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Factors Affecting the Choice of Adaptation Measures To Climate Change: The Case of Famers In the Sudano-Sahelian Area of Cameroon

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Abstract

There is widespread interest on the impacts of climate change on agriculture in Sub-Saharan Africa, and on the most effective investments to assist farmers strengthen factors influencing their choice of adaptation measures. The purpose of this study is to analyse the determinants affecting Cameroonian farmers' choice of adaptation measures to climate change using a multinomial logit model. Estimating the model across 303 farmers in 10 villages of the Sudano-Sahelian Area (SSA) of Cameroon, the analysis indicate that 71.4 percent of the investigated farmers have adapted to climate change, whereas 28.6 percent have not adapted to climate change. This analysis also shows that farmers prefer changing the varieties and the seed/harvest time in order to adapt to climate change. Experience of the head of household, land tenure, farm household income, and extensional education are factors influencing choice of adaptation.

Keywords: *climate change, adaption measures, farmers, multinomial logit model, Cameroon.*

JEL classification*: Q12, Q20, Q54*

1. Introduction

Understanding adaptation is an important goal in itself to assist planning by policy-makers and private individuals (Smit & Skinner, 2002). Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects to moderate harm or exploit beneficial opportunities (Intergovernmental Panel on Climate Change (IPCC), 2001). Adaptation has the potential to reduce adverse impacts of climate change and to enhance beneficial impacts. Climate change adaptations, as well as climate change mitigation, are necessary tools in dealing with climate change.

Many research findings indicate that climate change has significant impacts on tropical regions in Africa that depend on agriculture as their main source of livelihood (Apata et al., 2011; Seo et al., 2010; Badigger, 2010). Cameroon, like all the countries of Sub-Saharan Africa, is highly vulnerable to the impacts of climate change. The Sudano-Sahelian Area (SSA) of Cameroon especially ought to be concerned by climate change because the region is between 8° 36′ to 12° 54′ north latitude and 12° 30′ to 15° 42′ east longitude, with average temperatures ranging between 25 and 27°C during the cooler months (September–February) and between 27 and 30°C during the warmest months (March–August). In addition, the SSA is prone to drought and desertification (Abou et al., 2006) and its water resources are under threat, which affects energy sources (like the Lagdo dam). Moreover, rain-fed agriculture practiced by farmers and fishing activities -- from which 80% of the SSA population depend primarily on for food and livelihood -- are also under serious threat.

A large set of studies have indicated farmers perceive that climate is changing, and have developed coping strategies to adapt or reduce the negative impacts of climate change on their farming operations (Deressa & Rashid, 2010; Mertz et al., 2009; David et al., 2007). Some attempts have been made to analyse factors influencing the choice of adaptation measures to climate change and how farmers adapt to climate change in Africa (Apata, 2011; Hassan & Nhemachena, 2008; Deressa & Hassan, 2009; Admassie & Adenew, 2007; Deressa et al., 2009). Studies that have examined factors influencing the choice of adaptation measures to climate change and adaptation strategies in Africa, although informative, have not addressed the extent to which different socio-economic and environmental factors affect perceptions of climate change and adaptation (Akter & Bennet, 2009; Niggol & Mendelsohn, 2008; Agrawala & Frankhauler, 2008). Others that have analysed factors affecting the choice of adaptation methods have failed to explicitly explain how farmers perceive climate change and adapt to it (like Deressa et al. (2009) for Ethiopia, and Apata et al. (2009) for Nigeria). The study of Yong (2013) employed the Ricardian approach to estimate the monetary impact of climate change on agriculture in the SSA of Cameroon. Even though the Ricardian approach includes adaptation, it does not explicitly address factors influencing the choice of adaptation; and what adaptation methods they employ. This is the research gap that this study would like to address.

