

SOCIOECONOMIC DETERMINANTS OF ADAPTATION STRATEGIES TO CLIMATE CHANGE IN RICE FARMING COMMUNITIES IN EDO STATE, NIGERIA

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ABSTRACT

Rice is a major cereal in Nigeria in terms of its output and land area. The crop is currently grown in more than 70% of the States in the country. The current level of demand for rice in Nigeria is about 7 million metric tons which is more than the 4.9 million metric tons produced. The study examined *Socioeconomic determinants of* adaptation strategies to climate change on rice farming communities in Edo State, Nigeria. Primary data were collected from rice farmers that were selected using Multistage sampling technique from Edo north, Edo central and Edo south, using structured questionnaire. Result of the Socioeconomic determinants of climate change adaptation measures used were obtained from the multinomial logit analysis, it shows that No adaptation group was *categories* as the reference group with a chi-square value of 112.6 associated with ratio were significant ($p < 0.0001$). Among explanatory variables considered in the model, age, marital status, experience, secondary income, and farm size were significant. The major constraint was inadequate capital out of the six-constraint indicated by the respondent. This study recommends that respondent should form more co-operatives so as to pull resources together to acquire needed technologies.

Keywords: climate change, adaptation strategies, rice farming

INTRODUCTION

Climate change is one of the most serious environmental threats facing mankind worldwide. People of Africa are already experiencing the growing impacts of climate change. This region is particularly vulnerable to increasing floods, droughts and increased salinity of water supply used for irrigation has become a recurrent subject of debate globally and Nigeria is one of the countries contributing to global warming (Intergovernmental Panel on Climate Change (IPCC, 2018).

The United Nations Framework Convention on Climate Change (2019) defines climate change as: “a change of climate which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability are observed over period of time”. The impacts of climate change are greatly felt on Nigeria's agricultural sector. This in turn undermines the country's economy through loss of

gross domestic output, and reduction in the income/consumption of the most vulnerable population (Anabaraonye, 2019)

A recent research has shown that rice can be used to offset the major impacts of climate change because of its potentials and unique properties as a food crop for urban poor and rural rice-growing populations (Weilu, *et al.*, 2019). Introduction of rice into Nigeria is believed to have been in the 6th century. The red rice, *Oryza glaberrima* was the main species produced, until 1920 when white species *Oryza sativa* was introduced by Department of Agriculture. Now many varieties of *Oryza sativa* dominate the rice farming system in Nigeria. *Oryza sativa* has over 140,000 varieties and constitute the dominant cultivated and consumed species worldwide (Africa Rice Center, 2019).

Rice is a major cereal in Nigeria in terms of its output and land area. The crop is currently grown in more than 70% of the States in the country. In spite of availability of cultivable land

area only 3.7 million hectares of land representing approximately 10.6 percent of the 35 million hectares of land is under cultivation (Phillip, Jayeoba, Ndriyaya and Fatunbi, 2018). The current level of demand for rice in Nigeria is about 7 million metric tons which is more than the quantity produced (4.9 million metric tons) Agricultural data specialist Gro intelligence, (2019). To amend the problem, Africa Rice Center, International Institute for Tropical Agriculture (IITA) and Federal Ministry of Agriculture are frequently improving adaptation measures in rice farming in Nigeria. In addition, Nigerian governments have invested more to increase rice production than any other cereal. In 2018 for instance, the nation spent more than 122 million US Dollars on 330,000 rice farmers to increase rice production by additional two million tonnes (Premium times, 2019).

