Modelling Arable Crop Farmers' Decisions on Climate Change and Adaptation Strategies: A Multinomial Logit Analysis in Ogun State

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Abstract

Climate and rural farmers' resource allocation behaviour are primary determinants of agricultural productivity in Nigeria. Hence, knowledge of the rural farmers about climate change is important in order to offer adaptation practices that mitigate its adverse effects. This study, thus, investigated issues on climate change adaptation strategies among arable crop farmers in Ogun State. It utilized primary data collected from 150 arable crop farmers selected across Ogun State through a multistage sampling technique. The data were obtained through administration of questionnaire designed to elicit information on socio- economic characteristics, production activities, as well as adaptation behaviours of the respondents to climate change. The multinomial logit regression model was used to capture choice probabilities across the various options of climate change adaptation strategies. The study result revealed that most (81.08%) of the arable crop farmers were males, majority (69.6%) had no more than primary school education, with an average farming experience of 24 years. Furthermore, 22.97 percent of the respondents did not take up any adaptation strategy, while the remaining either targeted rains to plant (45.95%), used multiple strategies (12.16%), good soil conservation techniques (10.81%), or wetland farming (8.11%). The multinomial logit analysis result showed that household size ($p<0.05$), gender ($p<0.10$), years of residence in a community ($p<0.05$), educational level ($p<0.10$), frequency of extension contact ($p<0.01$), access to agricultural credit, and income from secondary occupation ($p<0.05$) are all important in explaining the choice of climate change adaptation strategies taken up by the arable crop farmers in Ogun State.

Keywords: Decision Making, Climate Change Adaptation Strategies, Arable Crop, Multinomial Logit.

Introduction

Agriculture places heavy burden on the environment in the process of providing humanity with food and fibre, while climate is the primary determinant of agricultural productivity. Studies indicate that Africa's agriculture is negatively affected by climate change (Pearce *et al*. 1996; McCarthy *et. al* 2001). Given the fundamental role of agriculture in human welfare, concern has been expressed by federal agencies and others regarding the potential effects of climate change on agricultural productivity. Interest in this issue has motivated a substantial body of research on climate change and agriculture over the past decade (Lobell *et al*, 2008; Wolfe *et al*, 2005; Fischer *et al*, 2002). Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and uncertain.

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001). Common adaptation methods in agriculture include: use of new crop varieties and livestock species that are more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems and changing planting dates (Bradshaw *et al*., 2004; Kurukulasuriya and Mendelsohn, 2006; Nhemachena and Hassan, 2007).

Climate change according to IPCC, 2001 (Intergovernmental Panel on Climate Change) can be defined as the change in the state of the climate that can be identified using statistical data by changes in the mean and variability of climate properties that has persisted for an extended period, typically decades or longer. It also refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage however differs from that in the United Nations Framework Convention on Climate Change (UNFCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of global atmosphere and that is, in addition to natural climate variability observed over comparable time period. (Currents, 2008).

Climate change is expected to exacerbate Africa's struggles with strained water resources and food security. Rising global temperatures are expected to increase flooding in coastal areas, cause declines in agricultural production, threaten biodiversity and the productivity of natural resources, increase the range of vector-borne and waterborne diseases, and exacerbate desertification; thus, they have a disproportionately adverse impact on Africa's agriculture-based economy (Mendelsohn *et al.* 2000). To make matters worse, Africa has a low adaptive capacity due to its dependence on rain fed agriculture, low levels of human and physical capital, and poor infrastructure. Of the first wave of studies on the effects of climate change on economic variables, most estimated the predicted loss of income from climate change through crop simulation experiments. The next generation of studies - Ricardian studies (such as by Mendelsohn and Dinar, 1994; 2003) and hedonic studies sought to capture adaptations to climate change by exploiting cross-sectional variance in climate and land prices. However, looking at how land rents change with climate misses an important part of the impact of climate change. Climate change is expected to cause an increase in drastic weather events and this, in combination with households employing costly risk-coping strategies, is likely to increase the probability of income shocks having an even larger impact on the poor.

It is evidenced that climate change will have a strong impact on Nigeria-particularly in the areas of agriculture; land use, energy, biodiversity, health and water resources. Nigeria, like all the countries of Sub-Saharan Africa, is highly vulnerable to the impacts of Climate Change (IPCC 2007; NEST 2004). It was also, noted that Nigeria specifically ought to be concerned by climate change because of the country's high vulnerability due to its long (800km) coastline that is prone to sea-level rise and the risk of fierce storms.