The decision-making of farmers is important in adapting to climate change at the farm level. Farmers' responses to climate change or their choice of adaptation methods is dictated by a host of socio-economic and environmental factors. The knowledge of these factors assists policy to strengthen adaptation through investing in these factors (Deressa et al., 2009). The objective of this study is to identify factors influencing the choice of adaptation measures to climate change in the SSA of Cameroon. The paper follows the approach taken by Kurukulasuriya and Mendelsohn (2006), but explores the case of farmers in the SSA of Cameroon.

This paper uses cross-sectional evidence to analyse determinants affecting farmers' choices of adaptation measures to climate change. By comparing choices of farmers who face different environmental conditions across the landscape, we examine quantitatively how farmers would adjust their current choices in response to future climate change. We apply this technique to study how climate affects the choice of adaptation measures by farmers in the SSA of Cameroon.

The remainder of the paper is structured as follows. The next section presents a conceptual and analytical framework, while section three describes data. Section four presents statistical and empirical results. Section five concludes with a summary of results and policy implications.

2. Conceptual and Analytical Framework

2.1 Conceptual Framework

The conceptual framework of this study is that agricultural technology adoption, climate change adaptation methods and other related models involve decisions on whether to adopt or not. Previous studies have observed that agricultural technology adoption models are based on farmers' utility or profit maximizing behaviours (Norris & Batie, 1987; Pryanishnikov & Katarina, 2003). Probit and logit models are the most commonly used models in agricultural technology adoption research (Hausman & Wise, 1978; Wu & Babcock, 1998). Binary probit or logit models are employed when the number of choices available is two (whether to adopt or not). Extensions of these models, most often referred to as multivariate models, are employed when the number of choices available is more than two. The most commonly cited multivariate choice models in unordered choices are multinomial logit (MNL) and multinomial probit (MNP) models. Multivariate choice models have advantages over their counterparts of binomial logit and probit models in two aspects (Wu & Babcock, 1998). First, they allow exploring both factors conditioning specific choices or combination of choices; and second, they take care of self-selection and interactions between alternatives.

These models have also been employed in climate change studies because of conceptual similarities with agricultural technology adoption studies. For example, Nhemachena and Hassan (2007) employed the multivariate probit model to analyze factors influencing the choice of climate change adaptation options in Southern Africa. Kurukulasuriya and Mendelsohn (2006) employed the multinomial logit model to see if crop choice by farmers is climate sensitive. Similarly, Seo and Mendelsohn (2006) used the multinomial logit model to analyze how livestock species choice is climate sensitive. Additionally, Deressa et al. (2009) adopted the multinomial logit model to analyze factors that affect the choice of adaptation methods in the Nile basin of Ethiopia.

This study therefore uses the conceptual constructs of the past studies above to analyze factors influencing the choice of adaptation measures to climate change among farmers in the SSA of Cameroon.

2.2 Analytical Framework

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* decides to use *j* adaptation option if the perceived benefit from option *j* is greater than the utility from other options (say, *k*) depicted as:

$$U_{ij}(\beta_j' X_i + \xi_j) > U_{ik}\left(\beta_j' X_i + \varepsilon_k\right) k \neq j \qquad (1)$$

Where U_{ij} and U_{ik} are the perceived utility by farmer *i* of adaptation options *j* and *k,* respectively; X_i is a vector of explanatory variables that influence the choice of the adaptation option; β_j and β_k are parameters to be estimated; 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:

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

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:

$$\begin{aligned}
P\left(Y=\frac{1}{X}\right) &= P\left(U_{ij}>\frac{U_{ik}}{X}\right) \\
&\text{¿} P\left(\beta_j' X_i+\varepsilon_j-\beta_k' X_i>\frac{0}{X}\right) \\
&\text{¿} P\left(\left(\beta_j'-\beta_k'\right) X_i+\varepsilon_j-\varepsilon_k>\frac{0}{X}\right) \\
&\text{¿} P\left(\beta^{\text{¿}} X_i+\varepsilon^{\text{¿}}>\frac{0}{X}\right) \\
&\text{¿} F\left(\beta^{\text{¿}} X_i\right) \qquad (2)
\end{aligned}$$

Where $\varepsilon^{¿}$ is a random disturbance term, $\beta^{¿}$ is a vector of unknown parameters that can be interpreted as the net influence of the vector of explanatory variables influencing adaptation, and $F(\beta^{¿} X_i)$ is the cumulative distribution of $\varepsilon^{¿}$ evaluated at $\beta^{¿} X_i$.

