# Determinant of Crop Preference among Food Crop Farmers in Nigeria: A Climate Change Adaptation Strategy

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***Abstract:*** **This study investigates the determinant of farmers' choice of food crops using a multinomial choice of crop selection. The analysis was based on agricultural data obtained from General Household Survey wave 4 for over 5000 farmers planting the six selected food crops (maize, rice, beans, groundnut, yam, cassava) across Nigeria. The climate variables for monthly rainfall and temperature for 1980- 2019 was obtained from Nigeria Meteorological agency. The multinomial logit regression model revealed that climate variables and other variables have varying effects on the probability of the choice of crop selected by farmers. One percent change in the explanatory variable leads to a more than proportionate change in the probability of selecting other crops relative to the maize (reference crops). The partial elasticities of rainfall, farm size are elastic for all the selected crops; labour is elastic for all the other crops and inelastic for rice and groundnut. The partial elasticities for the remaining variables, education, age, distance to market, are generally small in magnitude and are also inelastic. The study revealed that the choices of crop by farmers is sensitive to climate, the change in climate will therefore affect the production of some food crops that are sensitive to the harsh weather.**

***Key notes:*** **Temperature, Rainfall, Crops, Multinomial Logit, Elasticity**.

## I. INTRODUCTION

Crop selection is a vital aspect of crop production; the farmer is to select which particular crop or combination of crops to grow among many food crops available for planting. Climate however is a major factor to be considered when it comes to crop production; the recent change in the climate has left the farmers in a dilemma of which crop has to be chosen to suit the frequent change in the climate. The Erratic changes in the onset of rains in the last two decades had led to situations where crops planted with the arrival of early rains get stifled in the soil by an unexpected dry spell; resulting in harvest failures in Nigeria and other ecosystems that rely on rain-fed agriculture. The recent changes in climate experienced in the past decades through extreme temperature, frequent flooding and drought has become a recurrent subject of debate globally. Like other developing countries, the climate change and global warming challenge is enormous in Nigeria due to ubiquitous poverty, burning of firewood and farm residues, prevailing slash- and-burn agriculture and erosion. The climate change issue has become more threatening to the sustainable development of socioeconomic and agricultural activities of any nation and also to human existence by extension. It has been earlier estimated that a temperature increase of 2.5 degrees (°C) or more would cause a decline in crop yields and prompt food prices to increase because growth in global food demand is faster than expansion of global food capacity (Parry et al., 1999). The existence of climate change in Nigeria was predicted by IPCC (2001) and established by Odjugo (2012) who confirmed the evident of the rising in temperature, which was said to be significantly higher than the global mean. He went further to state that the generated statistics specified that climate change provoked drought and flood have seriously triggered major land degradation in Nigeria. In recent years, unreliable rainfall (changes in variance and seasons of rainfall) has been observed. It is now very common for some areas to receive rainfall that is not sufficient for crop production (drought), while other areas receive too much rainfall than the normal crop requirement, which leads to floods. Some areas experience early or late seasons of rainfalls which differ from the usual seasons; both conditions are not good for agricultural practices.

Agriculture in Nigeria plays a significant and decisive role in the economic and social development of the nation. The sector employs about 60-70 percent of the country's labor force and contributes 30-40 percent of the nation's GDP and is also the source of raw materials used in several processing industries as well as a source of foreign exchange earnings for the country (Ajetomobi 2010). The prominent role played by agriculture has been undermined due to its vulnerability to climate change and dependence on natural weather patterns and climate cycles for its productivity. Majority of the farming households live in rural areas and are dependent on local agriculture to meet their food needs and livelihood. The exposure of Nigerian agricultural sector to climate change has been a major concern to policy makers because of the sector's contribution to the economy of the country. The country now experience tenacious droughts and flooding, off season rainfall and dry spells which have altered the growing seasons across the country because of the high reliant on rainfall for agricultural practices. There is now a high decline in the yield of most cereals crop because the needed rainfall requirement for germination and sprouting of the cereal was not met at the time needed (McCarthy et al, 2001). A few degrees of warming in the tropics will generally increase yields while, yields of crops near to their maximum temperature tolerance and dry land crops will decrease. A large decrease in rainfall would have even greater adverse effect on yields and net revenue. Generally, two major categories of approaches to climate change were recognized in the Kyoto protocol, mitigation and adaptation. Mitigation is an action that limits global climate change through the reduction of GHG emissions and enhancing the sink of GHGs. Adaptation is viewed as part of the activities which society embarks on to lessen the destructive effects of climate change or take advantage of the beneficial opportunities which may arise from the change in climate (Mendelsohn, 2001). Several researches have been to incorporate adaptation in their climate change impact models in an attempt to improve the conceptual and empirical approaches to explain the characteristics of environmental problem and measuring environmental effects on agriculture. This study explores farmers' choice of crop as a means of adaptation to climate change. Farmers who are faced with different climate change will choose different types of planting system or plant some particular crops that can effectively adapt to the climatic condition of an agro-ecological zone which will help the crop yield to be likely less affected by climate change. This paper therefore investigates the choices of food crops cultivated by farmers as affected by climate variables.