In addition, almost two-third of Nigeria's land cover is prone to drought and desertification. Its water resources are under threat which will affect energy sources (like the Kainji and Shiroro dams). Moreover, rain-fed agriculture practiced and fishing activities on which two-third of the Nigerian population depend primarily for foods and livelihoods, are also under serious threat, just as the high population pressures of 140 million people surviving on the physical environment through various activities within an area of 923,000 square kilometres (IPCC 2007; NEST 2004).

Food crop farmers in south west Nigeria provide the bulk of arable crops that are consumed locally, so also, major food crop supplies to other regions in the country. The local farmers are experiencing climate change even though they have not considered its deeper implications. This is evidenced in the late arrival of rain, the drying-up of stream and small rivers that usually flow year-round, the seasonal shifting of the "Mango rains" and of the fruiting period in the Southern part of Oyo State (Ogbomosho), and the gradual disappearance of flood-recession cropping in riverine areas of Ondo state are among the effects of climate disturbances in some communities of South-Western Nigeria (BNRCC, 2008).

To approach the issue appropriately, one must take into account local communities' understanding of climate change, since they perceive climate as having a strong spiritual, emotional, and physical dimension. It is therefore assumed that these communities have an inborn, adaptive knowledge from which to draw and survive in high-stress ecological and socio-economic conditions. Thus, the human response is critical to understanding and estimating the effects of climate change on production and food supply for ease of adaptation. Accounting for these adaptations and adjustments is necessary in order to estimate climate change mitigations and responses.

Climate Change Impacts on Agriculture

Increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance have implications for future food availability. The potential impacts on rain fed agriculture *vis-à-vis* irrigated systems are still not well understood. The developing world already contends with chronic food problems, and Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts (WRI, 2005). The estimate for Africa is that 25 to 42 percent of species habitats could be lost, affecting both food and nonfood crops. Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which includes indigenous foods and plant-based medicines (McClean, Colin *et al*., 2005).

In developing countries, 11 percent of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries, and about 16 percent of agricultural GDP (FAO Committee on Food Security, Report of 31st Session, 2005). According to FAO, 2007, changes in ocean circulation patterns, such as the Atlantic conveyer belt, may affect fish populations and the aquatic food web as species seek conditions suitable for their lifecycle. Higher ocean acidity (resulting from carbon dioxide absorption from the atmosphere) could affect the marine environment through deficiency in calcium carbonate, affecting shelled organisms and coral reefs.

In sub Saharan Africa, including Nigeria, agriculture is the principal source of food, fibre, livelihood and foreign exchange earnings. (Badiane and Delgado, 1995). It contributes about 52% of the GDP, generates more than 85% of the foreign exchange earnings and employs about 80% of the population. Despite its high contribution to the overall economy, agriculture is characterized by its environmental, behavioural, and policy aspects, and environmental problems of agriculture largely stems from intensive human activities with the use of natural resources. This sector is also challenged by multitudes of factors of which climate related disasters like drought and flood, which often causes famine, are the major ones. Trade-offs between food security and the environment is what is being practiced in most developing countries. There are strong indications and ready evidence that the agricultural and food system as well as the rural areas across the world are experiencing major climatic changes (Apata, 2009; IPCC, 2007). This change has drastically reduced soil fertility and led to poor agricultural outputs particularly in Sub-Saharan Africa.

Climate change is widely recognised and accepted as a reality and that it poses serious challenges with far reaching social, political, economic and environmental consequences, particularly in most vulnerable countries. It is one of the biggest threats facing mankind today and it seriously impacts on the lives of more than 10% of the world's population every year. By 2030, the annual death toll from climate change is expected to reach half a million people a year and the figure is expected to reach 660 million by 2050, making it the biggest emerging humanitarian challenge in the world. Nevertheless, climate change is hardly known by many people including people in decision-making positions and those responsible for resource allocation, hence the low level of activities to address the problem. A majority of the world's population does not have the capacity to cope with the impact of climate change without suffering a potentially irreversible loss of wellbeing and risk of loss of life (Mujere, 2009).