Given that we investigate several adaptation choices, the appropriate econometric model would, thus, be either a multinomial logit (MNL), or multinomial probit (MNP) regression model. Both models estimate the effect of explanatory variables on a dependent variable involving multiple choices with unordered response categories. In this study, therefore, an MNL specification is adopted to model climate change adaptation behaviours of farmers involving discrete dependent variables with multiple choices. This method has now been used to analyze farmer adaptation decisions (Hassan & Nhemachena, 2008; Hisali et al., 2011).

The probability that farmer *i* will choose adaptation measure *j* among the set of adaptation measures follows the logistic distribution.

$$P_{ij} = prob(Y=1) = \frac{e^{x_i'\beta_j}}{1+\sum_{k=1}^{j} e^{x_i'\beta_k}}, j=1,2,\ldots\ldots\ldots\ldots J\,(3)$$

Where β is a vector of parameters that satisfy $\beta_j - \beta_K$ $¿(P_{ij}/P_{ik}) = X'¿$ (Greene 2003), *x* denotes the set of explanatory variables that influence the choice of the adaptation measure, *j* denotes adaptation measures.

Differentiating equation 3 with respect to each explanatory variable provides marginal effects of the explanatory variables given as:

$$\frac{\partial P_j}{\partial x_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{j-1} P_j \beta_{jk}\right)(4)$$

In order to avoid the sample selection problem, and to get asymptotically efficient estimators, the model parameters are estimated by maximum likelihood.

3. Data and Descriptive Statistics

3.1 Description of data

This study is based on a survey of data from farm households in the SSA of Cameroon. Farm household data were obtained from a cross-sectional household survey of farmers carried out in the framework of the ESA (Water-Soil-Tree) project during the 2008/2009 production year, on 303 cotton producers in 10 villages of the SSA of Cameroon. This sample allowed us to obtain data relating to 708 cultivated plots for cotton and the main food crops of the area: corn, peanuts, millet, cowpeas, sorghum and rice. The questionnaire for this survey attempted to capture information on the pertinent variables required to calculate crop net revenues, and to explain the variation in net revenues across representative sample villages.

The study administered questionnaires and held focus group discussions (FGDs) to elicit information. Both a structured questionnaire and interviews were held with indigent and local government officials, and all other stakeholders on climate change knowledge and adaptation. The study decomposes various measures of climate change adaptation. In addition, it also uses FGDs to find out the level of understanding of climate change from the farmers, as well as communities' perception of the vagaries in weather conditions and coping strategies adopted to survive. The study relied on monthly temperature data collected from the US Department of Defence satellites. The monthly precipitation data came from the Africa rainfall and temperature evaluation system (ARTES) (World Bank, 2003). Mendelsohn et al. (2004) reveal that weather stations give accurate measures of ground conditions. These monthly means were estimated from approximately 50 years of data (1951–2000) to reflect long-term climate changes rather than short-term variations. Ideally, the temperature and precipitation data for the 50 years leading directly up to 2008/09 would have been used, but because longer-term trends are of interest, and because climate change is most drastic in the longer run, using data from 1951–2000 rather than from 1951–2008 should not be of much practical concern. The temperature and precipitation data for each village comes from the same source. The study uses the climate data of the thin plate spline method of spatial interpolation, and imputes household-specific rainfall and temperature values using latitude, longitude, and elevation information for each household obtained from the survey.