The objectives of this study is to: investigate the socioeconomic characteristics of farmers planting the selected food crops, analyse the average net revenue generated from selected food crops by each state in Nigeria, investigate the impact of climate change on farmers' crops selection, determine other factors influencing the choice of crop selection by the farmers.

## II. THEORY

The study assumes that farmers choose amongst six types of commonly major food crops: yam, rice, maize, cassava, beans, groundnut or the combination of them. Given these choices, the farmer combines inputs to make outputs that maximize land value. We assume that the farmer will choose the combination of crops that maximizes estimated net revenues. Farmers switch from one farm type to another as climate changes, the overall response function captures this switching. However, by explicitly modeling the switching, analysts can see what changes farmers are making to stay on the peak profit locus.

The profit each farmer i obtained from choosing crop type j (j=1, 2,. . . or 6) is the following:

$$\pi_{ij} = V(K_j) + \varepsilon_i(K_j) \qquad (1)$$

Where, K is a vector of exogenous characteristics of the crop. For example, K could include suitable climate condition for crop growth and duration of growth. Crop prices and prevailing weather and market for the crop reflect the attractiveness of planting one crop to other crops. The profit function is composed of two components: the observable component V and an error term, ε. Farmers will choose the crop type that gives him the highest profit. In other words, the farmer will choose crop j over all other crop k if:

$$\pi^*(K_{ji}) > \pi^*(K_{ki}) \text{ for } \forall\, k = j \text{ or [or if } \varepsilon_i(K_{ki}) - \varepsilon_i(K_{ij}) < V(K_{ij}) - (K_{ki}) \text{ for } i=j \qquad (2)$$

More succinctly, farmer i's problem is:

$$\textbf{argmax}\ [\pi^*(K_{1i}), \pi^*(K_{2i}), \ldots\ldots \pi^*(K_{ji})] \qquad (3)$$

The probability $P_{ji}$ of the jth crop being chosen is

$$P_{ji} = \Pr[\varepsilon_i(K_{ki}) - \varepsilon_i(K_{ji}) < V_j - V_k]\ \forall\ k = j$$

$$\text{Where } V_j = V(K_{ji}) \qquad (4)$$

Assuming $\varepsilon_1$ is independently Gumbel distributed and $V_k = K_k \gamma_k + \alpha_k$, the probability that farmer i will choose crop j among the six crops is (McFadden 1973; Chow 1983):

$$P_{ji} = \frac{e^{K_{ji}\gamma_j}}{\sum_{k-1}^{3} e^{K_{ji}\gamma_j}} \qquad (5)$$

*Model Specification*

The general form of the Model specification for multinomial logit is:

$$\Pr(y_i = j) = \frac{\exp(X_i\beta_j)}{1+\sum_{j=1}^{J}\exp(X_i\beta_j)} \qquad (6)$$

And to ensure identifiability,

$$\Pr(y_i = 0) = \frac{1}{1+\sum_{j=1}^{J}\exp(X_i\beta_j)} \qquad (7)$$

Where for the i<sup>th</sup> crop, $y_i$ is the observed outcome and $X_i$ is the explanatory variable $\beta$ is the unknown parameter.

The model for this objective is summarized as follows:

$$P_{ij} = \frac{\exp(\gamma_j X_i}{1+\sum_{j=1}^{5}\exp(\gamma_j X_i)}\ for\ j=1,2,3,4,5 \qquad (8)$$

$P_{ij}$ is the probability of planting any of the selected crops.

$$P_{i0} = \frac{\exp(\gamma_j X_i}{1+\sum_{j=1}^{3}\exp(\gamma_j X_i)}\ for\ j=o \qquad (9)$$

$P_{i0}$ is the probability of planting maize, (base crop)

When estimating the model in practice, the coefficient of the reference group are normalized to zero (Maddala 1990; Green 1993, Rahji and Fakayode 2009). This is because the probabilities for all the choices must sum up to unity (Green 1993). Hence for 6 choices only (6-1) distinct sets of parameters can be identified and estimated. The natural logarithms of the odd ratio equation (6) and (7) give the estimating equation (Green 1993) as:

$$\ln \frac{(P_{ij})}{(P_{io})} \gamma_j X_i \qquad (10)$$

This denotes the relative probability of each of the crops to the probability of the reference crop. The estimated coefficient for each choice therefore reflect the effect of Xi's on the likelihood of the farmers choosing alternative crops relative to the reference crop. However, following Hill (1983) and Rahji and Fakayode (2009), the coefficient of the reference group (base crop) may be recovered using the formula

$$\gamma_6 = -(\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 + \gamma_5) \qquad (11)$$