Africa is generally acknowledged to be the continent most vulnerable to climate change. West Africa is one of the most vulnerable to the vagaries of the climate, as the scope of the impacts of climate variability over the last three or four decades has shown (IPCC, 2007). Recent food crises in countries such as Nigeria are reminders of the continuing vulnerability of the region to the vicissitudes of climatic conditions. This is in large measure due to weak institutional capacity, limited engagement in environmental and adaptation issues, and a lack of validation of local knowledge (SPORE, 2008; BNRCC, 2008; Royal Society, 2005; Adams *et al*, 1998). Accordingly, there is the need to gain as much information as possible, and learn the positions of rural farmers and their needs, about what they know about climate change, in order to offer adaptation practices that meet these needs.

Much of the Niger-delta wetland areas of Nigeria are now endangered due to climate variability, as witnessed by the significant reduction of their size in recent years. The maximum flooded area of the inner Niger Delta, which is the second largest wetland area in Africa, has dropped from approximately 37,000 km^2 in the early 1950s to 15,000 km^2 in 1990, coupled with what the environmental degradation of crude-oil exploration has done to Niger-delta wetlands areas (BNRCC, 2008).

Recent research has focused on regional and national assessments of the potential effects of climate change on agriculture (Lobell, *et al*, 2008; Hassan and Nhemachem, 2008; Fischer *et al*, 2002). These efforts have, for the most part, treated each region or nation in isolation and do not integrate (i.e. combined biophysical and economic) assessment of the potential effects of climate change on proletariat agriculture but mostly focus on world agriculture (ODI, 2007; Segerson and Dixon, 1998). Consequently, this research intends to investigate the effects of climate change at the grassroots by considering the determinants of the communities' adaptation to changes in climate. This is important because sustainability of agricultural production depends largely on actions of farmers and their ability to make decisions given the level of knowledge and information available to them.

Methodology

Description of the Study Area

The study area is Ogun State. Ogun State is one of the 36 states of the Federal Republic of Nigeria. It was carved out of the defunct Western State on the 3rd day of February, 1976, and it has total land area of 16,409.26sq.km. The estimated population is 3, 728, 098 according to Nigerian 2006 National Census release (Federal Republic of Nigeria, FRN, 2009). The climate of Ogun State follows a tropical pattern with the raining season starting about March and ending in November, followed by dry season. The mean annual rainfall varies from 128mm in the southern parts of the state to 105mm in the northern areas. The average monthly temperature ranges from 23°C in July to 32°C in February. The northern part of the State is mainly of derived Savannah vegetation, while the Central part falls in the rain forest belt. The southern part of the State has mangrove swamp.

The geographical landscape of the State comprises extensive fertile soil suitable for agriculture, and savannah land in the north western part of the State, suitable for cattle rearing. There are also vast forest reserves, rivers, lagoons, rocks, mineral deposits and an oceanfront. The rivers in the state provide veritable opportunities for farmers' to access the potentials of dry season as well as fadama farming.

The state capital is Abeokuta, which is about 100km north of Lagos, Nigeria's business capital. The state is made up of 20 Local Government Areas. The majority of the people of the state belongs to the Yoruba ethnic group of south-west Nigeria, and they are mainly Egba, Yewa, Egun, Awori, Ijebu , Remo, Ikale, and Ilaje. The greater proportion of the state lies in the tropical rain forest zone with a sizeable feature of guinea savannah in the far northern area of the state. The main occupation of the people of the state is farming, which is largely subsistence in scale.

The state is known to have a virile Agricultural Extension Programme which comprises of four agricultural zones identified by OGADEP as Abeokuta, Ilaro, Ijebu and Ikenne. Each zone is divided into blocks, as shown in Table 2, and each block into circles or cells and each of these is anchored by a Village Extension Agent (VEA) who oversees the activities of farmers in his coverage area, while a Block Extension Agent (BEA) anchors a block by overseeing activities of farmers in the coverage area.

Table 1: Zonal Structure of OGADEP, Ogun State.

Zones	Blocks
Abeokuta	Ilugun, Opeji, Ilewo, Olorunda, Wasinmi and Ifo.
Ilaro	Imeko, Sawonjo, Ado-Odo and Oke-Odan.
Ijebu-Ode	Ibiade, Ijebu-Ife, Ala, Ijebu-Igbo, Ago-Iwoye and Isoyin.
Ikenne	Isara, Simawa, Obafemi and Someke

Source: OGADEP, 1996.