3.2 Definition of Dependent Variables

In the SSA of Cameroon, farmers' abilities to adapt are limited by their lack of economic and technical resources; and their vulnerability is accentuated by heavy dependence on the climate because of the rain-fed system, diseases (malaria) and poverty. Given the diversity of the constraints they have to face, the general capacity to adapt to climate change is currently very low. There are no good national action plans that take into account short- or long-term climate changes. The adaptation methods most commonly cited in the literature include the use of new crop varieties and livestock species that are more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems, changes of planting dates, diversification from farm to non-farm activities, increased use of water and soil conservation techniques, and trees planted for shade and shelter (Nhemachena & Hassen, 2007).

Farmers were asked about their actions to counteract the negative impact of climate change. Regarding adaptation to change in rainfall patterns and temperature, about 39% had no adaptation strategy. The adaptation strategy most commonly used is soil conservation (29%). The methods commonly used are those implemented by development projects (DPGT, ESA) for nearly 20 years. Other adaptation strategies used by farmers are planting trees (5%), using different crop varieties (13%), irrigations (3%), early and late planting (11%). For this study, the dependant variable is the choice of adaptation measure: no adaptations, soil conservation, different crop varieties, early and late planting, planting trees, irrigation. In this analysis, no adaptation is used as the base category.

3.3 Explanatory Variables

Much of what we know about the research question (farm and farmers' characteristics related to adaptive capacity and propensity) in the adaptation process derives from the vast body of research on the dynamics of agricultural development and the diffusion of agricultural practices. Based on the review of literature on adoption of new technologies and adaptation studies, a range of household and farm characteristics, institutional factors, and other factors that describe local conditions are hypothesized to influence farmers' adaptation choice in the SSA of Cameroon.

3.3.1 Household characteristics

Generally the household characteristics considered having differential impacts on adoption or adaptation decisions are age, education level of the head of the household, family size, years of faming experience, and household income.

According to Adesina and Forson (1995), cited by Teklewold et al. (2006), there is no agreement in the adoption literature on the effect of age. The effect of age is generally location or technology-specific. The expected result of age is an empirical question. We may find that age negatively influences the decision to adopt new technologies. It may be that older farmers are more risk-averse and less likely to be flexible than younger farmers, and thus have a lesser likelihood of adopting new technologies. In another case, we may find that age positively influences the decision to adopt. It could also be that older farmers have more experience in farming, and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher probability of adopting the practice.

Higher level of education is often hypothesized to increase the probability of adopting new technologies (Daberkow & McBride 2003; Adesina & Forson 1995).

Indeed, education is expected to increase one's ability to receive, decode, and understand information relevant to making innovative decisions (Wozniak, 1984). *Wealth* is believed to reflect past achievements of households and their ability to bear risks. Thus, households with higher income and greater assets are in better position to adopt new farming technologies (Shiferaw & Holden, 1998). *Farming* experience increases the probability of uptake of all adaptation options because experienced farmers have better knowledge and information on changes in climatic conditions and crop and livestock management practices (Nhemachena & Hassan, 2007).

The influence of household size on the decision to adapt is ambiguous. Household size as a proxy to labour availability may influence the adoption of a new technology positively as its availability reduces the labour constraints (Teklewold et al., 2006). However, according to Tizale (2007), there is a possibility that households with many family members may be forced to divert part of the labour force to off-farm activities in an attempt to earn income to ease the consumption pressure imposed by a large family size.

3.3.2 Farm characteristics

Institutional factors often considered in the literature to influence adoption of new technologies are access to information via extension services (climate information and production technologies), cultivated area, access to credit and land tenure.