Furthermore, rice farmers in Edo State, Nigeria, provide bulk of the rice that is consumed locally in the State and major food crop supplies to other regions in the country. These farmers are experiencing late arrival of rainfall, the drying-up of streams and small rivers that usually flow year-round, the seasonal shifting of “the mango rains” and fruiting period which has drastically affected the output of rice production (Apata, Samuel, and Adeola, 2013). However, climate change is already impacting negatively on Nigeria through extreme temperatures, frequent flooding, droughts and increased salinity of water supplies used for irrigating rice farming (Mendelsohn and JX, 2017). At the moment, few studies have been carried out on economic impact of climate change on rice production in Edo State, Nigeria. This study is expected to add to the scanty knowledge of the socioeconomics determinants of climate change adaptation measures used by the respondents as well as their constraints to adaptation measures experienced in the study area.

METHODOLOGY

Area of Study

The study was conducted in Edo State and it has a total land area of 19,794 km² and a population of 3,745,253 (National Population Commission (NPC) projection, 2018). It lies approximately between Latitudes 05°44'N and 07°34'N and Longitudes 05°04'E and 06°43'E.

Average rainfall in the State ranges between 1,500 mm at the extreme north of the State and 3,500 mm in the south. Temperature averages are 25°C in the rainy season and 28°C in the dry season (Edo State Agricultural Development Programme, 2010).

The State has potential for rice cultivation. The weather variables of rainfall, temperature and the associated vegetation belts of swamp forest, rain forest, savannah and flood plains of rivers Niger, Osse, Ovia, Orie and Obe account for the suitability of all parts (all the 18 LGAs) of Edo State for rice cultivation. Upland and rainfed lowland ecosystems predominate in Edo State. As Ebonyi State is noted for Abakaliki rice, so Edo State, is noted for Ozigono (Illushi), Agbede, Anegbete and Ekpoma rice.

Sampling Procedure and Sample Sizes

Multistage sampling techniques were used for the selection of the respondents. The first stage was the grouping of the study area into three Agro-ecological zones Edo South, Edo Central, and Edo North. The second stage was the purposive selection of 2 Local Government Areas each from Edo South, Edo Central and Edo North. The criterion for this selection was the extent of rice cultivation in the areas. The third stage was the random selection of 2 villages per Local Government Area giving a total of 12 villages. The final stage was the random selection of 15 rice farmers from each village giving a sample size of 180.

Method of Data Collection.

The primary data were obtained from the rice farmers in Edo State, through administration of structured interview questionnaires. The primary data obtained include the socio-economic characteristics of the farmers such as age, marital status, gender, education, household size, farming experience, farmland size, rice farmland size, cropping system, sources of income and data on farmers' perception on climate change. The researcher and some trained enumerators from the Agricultural Development Programmed (ADP) collected the required data through structured questionnaire

Methods of Data Analysis

Multinomial Logit model were used in this study to estimate the determinants of adaptation measures to climate change used by the respondents' in the study area. The advantage of the multinomial logit is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories of climate change adaptation. This approach is more appropriate than the probit or logit models that have been conventionally used. The decision of whether or not to use any adaptation option could fall under the general framework of utility and profit maximization. Consider a rational farmer who seeks to maximize the present value of expected benefits of production over a specified time horizon, and must choose among a set of J adaptation options. The farmer i decide to use j adaptation option if the perceived benefit from option j is greater than the utility from other options (say, k) depicted as:

$$U_{ij} (\beta'_j X_i + \varepsilon_j) > U_{ik} (\beta'_k X_k + \varepsilon_k) \dots\dots\dots (1)$$

Where j is not equal to k

U_{ij} and U_{ik} are the perceived utility by farmer i of adaptation options j and k , respectively; and ε_j and ε_k are the error terms.