Data Types, Sources and Sampling Technique

This study was based on primary data. The primary data were obtained through administration of structured questionnaire on arable crop farmers in the study area. Data collected included the arable crop farmers' socio economic and production characteristics, actual adaptation strategies adopted by the respondents' as well as barriers to adaptation faced in the study area. The sample size used for this study was 150 arable crop farmers. Multi-stage sampling technique was used to select arable crop farmers from whom data were generated for this study. The first stage of sampling involved a random selection of two zones from the four OGADEP zones. Abeokuta and Ikenne zones were selected in this respect. The second stage involved a random selection of 50 percent of the total number of blocks in both Abeokuta and Ikenne zones, resulting in the selection of three blocks from Abeokuta zone, and two blocks from Ikenne zone using list of blocks in the zones as the sampling frame. The third stage involved a random selection of three cells from each of the selected five blocks in each zone using the list of cells obtainable from OGADEP as the sampling frame. The fourth stage involved a random selection of 10 arable crop farmers from each of the selected cells thereby giving a total number of 150 respondents.

The sampling procedure for this study is summarized in Table 2.

Table 2: Sampling Procedure for the study

STAGE	PROCEDURE	REMARKS

1.	Random selection of two zones from the four OGADEP zones.	Sampling frame was list of all the four OGADEP agricultural zones.
2.	Proportion random selection of half of the total number of blocks within each selected zone.	Sampling frame was list of all blocks under the OGADEP agricultural zones selected.
3.	Simple random selection of three cells each from the above selected blocks.	Sampling frame was list of all cells under the five OGADEP agricultural blocks selected.
4.	Simple random selection of 10 respondents from each of the cells selected above	List of all arable crop farmers under each cell obtainable from OGADEP was the sampling frame.

Analytical Techniques

Descriptive and Multinomial Logit regression model was used to analyse the collected data. 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:

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

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 dichotomous 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:

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

In this analysis, the five categories considered are given below:

1. Good Soil Conservation Techniques.
2. Irrigation/Drainage/Wetland farming.
3. Targeting rains to plant.
4. Multiple strategies.
5. No Adaptation, (reference category)

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.

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,
$X_{is\ are}$ the explanatory variables, and they included the following
X_1 = Farming experience in years
X_2 = Educational level
X_3 = Age in years
X_4 = Household size
X_5 = Years of residence in a community
X_6 = Secondary occupation income in naira
X_7 = Frequency of extension contact
X_8 = gender
X_9 = Marital status
X_{10} = Religion
X_{11} = Land size
X_{12} = Access to credit, 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, 2003 as:

$$P_{ij} = \quad \text{prob}(Y = 1) = \frac{e^{x'\beta}}{1 + \sum_{J=1}^{j} e^{x'\beta}} \qquad \text{(3)}$$

j= 1.....n

where **β** is a vector of parameters that satisfy **$\ln(P_{ij}/P_{ik}) = X'(\beta_j - \beta_k)$** (Greene, 2003).
Unbiased and consistent parameters estimates of the MNL model in Equation 13 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

$$\partial p_j/\partial x_k = Pj\left[\beta_{kj} - \sum_{J=1}^{j-1} P_j\,\beta_{jk}\right] \quad \ldots\ldots (4)$$

Results and Discussion

Distribution of Respondents by Personal Characteristics

Age is generally believed to be an important factor in farming activities. This is because younger farmers are believed to commit more energy into production activities, while older ones are likely to be more experienced which may also impact positively on their productivity. As shown in the Table 3, majority, (79.70%) of the respondents are economically active, with age between 31-60years, with the mean being 45.7years, indicating that they are mainly in the active age group.

With regards to gender of surveyed respondents, 81.08 percent of the respondents are males, while only 18.92 percent of the respondents are females showing that there are more male arable crop farmers in the study area than their female counterparts. From the table below, the sampled respondents are mostly married (86.49%), while 6.76 percent of them are single, 2.70 percent are divorced, while 4.05 percent are widowed. Christians constitute the majority of the respondents (60.81%), as against Islam which is (37.16%), while traditional worshippers constitute 2.03% of the respondents.

In terms of educational level, 36.49% of the respondents have no formal education, 2.07% had adult literacy training, while a reasonable percentage of the respondents, (30.41%) are educated up to the primary school level, and 19.59% up to secondary school level, while 3.38% of the respondents have vocational/technical education. Only 7.43 percent of the respondents have tertiary education.

From Table 3, about 43.92% of the sampled respondents have secondary occupation, while the remaining 56.08% do not have. The secondary occupation included mainly artisanship, trading, carpentry, hunting, cattle rearing, among others. In terms of extension contact, 86.49% of the sampled respondents have access to extension contact, while the remaining 13.51% do not have. Out of this, 86.49%, majority (72.3%) of the respondents had up to twelve times of extension contact in the last production season, while the mean contact frequency is 11times in the last production season. This shows that access of arable crop farmers to extension services across the study area is above average, but there is still the need for service intensification on the areas with lack of access in order to educate the farmers on innovation capable of improving their productivity.