Agricultural extension enhances the efficiency of making adoption decisions. In the world of less than-perfect information, the introduction of new technologies creates a demand for information useful in deciding on adopting new technologies (Wozniak, 1984). Of the many sources of information available to farmers, agricultural extension is the most important for analyzing the adoption decision. Based on the innovation-diffusion literature (Adesina & Forson, 1995), it is hypothesized that access to extension services is positively related to adoption of new technologies by exposing farmers to new information and technical skills. Also, in the specific case of climate change adaptation, access to climate information may increase the likelihood of uptake of adaptation techniques. Another variable that has received attention is access to credit, which commonly has a positive effect on adaptation behaviour (Caviglia-Harris, 2002; Saín & Barreto, 1996; Napier, 1991; Hansen et al., 1987). Any fixed investment requires the use of owned or borrowed capital. Hence, the adoption of a technology requires a large initial investment, which may be hampered by the lack of borrowing capacity (El Osta & Morehart, 1999).

With regard to cultivated area, households with a larger area of land are more likely to adapt (Bryan et al., 2009). Farm size positively and significantly leads to an increase in the livelihood of adapting to climate change and resources

(Gbetibouo, 2009). We expect that farms with a larger area of land are more likely to adapt to climate change.

Land tenure can contribute to adaptation because landowners tend to adopt new technologies more frequently than tenants, an argument that has justified numerous efforts to reduce tenure insecurity (Lutz et al., 1994; Shultz et al., 1997). Land ownership is widely believed to encourage the adoption of technologies linked to land such as irrigation equipment or drainage structures. Land ownership is likely to influence adoption if the innovation requires investments tied to land.

3.3.3 Others Factors

Local climatic conditions and agro-ecological conditions are expected to influence the decision to adapt. We therefore included village level climate variables (temperature and rainfall). Table 1 provides summary statistics of farmers' socioeconomic characteristics. The average farming experience of respondents is 13.22 years. The average cultivated area is 3.29 hectares; while 0.31 percent of respondents use credit. The average yearly household income is between 300 000 Fcfa-400 000 FCFA.

Table 1: Summary Statistics of Farmers' Socio-economic Indicators In the SSA of Cameroon

Variables	Minimum	Maximum	Mean	Std. Deviation
Households characteristics				
Education (years)	0	20	6.59	5.19
Household size (numbers)	1	18	7.22	3.17
Farming experience (years)	2	62	13.22	11.09
Household income(Fcfa) *	1	5	3.57	2,34
Farm characteristics				
Extension education **	0	4	2.32	0.69
Credit (1=yes, 0= no)	0	1	0.31	0.46
Cultivated area (Hectares)	0.02	10.92	3.29	1.99
Tenure (1= owned 0= otherwise)	0	1	0.72	0.45
Others factors				
Temperature (degree Celsius)	15.04	40.05	26.45	4.39
Rainfall (mm degree centigrade)	220.092	814.84	464.45	84.61

Notes: *Under 200 000 FCFA=1; between 200 000-300 000FCFA= 2; Between 300 000-400 000 FCFA=3; between 400 000-500 000FCFA= 4; More than 500 000FCFA=5.

**0 number=1; 1-3 number=2; 3-5 number=3; Above 5 number=4.

4. Results and Discussion

4.1 *Statistical Findings*

Farmers' adaptation to climate change is presented in Table 2. While 71.4 percent of farmers have adapted to climate change, 28.6 percent have not adapted.

Table 2: Farmers' Adaptation To Climate Change

	Number of respondents	Percent of respondents

	(Persons)	*(Percent)*
Yes	216	71.4
No	87	28.6
Total	303	100.0

Summary statistics indicate that there are five major constraints for adaptation in the SSA of Cameroon. These are lack of information, lack of access to credit, shortage of labour, land tenure, and poor potential for irrigation. Table 3 shows the major constraints to adaptation perceived by farmers in the area.

Table 3: Barriers to Adaptations

Constraints	**Percentages**
Lack of information	13
Lack of money	32
Shortage of Labour	16
Land tenure	33
Poor potential of irrigations	6
Total	**100**

Most of these constraints are associated with poverty. Lack of information on appropriate adaptation options could be attributed to scarcity of research on climate change and adaptation options. Lack of money hinders farmers from getting the necessary resources and technologies that facilitate adapting to climate change. If farmers do not have sufficient family labour or financial means to hire labour, they cannot adapt. This is true since adaptation to climate change is costly.