For each explanatory variable, the negative of the sum of its parameter for the five crops is the parameter for the reference crop (maize). The explicit form of the function is specified as follows.

$$P_{ij} = \beta_0 + \beta_1 Rain + \beta_2 Temp + \beta_3 Gender + \beta_4 Edu + \beta_5 Age \ldots\ldots \beta_9 Labor + \beta_{10} zonedummy \qquad (12)$$

Marginal effects and quasi – elasticities

The marginal effects or partial derivatives $(\frac{dP_j}{dX_i})$are obtained by differentiating equations (8) and (9) with respect to the particular explanatory variable. The derivation techniques implicitly indicate that neither the sign nor the magnitude of the marginal effects need bear any relationship to the sign of the coefficients used in obtaining them (Greene 1993). The partial derivatives were converted to quasi elasticities by using $\eta J_i = X_i(\frac{dP_j}{dX_i})$, where $X_i$ is the mean value of $X_i$. The quasi-elasticity represents the percentage point change in $P_j$ upon a one percent increase in $X_i$. These elasticities are superior to the coefficients and the partial derivatives by their ease of interpretation. However, like the derivatives they too may change sign as well as value when evaluated at different points (Basant 1997).

## III. MATERIALS AND METHODS

*Study Area*

This study was carried out in Nigeria, it is located in the tropical zone of West Africa between latitudes 4°N and 14°N and longitudes 2°2'E and 14°30'E with the total land area of 923 770 $km^2$. The country's north-south extent is about 1 050 km and its maximum east-west extent is about 1 150 km and estimated population of about 131,859,731 inhabitants. (July 2006 estimate, World Fact book) Nigeria is bordered to the west by Benin, to the northwest and north by Niger, to the northeast by Chad and to the east by Cameroon, while the Atlantic Ocean forms the southern limits of Nigerian territory. Land cover ranges from thick mangrove forests and dense rain forests in the south to a near-desert condition in the north eastern corner of the country. The total cultivable area is estimated at 61 million ha, which is 66% of the total area of the country.

Nigeria is a country with climatic contrasts and marked ecological diversity, it has different biophysical characteristics, agro-ecological zones, socio-economic conditions and ethnic nationalities which favours the cultivation of both cash crops and food crops. Presently, the country has thirty-six states and Abuja as the Federal Capital Territory, the country is also sub divided into six geopolitical zones and six agro-ecological zones.

*Data and Sources*

Secondary data was used for this study and was obtained from two different sources. The data on the types of farm production, farmers' household socioeconomic and demographic characteristics, detailed about the crop farming activities, farm outputs per hectare, farm size, and Net revenue were obtained from Nigeria general household survey. The Nigerian General Household Survey (GHS) is the result of a partnership that the Nigeria Bureau of statistics (NBS) has established with the Federal Ministry of Agriculture and Rural Development (FMARD), the National Food Reserve Agency (NFRA), the Bill and Melinda Gates Foundation (BMGF) and the World Bank (WB). GHS is a survey of over 22,000 households which is carried out annually throughout the country. Under the work of the partnership, a full revision of the questionnaire was undertaken and, at the same time, a sub-sample of the GHS now forms a panel survey. Its main objective is to collect information on the employment, unemployment, underemployment and the labour force. In addition, information on the demographic and socio-economic characteristics of the population was also collected. The information collected is vital to the Government, they are often used for the review and formulation of various social and economic policies and also essential to the private sector for business and research purposes. The wave 4 of this GHS data which includes the data on socioeconomic characteristics of farming households, on farm data on farm input and output, collected in 2018/2019 post planting and harvesting season was used for this research work

Data on climate variables which include January to December monthly mean for precipitation and average temperature from 1981 to 2019 was obtained from Nigeria Meteorological Agency which is the primary source of Meteorological data in the country. The Nigerian Meteorological Agency (NIMET) has a weather station network that is covering almost all the agro ecological zone in the country. Presently there are about 32 meteorological stations located across the country. Data for 5306 farmers planting the selected food crops where cleaned and used for this study.