Under the revealed preference assumption that the farmer practices an adaptation option that generates net benefits and does not practice an adaptation option otherwise, we can relate the observable discrete choice of practice to the unobservable (latent) continuous net benefit variable as:

$$Y_{ij} = 1 \text{ if } U_{ij} > 0, \text{ and } Y_{ij} = 0 \text{ if } U_{ij} < 0.$$

In this formulation, Y is a dependent variable taking the value of 1 when the farmer chooses an adaptation option in question and 0 otherwise. The probability that farmer i will choose adaptation option j among the set of adaptation options could be defined as follows:

$$\begin{aligned} P(Y=1/X) &= P(U_{ij} > U_{ik})/X \dots\dots\dots (2) \\ &= P[(\beta'_j X_i + \varepsilon_i - \beta'_k X_k - \varepsilon_k) > 0 / X] \\ &= P[(\beta'_j - \beta'_k) X_i + \varepsilon_j - \varepsilon_k > 0 / X] \\ &= P(\beta^* X_i + \varepsilon^* > 0 / X) = F(\beta^* X_i) \end{aligned}$$

Where ε^* is a random disturbance term, β^* is a vector of unknown parameters that can be interpreted as the net influence of the vector of explanatory variables influencing adaptation,

X_i are the explanatory variables, and they included the following

X_1 = Age (years)

X_2 = Educational qualification (No of years)

X_3 = Rice farmers experience (years) X_4 = Household size (No)

X_5 = Years of residence in a community (No)

X_6 = Secondary occupation income (Naira)

X_7 = main occupation

X_8 = Sex (male /female)

X_9 = Marital status (married, single, divorce, widow and widower)

X_{10} = Rice farm size (ha)

And $F(\beta^* X_i)$ is the cumulative distribution of ε^* evaluated at $\beta^* X_i$.

The Multinomial logit model is thus specified according to Green, 2011 as:

$$P_{ij} = \text{prob}(Y = j) = \frac{e^{\beta_j X_i}}{1 + \sum_{j=1}^{j=n} e^{\beta_j X_i}} \dots\dots\dots (3)$$

Where β is a vector of parameters that satisfy $\ln(P_{ij}/P_{ik}) = X_i'(\beta_j - \beta_k)$ (Greene, 2003). Unbiased and consistent parameters estimate of the MNL model in equation 5 require the assumption of independence of irrelevant alternatives (IIA) to hold. Specifically, the IIA assumption requires that the likelihood of a household's using a certain adaptation measure needs to be independent of other alternative adaptive measures used by the same household. Thus, the IIA assumption involves the independence and homoscedastic disturbance terms of the adaptation model in Equation 3. The validity of the IIA assumption is based on the fact that if a choice set is irrelevant, eliminating a choice or choice sets from the model altogether will not change parameter estimates systematically. Differentiating Equation 3 with respect to each explanatory variable provides marginal effects of the explanatory variables given as

$$\partial p_j / \partial x_k = p_j \sum_{j=1}^{j-1} [\beta_{kj} - \beta_{jk}] \dots\dots\dots (4)$$

Respondents Adaptation Strategies to climate change in The Study Areas

There were about eleven actual adaptation strategies being practiced by the sampled

respondents in the study areas. These are:

- i. Planting trees for shading
- ii. Practice mixed farming
- iii. Change from crop to livestock production
- iv. Practice more irrigation farming
- v. Change crop varieties
- vi. Targeting rain to plant
- vii. Practice water harvesting scheme
- viii. Income diversification
- ix. Rural - urban migration
- x. Change in planting dates
- xi. Good cultural practices such as mulching and use of improved seeds

The highlighted strategies above failed to produce satisfactory results in terms of the significance level of the parameters estimates. The model was thus restructured by grouping closely related choices together in the same categories. Change crop varieties, Practice mixed farming, Practice mixed cropping, Good cultural practices, Plant trees for shading were grouped in the same category labelled as “Good Soil Conservation Techniques” while practicing more irrigation farming and water harvest were grouped and labelled as Irrigation/water harvest. The third category are Change from crop to livestock production, moved from rural to urban area, income diversification was grouped and labelled as Income diversification. The fourth were Targeting rain to plant, change in planting date were grouped and labelled as Targeting rain to plant, followed by “Multiple strategies” category which is a series of combination of the first four categories. Lastly, the sixth category is No Adaptation, and it is labelled “No Adaptation”. The grouping of this study is in agreement with the classification of (Dixon *et al.*, 2001)

