. However, Shahbaz, Boz and Haq (2017) reported significant negative effects of farmers' age on crop diversification in a study in Punjab, Pakistan.

Farm income, access to credit, extension contact and farm size are other variables that exerted positive and significant effects on crop diversification decision. Farmers with higher farm income can afford the cost of the innovation and bear the risks associated with it. This finding is consistent with those of Anang and Amiku-zuno, (2015) and Obayelu *et al*. (2016). However, the response of crop diversity to farm income is very low as a 10% increase in farm income will result only in 0.000082 likelihood of participation. The results imply that older famers with improved farm income, and those that have better access to credit, have a higher likelihood to adopt crop diversification as a technology to improve their wellbeing. The results are in consonance with the findings of Al-zyoud (2014) in Jordan and Baffoe-Asare *et al*. (2013) in a study in central region of Ghana.

Apart from farm income, accessibility to reliable sources of credit to procure inputs needed to continue in the new production activities will in no doubt facilitate the propensity to adopt crop diversification farming system. Access to credit promotes the farmer's potential to acquire more inputs for crop production. Thus the more a farmer gets access to credit facilities on a more reasonable term, the more he/she will put this into productive crop enterprises thereby affecting crop diversification. As shown in Tab. IV, a 10% increase in access to credit will increase the likelihood of participation in crop diversification by 2.5%. This finding is in consonance with report of Arega *et al*. (2008).

Agricultural extension services are the major source of information to farmers apart from farmers groups. Thus, contact with extension agents will therefore increase a farmer's likelihood of adopting improved innovations such as diversification into higher value crops. This finding is in consonance with those of Samiee *et al*. (2009) who reported positive and significant influence of extension education and communication channels on the adoption of new technologies in Iran. Contact with extension agents appear to be the major predictor of crop diversification given the magnitude of its marginal effect, a 10% increase in extension contact will raise the propensity of diversifying crop production by 5%.

Crop diversity as a farming system requires additional land resource by the farmer for the cultivation of higher-value and early-maturing crops varieties. Thus, increased farm size is a precursor to farmers willing and ability to engage in crop diversity as the probability of adopting crop diversification increases with farm size. Agricultural land is a major production factor in rural farmers' livelihood activity. But the traditional land tenure system that is rooted in the culture of the people of southern Nigeria promotes inequality against women in access to natural resources, particularly land. As shown in Tab. IV, a 10% increase in land holding will raise the propensity of diversifying crop production by 2.7%. Research reports that found farm size as a positive and dominant predictor of crop diversification include those by Makate *et al*. (2016) in Zimbabwe, Abdullah *et al*. (2019) in Pakistan, Mekuria and Mekonnen (2018) in Ethiopia, Min, Huang and Waibel (2017) in China and Lazikova, Bandlerova, Rumanovska, Taka and Lazíkova (2019) in Slovakia. On access to credit Asante, Villano, Patrick and Battese (2018) found this variable to exert positive and significant influence of the likelihood of farmers to diversify crop production in a study in Ghana.

It should be noted however, that gender, marital status, farming experience, household size, years of education and attitude to risk of the farmers did not exert significant influence on the decision to participate in diversified crop production system; while education and attitude to risk exhibited a negative relationship, other aforementioned variables showed a direct association with crop diversification. These findings are consistent with the report of Sichoongwe, Mapemba, Tembo and Ng'ong'ola (2014) in a study of smallholder farmers in Zambia; Dessie, Abate, Mekie and Liyew (2019) study in northwest Ethiopia, as well as those of Kemboi, Muendo and Kiprotich (2020) in Kenya where gender, literacy status, family size and farm experience had no significant effects on farmers decision to adopt diversified cropping system.

OLS Estimates of the Intensity of Crop Diversification

The OLS model (outcome equation) was used to analyse the intensity of crop diversification among smallholder crop farmers in the study area (Tab. V). Selection bias was tested by the inclusion of the IMR in the outcome equation, which was not significant, thereby confirming the absence of sample selectivity bias. Years of education, credit access,

V: *OLS Estimates of Intensity of Crop Diversification*

Variable	Coefficient	Std, error	z-stat	Marginal effect
Sex	-0.0057	0.01821	-0.31	-0.005
Age	0.0020	0.00149	1.34	0.002
Marital status	-0.0147	0.02085	-0.71	-0.015
Years of education	0.00606	0.00228	2.66***	0.006
Farming experience	0.000194	0.00076	0.25	0.0002
Farm income	-8.45e-07	7.56e-06	-1.12	-8.45e-07
Credit access	0.0582	0.02755	2.11**	0.06
Attitude to risk	0.0367	0.01817	2.02**	0.04
Ext access	0.0760	0.05422	1.40	0.076
House hold size	0.0003	0.00375	-0.07	-0.0003
Farm size	0.0507	0.0274	1.85*	0.05
Constant	0.4128	0.2150	1.92	
mills lambda	0.0203	0.07416	0.27	
rho	0.21367			
sigma	0.09478326			

*** ($p < 0.01$);** ($p < 0.05$); ($p < 0.1$)*
Source: Computed from survey data, 2019

attitude to risk and farm size were the variables that had positive and significant impact on the intensity of crop diversification. The more educated farmers are the greater the likelihood to intensify the use of innovative technologies that will expand their output and enhance food security of their households. Also, educated farmers are more efficient to obtain and understand new techniques in a short period of time compared to their uneducated counterparts (Inoni, Tobih, and Idoge, 2016). The effect of education is however low as a 10% increase in the level of education will result in a 0.06% increase in the probability of diversity intensification. Comparable results were reported in the studies by Aheibam *et al.* (2017) in India, Shahbaz, Boz and Haq (2017) in Pakistan and Dembele *et al.* (2018) in Mali, where increase in education and training of farmers raised the likelihood of the intensity of participation in diversified cropping system. Nevertheless, Kurdys-Kujawska, Zawadzka and Sompolska-Rzechuła (2018) found the propensity to diversify crop production to decrease with rising level of education in Poland, while Abdullah *et al.* (2019) affirmed that higher level of education may reduce farmers' propensity to participate in farm-based innovations due to more lucrative off-farm opportunities that may be available to them.