## IV. RESULTS AND DISCUSSION

*Socio-economic characteristics of farmers by selected Crops.*

The socioecenomic characteristics of farmers planting the selected crops is reveled in Table 1, this study reveals that farmers in Nigeria are in their active ages, which is expected to increase their productivity. Major population of the farmers planting the selected crops are between 31 and 40, this shows that more youths are now getting involved in farming in recent times than the old people. Of all the selected crops, groundnut has the least population of farmers that are above 70 years, while yam has the highest. Which means groundnut farmers are expected to be more productive than other farmers planting the remaining selected crop. While yam farmers may be less productive as others because they have more population of farmers who are above 70 years than the other crops selected for this study. However, older farmers will have more years of experience which should also assist their farm productivity.

Furthermore, Table 1 showed that the populations of male farmers are more than that of the female counterparts for all the selected food crops. This implies that the population of the male farmers is more than female farmers in Nigeria. It is generally believed that male farmers are more productive than their female counterparts, this means male farmers should have increased crop yield and net revenue generated from their farm production. The distribution of marital status of the farmers by crops based on the findings from the study showed that about 80 percent of the farmers in Nigeria are married while only 20 percent are singles. The study further showed that about 80 percent of the farmers planting each of the crops have at least 6 years of formal education.

Table 1: Socio-economic characteristics of farmers by selected Crops

| Socioeconomic Characteristics | Beans | Cassava | G . Nut | Maize | Rice | Yam |
|---|---|---|---|---|---|---|
| Age 21-30 | 232 ( 22.44) | 140(18.59) | 103(24.88) | 374(22..33) | 73(23.25) | 232(20.79) |
| 31-40 | 291(28.14) | 200(26.56) | 110(26.57) | 479(28.60) | 89(28.34) | 278(24.91) |
| 41-50 | 231(22.34) | 198(26.29) | 88(21.26) | 359(21.43) | 81(25.80) | 266(23.84) |
| 51-60 | 161(15.57) | 122(16.20) | 66(15.94) | 250(14.93) | 44(14.01) | 118(15.14) |
| 61-70 | 84 (8.12) | 67(8.90) | 41(9.90) | 160(9.55) | 21(6.69) | 118(10.57) |
| > 70 | 35(3.38) | 26(3.450 | 6(1.45) | 53(3.16) | 6(1.91) | 53( 4.75) |
| Sex | | | | | | |
| Male | 545(52.71) | 379(50.33) | 216(52.17) | 862(51.46) | 161(51.27) | 563(50.45) |
| Female | 489(47.29) | 374 (49.67) | 198(47.83) | 813(48.54) | 153(48.73) | 553(49.55) |
| Marital Status | | | | | | |
| Married | 867(83.85) | 619(82.20) | 347(83.82) | 1366(81.55) | 248(79.98) | 896(80.29) |
| Single | 167(16.15) | 134(17.80) | 67(16.18) | 309(18.45) | 66(21.02) | 220(19.71) |
| Years of Education | | | | | | |
| 0 | 196(18.96) | 35(4.65) | 82(19.81) | 151(9.01) | 37(11.78) | 81(7.26) |
| 1-6 | 302(29.21) | 307(40.77) | 101(24.40) | 526(31.40) | 92(29.30) | 382(34.23) |
| 7-12 | 353(34.14) | 266(35.33) | 154(37.20) | 677(40.42) | 129(41.08) | 460(41.22) |
| 13-18 | 183(17.70) | 145(19.25) | 77(18.60) | 321(19.16) | 56(17.83) | 193(17.29) |

Figures in parentheses are percentage

Source: Arthors 20Computed from GHS wave 4 data

*Distribution of Net revenue generated from selected crops grown across Nigeria***.**

Figure 1 presents the spatial distribution of the average net revenue generated in various states in the country from the six various crops selected. The portion of the map represented with the dark brown colour shows states where farmers have the least average net revenue generated. They have their average net revenue of ₦25,000 and the net revenue ranges between ₦22931 and ₦32234 per annum, the states are Sokoto, Enugu, Imo, Akwa Ibom and Abia. The average net revenue per annum of farmers in Cross River, Kano, Jigawa, Yobe, Osun and Ondo state varies from thirty to fifty thousand Naira (₦ 30 ,000 and ₦50, 000). Farmers from Bauchi, Kogi, Benue, Lagos and other states depicted with white colour on the map realized between forty-nine and sixty-four thousands (₦49000 - ₦64000) as net revenue from the selected crops. Oyo state and other states represented with blue colour, the farmers generated average net revenue between ₦ 63,000 and ₦ 86,000 naira from the selected crops. Adamawa state with average net revenue of about ₦ 150,000 per annum and it is the highest in the country.