Land tenure has been associated with high population pressure, which forces farmers to intensively farm a small plot of land. Poor irrigation potential is most likely associated with the inability of farmers to use the water that is already there due to technological incapability.

The reasons of farmers not doing the farm level adaptations options are illustrated in Table 4. Lack of information is the prominent constraint.

4.2 Econometric Results

In Table 4, we estimate the probability each adaptation measure is selected using a multinomial choice (Eq. (3)). The probability of choosing each adaptation measure was assumed to be a function of temperature and precipitation.

Table 4: Constraints to Farm-Level Adaptations

Lack/ Shortage	**Changing crop varieties**	**Early and late planting**	**Soil conservations**	**Planting trees**	**Irrigatin g**
Information	54.0	38.0	45.0	37.0	25.0

Money/ Credit	32.0	29.0	13.0	14.0	26.0
Labour	3.0	19.0	21.0	18.0	15.0
Land	6.0	5.0	7.0	17.0	11.0
Water	2.2	1.0	4.0	5.0	13.0
Others*	2.8	8.0	10.0	8.0	10.0

*Not observing the importance and other reasons

Results from the multinomial logit model of the determinants affecting adaptation to climate change are present in Table 5. We used the Hausman test for the validity of the IIA assumption, using STATA software.

Table 5: Results of the Multinomial Logit Adaptation Model

Variables	Soil conservation	Different crop varieties	Early and late planting	Planting trees	Irrigations
	Coeff. (P-value)	*Coeff. (P-value)*	*Coeff. (P-value)*	*Coeff. (P-value)*	*Coeff. (P-value)*
Education	-0.0251 (0.36)	0.3156 (0.79)	0.0331 (0.102)	0.4331 (0.19)	0.019 (0.52)
Household size	0.2448*** (0.015)	0.291 (0.22)	-0.375 (0.37)	-0.904 (0.14)	0.531 (0.92)
Farming experience	0.0823*** (0.000)	0.0187* (0.079)	0.0331** (0.002)	0.0171 (0.229)	0.071 (0.28)
Household income	-0.3107 (0.79)	-0.1136* (0.078)	-0.099 (0.830)	0.6925 (0.32)	0.515* (0.089)
Extension services	0.3692** (0.049)	0.4803*** (0.010)	0.4702** (0.035)	0.4538 (0.077) *	0.5297** (0.019)
Access to Credit	0.311* (0.079)	0.3164 (0.29)	-0.9664 (0.68)	1.2225 (0.212)	0.5177 (0.71)
Cultivated Area	0.0187 (0.179)	0.0525* (0.066)	0.1225 (0.034) **	-0.1137 (0.233)	0.899 (0.036) **
Land Tenure	0.2631* (0.09)	0.3041 (0.29)	0.6508 (0.20)	0.4138 (0.55)	0.1282 (0.043)
Rainfall	0.1077 (0.211)	0.0943* (0.08)	-0.0031* (0.09)	-0.0051 (0.99)	0.0831** (0.407)
Temperature	0.6403* (0.067)	0.1831 (0.587)	-0.259*** (0.01)	0.3195 (0.38)	0.4541 (0.121)
Constant	-2.7022*** (0.000)	-3.2044*** (0.000)	-3.7845*** (0.000)	-2.662*** (0.000)	-4.7925*** (0.000)
Base category	No adaptation				
Number of observations	299				
LR chi-square	129.27***				
Log likelihood	-1338.5854				
Pseudo-R^2	0.0811				

Note: ***, **, * indicate significance at 1%, 5% and 10% level.

The results from the Hausman test indicate that we fail to reject the null hypothesis of independence of the adaptation measures under consideration. The results implied that the application of the MNL specification to model the determinants of adaptation measures was justified. We tested the model for multi-collinearity using the variance inflation factor (VIF). The variance inflation factor of all the variables are less than 10 (1.06 to 1.89), which indicates that multi-collinearity is not a serious problem in this model.