For credit access, only 17.57percent of the respondents had access to credit facilities, while the remaining 82.43percent of the sampled respondents do not have access, this may limit the ability of the farmers in the latter category to expand their scale of production. This lack of access to credit facilities may be due to low literacy level of farmers, high interest rates being charged by financial institutions, and other bureaucratic bottlenecks which always characterize loan acquisition and disbursement in this country.

The distribution of respondents by household size is also shown in Table 3. From the table, about 15.54 percent of the surveyed respondents have household size of between 1 and 4 members, 52.03 percent have household size of between 5 and 9 members, and 27.07 percent have household size of between 10 and 14 members, while 4.73 percent have above 15persons as household size. The mean household size for the sampled respondents is approximately 8 persons, implying that other members of the household can provide labour in agricultural production. This could however lead to the use of child labour at the expense of formal education.

It is obvious from the Table 3 that 65.54percent of the respondent cultivated less than 1ha of farmland, 10.81percent cultivated between 1.101ha and 1.5 ha of farmland, 13.51percent cultivated between 1.501ha and 2.0 ha of farmland. In all, 89.86 percent of the sampled respondents' cultivated up to 2ha, thus corroborating the true picture of the subsistence nature of arable crop farming in Nigeria. About 10.13percent of respondents cultivated greater or equal to 2.5 ha of farmland, showing that the bulk of the food crop producers operate on a small-scale. The mean land size cultivated by the respondents' is approximately 1ha. The table also revealed that the predominant crop types grown by the arable crop farmers was maize, followed by cassava and vegetables, while other crop types grown included rice melon and pepper, indicating that they are truly arable crop farmers.

Table 3: Description of Respondents by Personal Characteristics

Personal Characteristics		Frequency	Percentage	Mean
Age (years)				
	30 or less	20	13.51	
	31 – 40	26	17.57	
	41 – 50	48	32.43	47.5

	51 – 60	44	29.73	
	Above 60	10	6.76	
Gender				
	Male	120	81.08	
	Female	28	18.92	
Marital Status				
	Married	128	86.49	
	Single	10	6.76	
	Divorced	4	2.70	
	Widow	6	4.05	
Religion				
	Islam	55	37.16	
	Christianity	90	60.81	
	Traditional worshipper	3	2.03	
Educational level				
	No formal education	54	36.49	
	Adult Literacy Training	4	2.70	
	Primary education	45	30.41	
	Secondary education	29	19.59	
	Technical/Vocational education	5	3.38	
	Tertiary education	11	7.43	
Farming experience group				
	20 or less	73	49.32	
	21-30	44	29.73	
	31-40	21	14.19	23.5
	41-50	9	6.08	
	above 51	1	0.68	
Secondary occupation income group				
	0 or less	90	60.81	
	5000-20000	30	20.27	
	21000-40000	16	10.81	
	41000-80000	5	3.38	26,387
	81000-150000	3	2.03	
	150000-400000	2	1.35	
	401000 and above	2	1.35	
Contact frequency group				
	0 or less	20	13.51	
	1-6	40	27.03	
	7-12	47	31.76	10.89
	13-18	11	7.43	
	19-25	20	13.51	
	above 25	10	6.76	

Household size group				
	1-4	23	15.54	
	5-9	77	52.03	8.1
	10-14	41	27.70	
	above 15	7	4.73	
Land size group				
	0.5 ha or less	47	31.76	
	0.501- 1 ha	50	33.78	
	1.01 - 1.5 ha	16	10.81	1.11
	1.501 - 2 ha	20	13.51	
	2.01 - 2.5 ha	2	1.35	
	Above 2.5 ha	13	8.78	
Crop types grown				
	Vegetables	51	34.5	
	Cassava	123	83.1	
	Cocoyam	133	89.9	
	Pepper/Tomato/Okra	15	10.2	
	Yam	10	6.8	
	Garden egg/Potato/Beans	3	2.0	
	Rice	20	13.5	
	Melon	14	9.5	

Source: Field survey, 2010.