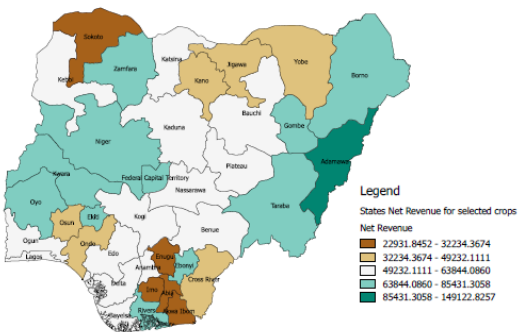


Figure 1: Spatial distribution of Net revenue generated from the six selected crops   Source: Author (computed from wave 4 GHS data)

*Impact of Climate Variables on farmers Crop Choices*

Climate variables play a major role in the selection of crops to be cultivated by farmers. It affects the farmers' probability of preferring a particular crop selection to another. Multinomial logit regression was used for the analysis the dependent variable is crop choice variable, indicating six crops selected for this study. (Cassava, maize, sorghum, rice, groundnut and yam). Maize was used as the base crop because it's widely cultivated across the country due to the fact that it can easily thrive well and adapt to many climatic condition in many parts of the country.

The mean monthly temperature and rainfall for growing seasons of selected crops are the main variables of interest. The other variables which are controlled in this model are household size, age, gender and farmers years of formal education and farm size. The zone dummy was included to take care of the soil variability between the zones.

Table 2 presents the result of multinomial logit regression; climate variables have statistically significant effect on the probability of crop selection. The coefficients of temperature are negative for cassava and groundnut but positive for beans, yam and cassava. Rainfall coefficient is negative for Beans and positive for rice, yam, cassava and negative for beans, groundnut. This means that higher temperature decreases the probability that the farmers will choose to plant rice and groundnut and increases the probability that the farmer plant maize but increases the probability that farmers will prefer planting of.

An increase in temperature by $1^{O}$C will increases the probability of selecting cassava by 20%, yam by 25% and beans by 60% and reduces the probability of selecting maize by 80%, 75% and 40% respectively. Also, increase in temperature by $1^{0}$C reduces the probability of selecting rice and groundnut by 29% and 13% and increase the probability of selecting maize for cultivation by 71% and 87% respectively. The coefficients on rainfall are significantly negative for beans, and groundnut but positive for cassava, yam and rice this implies that increase in rainfall decreases probability farmers planting beans and groundnut and increases the likelihood for selecting maize and decrease in the amount rainfall increases the probability of selecting groundnut and maize and reduces the probability.

In this study, the sex of the farmers does not affect the choice of the crops selected by the farmers, which means the selected food crops are not gender bias.   The higher the level of education the lower the probability of selecting beans by 7.5%, rice and yam by 2.7%, groundnut by 3.4% and cassava by 3.0%. Rainfall reduces the probability of selecting beans and groundnut by 20% and 5%. That is, in warm and dry places, beans are more likely to be selected while in cooler and wet locations; rice will be more preferable also cassava and yam will be preferred in places with relatively cooler and wet climate.

Table 2:  Impact of climate change on Crop Choice (Multinomial Logit Regression)