The chi-square results show the likelihood ratio statistics are highly significant, suggesting the model has strong explanatory power. The coefficient of household size is significant, and positively related to soil conservation measures. A large household will be more willing to choose this category as an adaptation option. This category includes adaptations such as erosion control facilities, cropping systems under plant cover, chemical treatments that are labour-intensive especially in small-scale farming, which involves household labour.

Surprisingly, the results suggested that education level did not have a significant impact on the probability of choosing any adaptation technique. The coefficient on farming experience is significant and positively related to several adaptation measures to climate change. Farming experience increases the probability of changing variety seed time/harvest time, soil conservation, and changing cultivation crop. This result implies that experienced farmers are more likely to adapt to climate change. Experienced farmers have high skills in farming management and techniques. Therefore, they are able to cope with difficulties when facing climate change. These results confirm the findings of Nhemachena and Hassan (2007) in a similar study of adaptation in the Southern Africa region. Experienced farmers have high skills in farming techniques and management, and are able to spread risk when facing climate variability by exploiting strategic complementarities between activities such as crop-livestock integration.

The coefficient on farm household income is significant and negatively related to changes in cultivation crop. It can be inferred that farmers with lower income try to adopt a new cultivation crop more easily than plant an existing crop. Famers with higher income try to adopt irrigation. The coefficient on cultivated area is significant and positively correlated with two adaptation measures to climate change. Cultivated area increases the probability of changing seed time/harvest time, the probability of changing variety and choosing irrigation as an adaptation measure. Indeed, large-scale farmers are more likely to adapt because they have more capital and resources. Therefore, they can easily invest in irrigation technologies, which demand high investment costs. Large farm sizes also allow farmers to diversify their crop options and help spread the risks of loss associated with change in climate.

The coefficient of extensional education is significant and positively related to several adaptation measures. Extensional education increases the probability of changing variety and seed time/harvest time, soil conservation by controlling use of chemicals/fertilizers, changing cultivation crop, and using crop diversification and other adaptation measures. Farmers who have access to extension services are more likely to be aware of changing climatic conditions; and to have knowledge of the various management practices that they can use to adapt to changes in climatic conditions.

As expected, access to credit increases the likelihood of adaptation. Poverty or lack of financial resources is one of the main constraints to adjustment to climate change. In a study on Tanzania, O'Brien et al. (2000) report that despite numerous adaptation options that farmers are aware of and willing to apply, the lack of sufficient financial resources to purchase the necessary inputs and other associated equipment (e.g., purchasing seeds, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation. The results show that access to credit increases the likelihood that farmers will take up soil conservation measures.

Having secure property rights increases the probability of farmers to adapt by percent. The results show that access to land tenure increases the likelihood that farmers adopt soil conservation techniques and irrigation. With proper property rights, farmers may be able change their amount of land under cultivation to adjust to new climatic conditions (Hassan & Nhemachena, 2008).

Households living in regions with high temperatures have an increased likelihood of adapting. In SSA, households are more likely to choose the following adaptation options: (1) soil conservation; (2) portfolio diversification, such as by changing their types of crops (e.g., from maize to sorghum, a more heat-tolerant crop); (3) intensification irrigation; and (4) changing their seed times. A decrease in rainfall is likely to push farmers to delay their planting dates.

Table 6 presents the estimated marginal effects from the multinomial logit model. This compares the choice of adaptation to climate change with no adaptation where the marginal effects and their signs reflect the expected change in probability of preferring to adapt climate change to no adaptation (the base) per unit change in an explanatory variable.