Distribution of Respondents by Adaptation Strategies to Climate Change

As indicated in figure 1, targeting rains to plant (resulting to either early or late planting) is the most commonly used (45.95%) method of adaptation. Use of irrigation coupled with construction of proper drainage channels as well as wetland farming is the least practiced (8.11%) adaptation strategy among the major adaptation methods identified among arable crop farmers interviewed for the study. More use of targeting rains to plant as an adaptation strategy could be attributed to the inherent nature of peasant farmers as they rely on natural weather conditions. Also, the limited use of irrigation coupled with construction of proper drainage channels as well as wetland farming could be attributed to low level of capital as an important input in production and restricted access to wetlands for farming activities. Moreover, 10.81 percent of the respondents adopt good soil conservation techniques such as planting cover crops, mulching, as well as re-supplying of missing seedlings. Nevertheless, 12.16 percent of the respondents engaged in multiple strategies such as the combination of Good Soil conservation techniques with Targeting rains to plant, as well as Irrigation/Drainage/Wetland farming. 22.97 percent of the surveyed farmers reported that they have not taken any adaptation strategies indicated on the figure 1 due to many reasons.

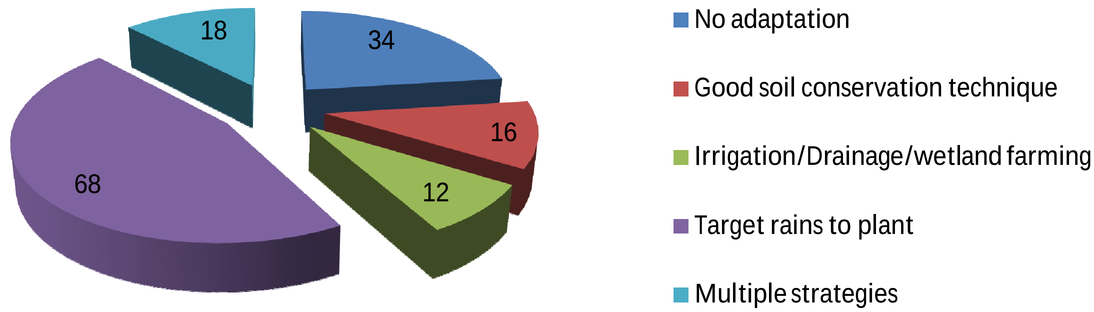

Figure 1: Distribution of respondents by adaptation strategies to climate change

Source: Field Survey, 2010.

Determinants of Arable Crop Farmers' Decisions on Climate Change Adaptation Strategies

Multinomial Logit model was used in this study to estimate the determinants of respondents' adaptation behavior to climate change in the study area. There were about eight actual adaptation strategies being practiced by the sampled respondents in the study area. These are:

1. Good cultural practices such as mulching and re supplying of seedlings.
2. Planting cover crops.
3. Irrigation of farmland.
4. Construction of proper drainage channels.
5. Wetland/ Fadama farming.
6. Targeting rainfall to plant, leading to either early or late planting.
7. Praying for God's intervention.
8. No adaptation.

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 category. Good cultural practices and planting of cover crops were grouped in the same category labelled as "Good Soil Conservation Techniques", while Irrigation of farmland, Construction of proper drainage channels and wetland farming were grouped and labelled as "Irrigation/Drainage/Wetland farming" category. The third category is "Targeting rains to plant", followed by "Multiple strategies" category which is a series of combination of the first three categories. Lastly, the fifth category is a combination of Praying for God's intervention and No Adaptation, and it is labelled "No Adaptation". Accordingly, the choice set in the restructured Multinomial Logit model included the following adaptation options:

1. Good Soil Conservation Techniques.
2. Irrigation/Drainage/Wetland farming.
3. Targeting rains to plant.
4. Multiple strategies.

5. No Adaptation

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 4. The result revealed that explanatory variables in the model significantly explain the determinants of adaptation behaviour of respondents to climate change in the study area. The Chi-square value of 117.76 associated with the log likelihood ratio was significant ($p<0.01$) suggesting strong explanatory power of the model.

The study found out that household size is a significant ($p<0.05$) but negative, implying that an increase in household size will decrease the probability of respondents’ choosing good soil conservation techniques such as good cultural practices and planting cover crops as an adaptation option. Also, the odds of choosing good soil conservation adaptation option as opposed to not adapting at all is 0.70 (70 percent) per unit decrease in household size.