Accordingly, the choice set in the restructured Multinomial Logit model included the following adaptation options:

- i. Good Soil Conservation Techniques

- ii. Irrigation/water harvest
- iii. Targeting rain to plant
- iv. Multiple
- v. Income diversification
- vi. No adaptation

RESULTS AND DISCUSSION

To estimate this model there is need to normalize on one category, which is referred to as the “reference state.” In this analysis, the last category (No Adaptation) is the “reference state.” The reference category for the multinomial logit analysis was no adaptation, and the result is presented in the Table 1. The result revealed that explanatory variables in the model significantly explain the determinants of adaptation measures of respondents to climate change in the study area. The Chi-square value of 112.16 associated with the log likelihood ratio was significant ($p < 0.0001$) suggesting strong explanatory power of the model. Among the explanatory variables considered in the model, age, educational qualification, rice farmers experience, household size, years of residence in a community, secondary occupation income, main occupation, sex, marital status, rice farm size were the factors that influence adaptation measures of respondents across the different adaptation strategies employed by the respondents in the study area.

The study found out that household size is significant ($p < 0.01$) and positive, implying that a unit increase in household size will also increase the probability of respondent choosing Income diversification as an adaptation option by 2.70 in relation to the reference group. Household size is an important asset in terms of working together in household economic activities (Andrew, Christopher and Emmanuel, 2016) It can hinder the adoption of measures in areas where farmers are very poor and the family resources are used for other commitment with little left purchasing an innovation and on the other hand, can be an incentive for adoption of new technologies as more agricultural output is required to meet family food consumption need.

Table 1. Determinant of Climate Change Adaptation Measures

Variable	Good Soil Conservation Techniques	Targeting rain to plant	Irrigation/water Harvest	Income diversification	Multiple strategies
	coefficient	Coefficient	Coefficient	Coefficient	coefficient
Intercept	-1.506 (-0.62)	-3.501 (-1.92) *	-6.773 (-2.62)***	-7.983 (-3.26)***	-2.869 (-1.62)
Age	-0.052 (-0.86)	-0.022 (-0.54)	0.598 (1.13)	0.132 (2.70)***	0.017 (0.39)
Household size	0.258 (0.10)	0.267 (1.51)	-0.138 (-0.61)	-0.112 (-0.49)	0.045 (0.23)
Education	0.101 (1.03)	0.074 (1.03)	0.128 (1.34)	-0.026 (-0.33)	0.012 (0.17)
Cooperative society	-0.572 (-0.66)	0.502 (0.76)	0.490 (0.62)	0.080 (0.09)	-0.962 (-0.14)
Marital status	-1.959 (-2.22)**	-0.854 (-1.39)	-0.075 (-0.09)	0.335 (0.40)	-0.377 (-0.59)
Experience	0.097 (0.95)	0.172 (2.70) ***	0.084 (1.02)	0.217 (2.75)***	0.031 (0.41)
Major occupation	0.795 (1.56)	-0.511 (-1.56)	0.246 (0.66)	0.124 (0.29)	-0.403 (-1.15)
Secondary income	-0.006 (-1.74)*	-0.006 (-2.81)***	-0.006 (-2.07)**	-0.008 (-2.55)**	-0.007 (-2.78)***
Farm size	-0.068 (-0.19)	0.359 (1.80)*	0.348 (1.57)	-0.064 (-0.22)	0.076 (0.35)
Years of experience	0.067 (1.36)	0.047 (1.29)	0.0278 (0.71)	0.097 (2.33)**	0.068 (1.90)**
Years of residence	0.010 (0.37)	0.004 (0.21)	0.033 (1.55)	-0.021 (-0.87)	0.016 (0.86)

Source: Computed from Survey Data; 2017. Z-values are in parenthesis *** Coefficients significant at 1%, ** Coefficient significant at 5%,

* Coefficient significant at 10%, Chi square of Log likelihood=112.16***

The coefficient of number of years of experience in a community is also significant ($p < 0.05$) and positive both for multiple strategies and income diversification, implying that a unit increase in this variable will increase the probability that the respondents will choose each of these adaptation options by 1.90 and 2.33 respectively in relation to the reference group. This is because with increase in the years of experience of an individual in the community, there is higher possibility of an individual having access to more information and knowledge about climate in the community, thus aiding his ability to adopt new

innovations to improve his farming activities and livelihood in general.