Experience increases the probability of adapting to climate change. As can be seen in Table 5, experience significantly increases soil conservation and early/late planting as adaptation methods. A unit increase in the number of years of experience would result in a 0.46% increase in the probability of soil conservation measure and in a 0.23% increase in seed time/harvest time change. Moreover, most of the marginal values of extensional education are positive across all adaptation options, indicating the positive relationship between experience and adaptation to climate change.

Table 6: Marginal Effects from the Multinomial Logit Climate Change Adaptation Model

Variables	Soil conservation	Different crop varieties	Early and late planting	Planting trees	Irrigation
Education	0.0004	0.0025	0.0007	0.0014	0.0002
Household size	0.0050	0.0124	0.0014	0.0019	0.0088
Farming experience	0.0046**	0.0028	0.0023***	0.0208	0.0186
Household income	0.0084**	-0.0092*	0.0186	0.0004	0.0134
Extension services	0.0037**	0.0021*	0.0044**	0.0058*	0.0133
Access to Credit	0.0083	0.0257	0.0145	0.0048	0.0004
Cultivated Area	0.0068**	0.0045*	0.0057	0.0073	0.0008
Land Tenure	0.0045**	0.0094	0.0033	0.0035***	0.0051
Rainfall	0.0053	0.0351	0.0096**	0.0272	0.0065*
Temperature	0.0104	0.0055	0.0073	0.0020	0.034

Note: ***, **, * indicate significance at 1%, 5% and 10% level.

Land tenure has a positive and significant impact on soil conservation and planting trees. For instance, a unit increase in land tenure results in a 0.45% increase in the probability of soil conservation; and 0.35% in the probability of planting trees.

The income of households surveyed has a positive and significant impact on soil conservation through controlled use of agricultural chemicals and fertilizers. A unit increase in farm income increases the probability by 0.84%. Conversely, the results of this analysis reconfirm that decreasing farm income significantly increases the likelihood of cultivation crop change.

5. Conclusion and Policy Implications

Climate change is expected to negatively affect agricultural production. Proper adaptation measures in the agricultural sector are required to minimize negative impacts of climate change. The purpose of this study was to analyze the determinants affecting SSA of Cameroon farmers' choice of adaptation measures to climate change using a multinomial logit model.

The major findings of this study are summarized as follows. First, the results indicate that 71.4% of farmers have adapted to climate change, and 28.6% have not adapted to climate change. The main adaptation strategies of farmers in the SSA of Cameroon are soil conservation, different crop varieties, early and late planting, planting trees, and irrigation. The results highlight that household size, wealth, farm size, farming experience, extension, access to credit, household income, land tenure, high temperature, and low rainfall are the factors that enhance adaptive capacity to climate change.
This study provides several policy implications for counter-measures to climate change in the agricultural sector. First, proper education and training programs about climate change should be developed for the farmers. Examples of these education and training programs include education about cultivation techniques for new varieties and cultivation crops; and education about technologies to prevent new blights, pests, and weeds. Second, policies to strengthen farmers' activities in farmer organizations as a social capital should also be developed. Policies that encourage informal social networks can promote group discussions and better information flows, and enhance adaptation to climate change. Third, the results of empirical analyses confirm that variety change and seed/harvest time change were affected by experience, cultivated area, and extensional education. Consequently, policies aiming to promote adaptation to climate change need to emphasize the crucial role of providing extensional education to enable farmers to adapt to climate change. Finally, the results from the marginal analysis indicate that household characteristics such as experience, farm area, farm income and extensional education, which could be enhanced through policy intervention, have significant impact on adaptation to climate change. Thus, investment in education systems, and sufficient input supply, which increases farm income and use of information in the rural areas, can be underlined as a policy option in the reduction of the negative impacts of climate change.

One important limitation of this study is that it lumps all crops into one category. Different crop types are affected differently by climate change, hence the need for further disaggregation. While this disaggregated selection of crop types is beyond the scope of this study, given the broad scale of the analysis, it will be necessary as a second step to conduct more crop type-specific analysis as farm-level adaptation is conditioned by local circumstances and the specifics of the available agricultural options.

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