The coefficient of number of years of residence in a community is also significant ($p<0.05$) and positive both for “Good soil conservation techniques” and “Irrigation/Drainage/Wetland farming”, implying that an increase in this variable will increase the probability that the respondents will choose each of these adaptation options respectively. This is because with increase in the years of residence of an individual in the community, there is higher possibility of an individual having access to more social capital in the community, thus aiding his ability to adopt new innovations to improve his farming activities and livelihood in general. In the same vein, the odds of adopting each of these strategies by the respondents compared to not adopting at all are 1.08 and 1.09 respectively for each of the adaptation strategies mentioned above.

Moreover, coefficient of Income from secondary occupation was also found to be significant ($p<0.05$) and positive for the adaptation strategy of good soil conservation technique, implying that a change in income from secondary occupation will likely cause an increase in the respondents behaviour to choosing this adaptation strategy. This is because wealthier households are likely to be willing to adapt by investing in good soil conservation techniques. This follows the view of Knowler and Bradshaw, (2007) that the adoption of agricultural technologies requires sufficient financial well- being. Thus, expanding smallholder farmers’ access to off-farm sources of income increases the probability that they will invest in farming activities. The associated odd of respondents adopting this strategy compared to the reference category for each unit increase in income from secondary occupation is 1.00.

Coefficient of Educational level of respondent was also found to be significant ($p<0.10$) and positive for strategies of Irrigation/Drainage/Wetland farming and Multiple Strategies, implying that an increase in this variable will increase the likelihood of sampled respondents choosing these strategies, with associated odd values of 1.78 and 2.17 respectively . Generally, higher level of education is believed to be associated with access to information on improved technologies and productivity consequences as evidenced from various sources indicates that there is a positive relationship between the education level of the household head and the adoption of improved technologies and adaptation to climate change (Maddison, 2006). Therefore, farmers with higher levels of education are more likely to better adapt to climate change by taking up multiple strategies.

Furthermore, the coefficient of frequency of extension contact was found to be significant and positive, for strategies of good soil conservation techniques ($p<0.01$), targeting rains to plant ($p<0.01$), and for multiple strategies ($p<0.05$) implying that an increase in this variable will increase the likelihood of sampled respondents choosing these strategies respectively. The associated odd values of choosing the strategies by respondents as opposed to not adapting at all are 1.16, 1.14, and 1.12 respectively. With these in mind, farmers who have access to extension services are more likely to be aware of changing climatic conditions (confirmed by the probit models, above) and to have Knowledge of the various management practices that they can use to adapt to changes in climatic condition.

In terms of credit access, the result revealed that this variable is significantly ($p<0.10$) and positively affecting adaptation behaviours of respondent to good soil conservation techniques, with an associated odd value of 5.21 per unit increase in access to credit facility. From the table, an increase in the number of respondents having credit access will increase the likelihood of adaptation. This is true because poverty or lack of financial resources is one of the main constraints to adjustment to climate change. In this study also, a large percentage of the respondent cited lack of financial resources as the main constraint or barrier to adaptation.

In terms of Religion, the result revealed that this variable is in favour of respondents practicing Islam. Religion is significant ($p<0.10$), and positively affecting adaptation behaviours of respondent to taking Multiple Adaptation Strategies with an associated odd value of 4.41 per unit increase in this variable.

In terms of gender, the result revealed that this variable is in favour of the males. Gender is significant ($p<0.10$) and negatively affecting adaptation behaviours of respondent to Irrigation/Drainage/Wetland farming as well as Targeting Rains to plant, each with associated odd values of 0.10 and 0.28 respectively per unit increase in number of male respondents. From the table, an increase in number of male respondents will decrease the likelihood of taking up these adaptation options.

Table 4: Determinants of adaptation behavior of respondents

Variables	Good soil conservation technique		Irrigation/Drainage/Wetland farming		Targeting Rains to plant		Multiple Strategies	
	Parameter	Odd-ratio	Parameter	Odd-ratio	Parameter	Odd-ratio	Parameter	Odd-ratio
Intercept	-21.98 (6942.07)	-	-4.25 (6277.93)	-	29.99 (3731.61)	-	-23.09 6528.41)	-
Farming Experience in years	-0.04 (0.05)	0.96	0.09 (0.07)	1.09	-0.02 (0.04)	0.98	-0.02 (0.05)	0.98
Educational Level	0.08 (0.31)	1.08	0.57* (0.44)	1.78	0.14 (0.21)	1.15	0.77*** (0.31)	2.17