Access to credit and attitude to risk are other variables that affect the extent of crop diversity strategy. Credit is routinely required as working capital for daily farm operations if the level of intensification must be sustained by the farm household in the face of several challenges such as climate change and credit constraints. Thus, a unit rise in access to credit will increase the intensity of crop diversification by 0.06%. This finding conforms to the works of Abdullah *et al.* (2019). Attitude to risk does not only influence the decision to diversify crop production but also the intensity of crop diversification, as venturing into new methods of production require some measures of risks. Nevertheless, crop diversification itself is an effective strategy for farmers to mitigate risks such as crop failures, disease outbreaks and environmental hazards. The study reveals that the likelihood of intensive crop diversification will be increased by 0.04% if farmers exhibit a 1% increase in risk aversion.

The results in Tabs. IV and V clearly revealed that socio-economic factors such as age, farm size, farm income, extension contact and credit access exerted positive and significant effects on the likelihood of diversification, while years of education, credit access, attitude to risk and farm size impacted the extent of crop diversification. Therefore, the null hypothesis that socio-economic variables had no significant influence on crop enterprise diversification is rejected. Similarly, the null hypothesis of the effects of institutional factors, proxied by access to extension services, was also rejected as the results revealed that access to extension services is the major predictor of the probability of participating in crop diversity production system.

Constraints to Crop Diversification Farming Strategy

A four-point likert-type scale was used to determine significant constraints that affected farmers' participation in crop diversification farming strategy. The scale ranged from 1 (very insignificant), 2 (insignificant), 3 (significant), to 4 (very significant). Farmers' responses to each constraint statement were analysed using one sample t-test. The results revealed that apart from scarcity of improved seeds and farmers' inexperience in the cultivation of newly introduced crops, all other factors posed serious and significant constraints to farmers' adoption of crop diversification strategy (Tab. VI). Policy interventions should be adopted in order to address institutional impediments to the adoption of crop diversification as a profitable strategy that will improve the wellbeing of smallholder farming households. The extension delivery system should be overhauled as well as measures to make credit available to farmers timely and at affordable interest rate to facilitate farm operations.

CONCLUSION

The study analysed socio-economic factors that influenced farming households' decision to adopt crop diversification strategy, as well as the determinants of the extent crop diversification using data from a cross-section of farmers in Delta State, Nigeria. The results showed that several variables drive crop enterprise diversification, but the major predictors of the propensity to diversify were extension contact, farm income, farm size, access to credit, and farmer's age. Furthermore, access to affordable and readily available credit is another hurdle farmers must scale in order to participate in diversification, as such a decision demands that farmers have adequate financial resources to maintain existing production operations while contemplating expansion to higher value crops. As with many new ventures, there are always some elements of risks attached, thus attitude to risk exerted positive and significant effects on the extent of crop diversification. Other variables that have similar effects were credit access, farm size and years of education. This is logical because once farmers adopt crop diversification as a strategy, the need for additional land space for operation will arise as well as production credit. Access to land, production inputs and farm credit have been recurrent issues in the agricultural policy framework of many sub-Saharan African countries. Yet input supplies in the right quantity, quality and time have remained a mirage in the face of economic challenges that have constrained the operations of agricultural development agencies. The implications of the findings are that designing a successful rural agricultural development programme with a view to expanding farmers' adoption and participation in diversified cropping system requires a thorough analysis of the gamut of factors that could impinge on the outcome of such a strategy. A down-top approach that will involve the farmers at every stage from conception, to design, implementation and evaluation should be encouraged for farmers to enjoy the benefits of agricultural diversification.

Therefore, concerted efforts must be made by government to support small-scale farmers through reform in land access rights and guaranteed credit at single digit interest rate without undue bureaucracy, to enable them to procure required inputs at the right time for production. Also, farmers must take their destinies in their own hands, by imbibing a saving culture through engaging in rotating savings and credit groups as well as cooperative societies to mobilise savings. Such savings could be used for bulk procurement of essential inputs which will be accessible to farmers

VI: *One Sample T-test of Constraints to Crop Diversification*

Constraint	Test Value = 3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Lack of extension contact	2.138	235	0.034**	0.07097	0.0056	0.1364
Scarcity of improved seeds	-0.655	235	0.513	-0.02216	-0.0889	0.0445
Lack of access to credit	3.175	235	0.002***	0.09386	0.0356	0.1521
Scarcity of farm labour	2.294	235	0.023**	0.08894	0.0126	0.1653
Inexperience in cultivating new crops	0.602	235	0.547	0.01831	-0.0416	0.0782
Scarcity of farm land	2.601	235	0.010***	0.09915	0.0240	0.1743
Low level of education	3.478	235	0.001***	0.14534	0.0630	0.2277

Source: Computed from survey data, 2019; *** ($p < 0.01$); ** ($p < 0.05$)

in different production clusters all through the production season. Institutional support through effective public agricultural extension delivery system is also recommended to assist farmers to cope with new challenges that crop diversification will bring. Crop diversification appears to be the readily available strategy to boost output, stabilize income and guarantee food security among farming households in Nigeria, and donor agencies and government at all levels must support it if the war against hunger and food insecurity must be won.

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