| | *Dependent variable:* | | | | | |
|---|---|---|---|---|---|---|
| | Beans | Rice | G. nut | Yam | Cassava | Reference Crop (Maize) |
| Rain | -0.207*** | 0.101*** | -0.054*** | 0.303*** | 0.025*** | -0.168 |
| | (0.0304) | (0.0614) | (0.0204) | (0.0202) | (0.0103) | |
| | | | | | | |
| Temp | 0.605*** | -0.293*** | -0.133*** | 0.254*** | 0.220*** | -0.653 |
| | (0.012) | (0.016) | (0.014) | (0.010) | (0.016) | |
| | | | | | | |
| Gendermale | 0.172 | 0.036 | 0.029 | -0.103 | -0.108 | -0.026 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| | (0.105) | (0.141) | (0.137) | (0.100) | (0.125) | |
| | | | | | | |
| Zonenorthcentral | 0.542*** | 2.485*** | 2.568*** | 3.260*** | -1.475*** | 7.380 |
| | (0.283) | (0.243) | (0.651) | (0.463) | (0.751) | |
| Zonenortheast | 0.721*** | 0.094*** | -0.788*** | -1.605*** | -1.740*** | 16.181 |
| | (0.191) | (0.229) | (0.037) | (0.171) | (0.205) | |
| | | | | | | |
| Zonenorthwest | 0.660*** | -11.302*** | -2.711*** | -1.510*** | -1.318*** | 3.318 |
| | (0.200) | (0.00002) | (0.285) | (0.148) | (0.160) | |
| | | | | | | |
| Zonesoutheast | 3.774*** | -9.098*** | 0.599*** | 1.302*** | -1.863*** | 5.286 |
| | (0.203) | (0.00003) | (0.198) | (0.157) | (0.279) | |
| | | | | | | |
| Zonesouthsouth | 2.324*** | 3.243*** | 2.664*** | 1.856*** | 0.282 | -10.368 |
| | (0.254) | (0.266) | (0.207) | (0.200) | (0.246) | |
| | | | | | | |
| Zonesouthwest | -0.831*** | 2.955*** | -2.601*** | 0.547** | -0.508** | 0.438 |
| | (0.075) | (0.276) | (0.019) | (0.261) | (0.253) | |
| | | | | | | |
| Edu | -0.075*** | -0.027* | -0.034** | -0.027** | -0.030** | 0.193 |
| | (0.011) | (0.015) | (0.014) | (0.011) | (0.014) | |
| | | | | | | |
| Age | -0.001 | -0.009* | -0.0004 | 0.011*** | 0.006 | 0.007 |
| | (0.004) | (0.005) | (0.005) | (0.004) | (0.005) | |
| | | | | | | |
| Farmsize | -0.076*** | -0.0004 | -0.029** | 0.048*** | 0.048*** | 0.013 |
| | (0.013) | (0.013) | (0.014) | (0.007) | (0.007) | |
| | | | | | | |
| Distoroad | 0.016** | 0.018** | -0.004 | 0.007 | 0.183*** | 0.220 |
| | (0.006) | (0.009) | (0.009) | (0.007) | (0.008) | |
| | | | | | | |
| Distomkt | -0.006*** | -0.012*** | -0.017*** | -0.037*** | 0.005*** | 0.074 |
| | (0.001) | (0.002) | (0.002) | (0.002) | (0.002) | |
| | | | | | | |
| Labor | -0.002 | 0.007*** | 0.012*** | 0.004*** | 0.003* | 0.024 |
| | (0.001) | (0.002) | (0.002) | (0.001) | (0.002) | |
| | | | | | | |
| Constant | 2.725*** | -8.731*** | 5.404*** | -7.330*** | -7.014*** | 14.946 |
| | (0.046) | (0.008) | (0.017) | (0.011) | (0.003) | |
| Observation | 1034 | 314 | 414 | 1116 | 753 | 1675 |
| | | | | | | |

*** means significant at 1%, ** means significant at 5% and * means significant at 10%; number of observations= 5306, Pseudo $R^2$= 0.5327, log-likelihood = -1380.6750. Akaike Inf. Crit 10,106.680

Source: Authors computations 2020

*Marginal Effects and the Quasi-elasticity*

The estimated marginal effect and the quasi-elasticities calculated for the significant variables are revealed in Table 3. The values of the estimated marginal effects and the quasi – elasticities calculated for the significant variables overall selected crops following Basant (1997). The significant variables affects the probability of selecting various crops. It is noteworthy that estimates not significantly different from zero indicate that the regressor or explanatory variable concerned does not affect the probability or choice of crop selection in its decision relative to the reference crop and other crops selected. These results helped in achieving the second objective of this study, the quasi–elasticities rather than the marginal effects are used for explanatory purposes because they are easier to interpret. The partial elasticities of rainfall, farm size are elastic for all the selected crops, labour is elastic for all the other crops and inelastic for rice and groundnut. This means that a one percent change in the explanatory variable leads to a more than proportionate change in the probability of selecting other crops relative to the reference crops.

The partial elasticities for the remaining variables, education, age, distance to market, are generally small in magnitude and are also inelastic. The inelasticity of the variables suggests that the probability of selecting any crop and of the base crop is not greatly affected by marginal changes in the variables as a one percent change in the variable leads to a less than proportionate change in the probability of selecting any of the crops.

Table 3: Marginal effect and the Quasi-Elasticities estimated

| Variables | Beans | Rice | G. nut | Yam | Cassava | Reference crop(Maize) |
|---|---|---|---|---|---|---|
| Rain | -0.0013 | -0.0053 | -0.0071 | 0.0024 | 0.0027 | 0.0128 |
| | (3.0097) | (6.0012) | (1.0038) | (1.0031) | (1.0051) | (2.0027) |
| | | | | | | |
| Temp | -0.0013 | -0.0013 | -0.1225 | 0.0025 | -0.0331 | -0.1774 |
| | (1.2584) | (0.8984) | (0.7081) | (0.7232) | (0.5369) | (0.1966) |
| | | | | | | |
| Zone | 0.0100 | -0.8546 | 0.2607 | -0.0214 | 0.1152 | -0.1501 |
| | (1.7339) | (20.2417) | (0.7853) | (2.2163) | (0.9291) | (0.3431) |
| | | | | | | |
| Edu | -0.0124 | 0.0016 | 0.0012 | 0.0015 | 0.0031 | -0.0514 |
| | (0.0143) | (0.015) | (0.0147) | (0.0055) | (0.0521) | (0.3431) |
| | | | | | | |
| Age | 0.0022 | -0.0051 | -0.0009 | 0.0115 | 0.0002 | -0.0017 |
| | (0.0023) | (0.005) | (0.072) | (0.0125) | (0.0076) | (0.0050) |
| Farmsize | -0.0761 | -0.0008 | -0.0125 | 0.0611 | 0.0204 | 0.0542 |
| | (2.0731) | (1.013) | (3.0018) | (0.8505) | (1.0052) | (1.0372) |
| Distomkt | 0.0013 | -0.0004 | -0.0002 | -0.0314 | 0.0015 | 0.0021 |
| | (0.0731) | (0.002) | (0.0131) | (0.0379) | (0.1761) | (0.0153) |
| | | | | | | |
| Labor | -0.0035 | 0.0022 | 0.0015 | 0.0032 | 0.0013 | 0.0223 |
| | (1.0019) | (0.802) | (0.776) | (3.0041) | (2.0033) | (1.0414) |
| | | | | | | |