Age	0.05 (0.06)	1.05	-0.02 (0.06)	0.98	0.00 (0.03)	1.00	0.03 (0.04)	1.03
Household size	-0.35** (0.17)	0.70	-0.32 (0.18)	0.72	-0.12 (0.09)	0.88	-0.17 (0.12)	0.84
Years of residence	0.07** (0.03)	1.08	0.09** (0.05)	1.09	0.03 (0.02)	1.03	0.03 (0.03)	1.04
Secondary occupation income	0.00** (0.00)	1.00	0.00 (0.00)	1.00	0.00 (0.00)	1.00	0.00 (0.00)	1.00
Extension contact frequency	0.15*** (0.06)	1.16	-0.06 (0.09)	0.94	0.13*** (0.05)	1.14	0.12** (0.06)	1.12
Respondent is a Male	-0.60 (1.34)	0.55	-2.30* (1.45)	0.10	-1.28* (0.86)	0.28	-0.49 (1.13)	0.61
Respondent is a Female	0.00 -	-	0.00 -	-	0.00 -	-	0.00 -	-
Respondent is Married	1.36 (3934.40)	3.89	-15.15 (2941.33)	0.00	-14.58 (2941.33)	0.00	1.79 (5142.36)	5.98
Respondent is Single	2.65 (3934.40)	14.10	-14.38 (2941.33)	0.00	-13.53 (2941.33)	0.00	1.61 (5142.36)	5.00
Respondent is Divorced	1.75 (3934.40)	5.73	-31.79 (4387.86)	0.00	-15.59 (2941.33)	0.00	2.59 (5142.36)	13.31
Respondent is Widowed	0.00 -	-	0.00 -	-	0.00 -	-	0.00 -	-
Respondent is a Muslim	0.09 (4049.14)	0.92	-0.70 (3862.53)	0.50	-15.24 (2296.42)	0.00	1.48* (0.78)	4.41
Respondent is a Christian	0.17 (4049.14)	1.18	-1.45 (3862.53)	0.23	-16.12 (2296.42)	0.00	-0.12 (0.00)	0.88
Respondent is a Traditional worshipper	0.00 -	-	0.00 -	-	0.00 -	-	0.00 -	-
Land size of 1ha or less	12.86 (4039.47)	384785.82	20.92 (3980.19)	1219116463.91	0.78 (1.59)	2.17	17.51 (4021.98)	40328369.50
Land size of 1.01 to 1.5 ha	17.91 (4039.47)	59722836.13	17.27 (3980.19)	31727484.63	1.38 (1.42)	3.99	17.30 (4021.98)	32638405.51
Land size of 1.501 to 2 ha	17.60 (4039.47)	43947663.81	18.41 (3980.19)	98786329.21	2.02 (1.50)	7.53	17.14 (4021.98)	27827995.26
Land size of 2.01 to 2.5 ha	18.97 (4039.47)	173140484.39	19.08 (3980.19)	193586592.25	1.83 (1.67)	6.25	2.58 (4391.45)	13.19
Land size of above 2.5 ha	0.00 -	-	0.00 -	-	0.00 -	-	0.00 -	-
Credit Access	1.65* (1.01)	5.21	-0.26 (1.54)	0.77	0.62 (0.77)	1.85	1.01 (1.02)	2.74
No Credit Access	0.00 -	-	0.00 -	-	0.00 -	-	0.00 -	-

Standard errors are in parenthesis

**** Coefficients significant at 1%*
*** Coefficient significant at 5%*
** Coefficient significant at 10%*
*Chi square of Log likelihood=117.76****
Source: Computed from Survey Data; 2010.

Conclusion and Recommendations

The multinomial logit result highlighted that household size and gender in favour of the males are negatively influencing adaptation behaviours of respondents to climate change. While years of residence in a community, educational level, frequency of extension contact, access to agricultural credit, married respondents, and income from secondary occupation are having positive influence adaptation behaviours of respondents to climate change. It is therefore recommended that:

- Policies from government and other stakeholders should ensure that farmers have access to sufficient credit to increase their ability and flexibility to change production strategies in response to the forecasted climate conditions. There should also be investment on yield increasing technology packages to increase farm income.
- Also, there should be encouragement of informal social net works among farmers and in our rural communities as it has the potentials of increasing social capital useful for adaptation.
- Lastly, farmers should be encouraged to acquire formal education as it has the likelihood of increasing the possibility of taking up adaptation strategies. Also, there should be increased access to extension services to educate farmers more, and disseminate useful agricultural innovations that will improve living standards of the farmers.

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