Moreover, coefficient of Income from secondary occupation was also found to be negatively significant ($p < 0.10$) for good soil conservation, ($p < 0.05$) irrigation/water harvest and Income diversification while targeting rain to plant and multiple strategies are ($p < 0.01$) and this implying that a unit increase in this variable will decrease the probability that the respondents will choose each of these adaptation options by 1.74, 2.07, 2.55, 2.78 and 2.81 respectively in relation to the reference group. This follows the view of (Solomon and Edet 2018) that the adoption

of agricultural technologies requires sufficient financial well-being. The poor household's farmers are most likely not to be able to adapt, since investing in most adaption strategies are expensive. Coefficient of farm size of respondent was also found to be significant ($p<0.01$) and positive for targeting rain to plant, implying that a unit increase in this variable will increase the likelihood of sampled respondents choosing this strategy by 1.83 in relation to the reference group.

Furthermore, Age was found to be significant and negatives, for strategies of targeting rains to plant ($p<0.10$), Irrigation/water harvest ($p<0.01$), and Income diversification ($p<0.01$) implying that a unit increase in this variable will increase the likelihood of sampled respondents choosing these strategies by, -1.92, -2.62 and -3.26 respectively. Age is surrogate for experience and as such, the farmer will not hesitate to employ measures he has witnessed over time that guarantee good harvest. The result obtained is in line with that of Gbetibouo (2009), who observed that experienced farmers are more likely to adapt to perceived climate change. Finally, marital status

was found to significantly ($p<0.05$) and negatively affecting adaptation behaviours of respondent to good soil conservation techniques. From the table, a unit increase in the variable of respondents will decrease the likelihood of adaptation by -2.22 in relation to the reference group.

Constraint of Adaptation Being Experienced by Respondents in the Study Area

The result of the constraint to climate change among the respondents is presented in Table 2. the main constraining factors that hindered the adaptation to climate change among the respondents was inadequate capital 49.3% of them, , poor access to land was the second most important constraint 33.4%, poor climate information system 7.8%, high cost of labour 5.6%, and poor irrigation potentials 4.2% and poor market condition 2.7%, and the findings are in line with Nwalieji (2016) who affirmed that farmers need loans to invest in quality inputs; training and information to increase production and meet quality standards.

Table 2. Distribution of Respondents according to Constraints to Adaptation

Barriers	Percentage
Inadequate capital	46.3
Poor access to land	33.4
Poor climate information system	7.8
High labour cost	5.6
Poor irrigation potentials	4.2
Poor market conditions	2.7

Source: Field survey, 2017

SUMMARY, CONCLUSION AND RECOMMENDATION

It was concluded that targeting rain to plant was the leading adaptation measures practices by the respondent in the study areas while secondary income sources was the major factors influencing all the adaptation measures by the respondent in the study areas. Furthermore, majority of the respondents, perceive climate change as a problem in the study areas. The finding recommended that farmers need to form more co-operative society so as to pull resources together to serves as their secondary income which will help them, in solving their problems of climate change in the study area. The study also recommends that Nigerian Meteorological Agency and other climate change

organisations should create climate change awareness centers in each Local Governments' Area of the State to improve on the awareness level and enable farmers access information on climate change in their areas. The use of extension agent should be encouraged by the government to create more awareness on the impact of climate change and adaptation measures to be adapted by respondents.

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