Marginal effects are above while partial elasticities are in bracket

Source: Authors computations 2020

*Graphical presentations of effect of some independent variables on the probability of crop selection*

*Effect of Rainfall on the probability of crop selected by farmer.*

Figure 2 shows the impact of rainfall on the probability of the choice of crop selected by the farmers. Crops require adequate rainfall for growth but the requirement varies for each crops, sixty (60) percent probability of selecting a crop is determined by rainfall. There is 30 percent probability that the farmers will select cassava and 60 percent probability that farmers will select yam as there is increase in rainfall. Farmers will prefer the choice of planting groundnut and beans when there is low rainfall, when rainfall is at the extremes the probability of making maize choices reduces.

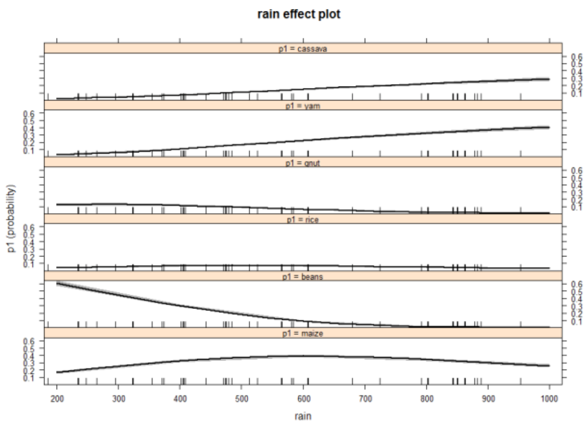


Figure 2: Impact of rainfall on probability of crop selection by farmers

*Effect of Temperature on the Probability of Crop Selected by Farmers.*

Temperature is part of the basic requirement for plant growth; however, excessive rise in temperature can be detrimental to plant growth just as other climatic variables. As revealed from Figure 3, temperature does not really have effect on the choices of cassava and rice. The probability that the farmers will select yam increases as the temperature increases, when there is low temperature of about $22^0$c to $25^0$c there is less than 2 percent probability that the famers will prefer to select rice to other crops. As the temperature getting to the extreme the probability that farmers will prefer to select beans reduces. There is 40 percent probability that the famers will prefer maize when there is an average temperature of $26\text{-}27^0$C

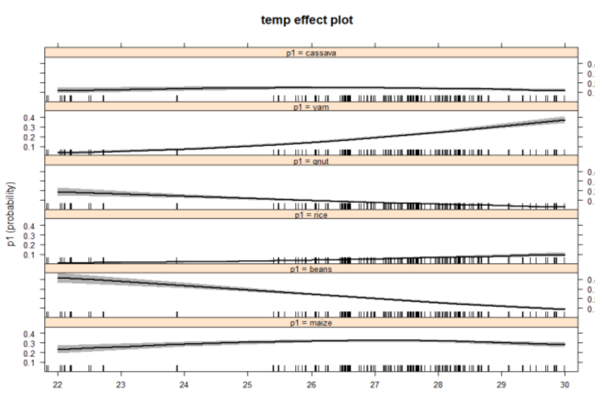


Figure 3: Effect of Temperature on probability of crop selection

*Effect of farmers' education on the probability of crops selected by farmers*

Education is not part of the basic requirement for the growth of plant but the knowledge can however assist the farmer in choosing the best method of planting which can increase the output. Figure 4 shows the impact of farmers' years of formal education on the probability of crops selected by farmers. Education has about 30 percent impact in affecting the choices of crops selected by the farmer. The probability that farmers will prefer to select maize to other crops increases as the farmers' level of education increases, reduces the probability for picking beans. Education increases and have no impact probability of selecting the remaining crops.

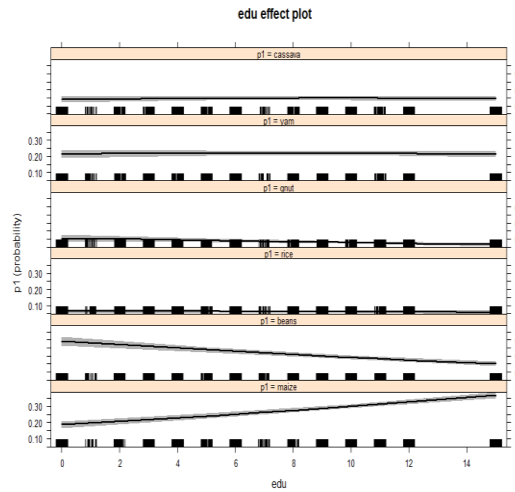


Figure 4: Effect of Years of formal education on probability of crop selection by farmers

*Effect of Distance to market on the probability of crops selected by farmers*

The proximity of market from the farm is very important to the choice of crop selected by the farmers. When the market is too far the cost of transportation may tend to increase the cost of production which will reduce the net-revenue, figure 5 revealed that there is above 50% probability that farmers will select maize and cassava when far distance and not select yam. The distance to the market does not really affect the probability of selecting rice and groundnut. The nearer the farm the higher the probability that farmers will select beans and vice versa.

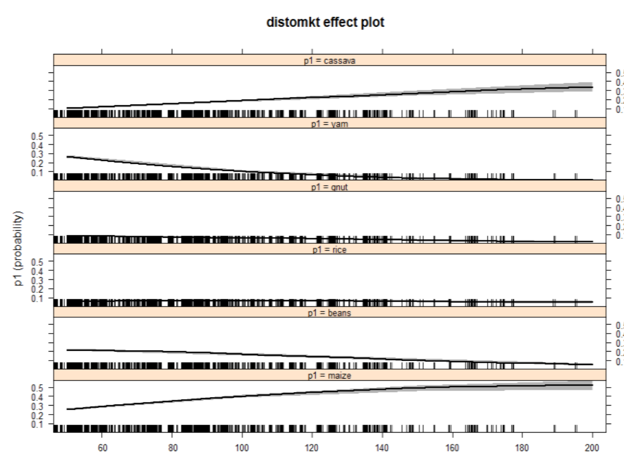


Figure 5: Effect of market distance on probability of crop selection by farmers

*Effect of farm size in the probability of the choice of crops selected by farmers*

Figure 6 reveals the effect of farm size on the choices of crops selected by the farmers. Farm size does not affect farmers' choices for rice, beans and groundnut. There is 50 percent probability that farmers with large farm size will prefer planting of cassava and yam to other crops.There is 10 percent probability that farmers with small farm size will select maize for planting, while there is 30percent probability that farmers with small farm size will prefer to select maize for planting than other crops.

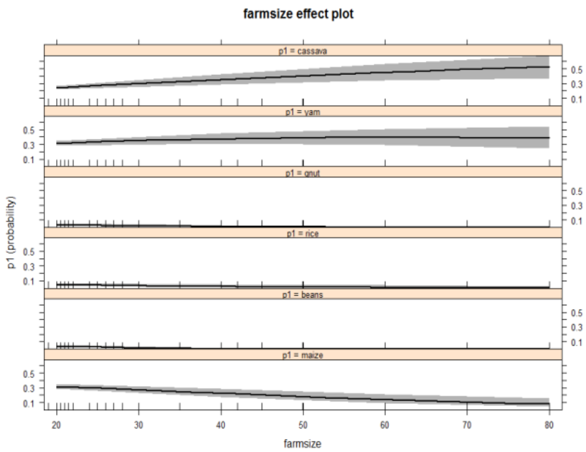


Figure 6: Effect of farm size on probability of crop selection by farmers

## V. CONCLUSION

This paper expands empirical models for crop choice to examine how farmers' crop choices are influenced by climate and other variables. The paper models the choice of whether to grow any of the six selected food crops: rice, maize, beans, groundnut, cassava and yam, and test whether these choices are influenced by temperature and precipitation. The study revealed that the choices of crop is sensitive to climate. Farmers are more likely to pick beans rice groundnut and yam in the North central zone of the country than maize while the north west prefers beans may be because they have a drier temperature. It was revealed from the study that the selections of the food crops are not affected by the sex of the farmers. Farms size and distance to market has varying effects on the choice of crop selection. Finally, the study concludes that the recent change in climate had altered the choices of crop planted by the farmers in various agro-ecological zones in Nigeria. The study also found that farmers often choose crops to survive the harsh conditions in Nigeria, such as beans and – groundnut and sometimes cassava.

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