COLLECTIVE ACTION AND FARMERS' PRIVATE ADAPTATION TO CLIMATE CHANGE: EVIDENCE FROM THE SAVANNA REGION IN TOGO

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Paper presented at the Agricultural Economics Society (AES) Annual Conference 2014. Paris, 9-11 April, 2014 and in the International Conference on Enhancing Resilience to Climate and Ecosystem Changes in Semi-Arid Africa (CECAR), August 6-7th, 2014. Tamale, Ghana.

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ABSTRACT

Climate change is a reality and farmers in developing countries often face capital constraints in adapting to climate change. Can collective action at household level be utilized to facilitate the adaptation? This study uses principal component analysis to recover the underlying latent variables of collective action at household level, given the fact that collective action is not directly observed. Two factors, namely cooperative capacity and effective cooperation, are hypothesized to capture collective action and were further used in a two-step multivariate probit to examine whether collective action is systematically linked to adaptation to climate change. The results suggest, in general, that collective action at the individual level in the form of cooperative capacity and effective cooperation does affect farmers' private adaptation to climate change. Consequently, an important policy message from these results is that enhanced farm households' participation in collective action initiatives can significantly increase the uptake of adaptation strategies, such as water and soil conservation and irrigation practices by farm households. Another important result of this study is that climate change could enhance collective action initiatives. Given that farmer groups are not always successful, there is a need to better understand under what conditions collective action is useful and viable.

Key words: climate change, adaptation, collective action, agriculture, the Savanna region of Togo, two step multivariate probit.

1. INTRODUCTION

Although agriculture is still the core sector for economic growth in Togo, agricultural productivity has been declining in recent years. The sector employs over 65% of the country's population, mainly in subsistence agriculture, and contributes to the GDP at the level of, on average, 38% over the last ten years (Rapport National d'Investissement, 2008), According to the Ministry of Agriculture, this decline is mainly due to climate variability and change.

Togo is experiencing climate change (NAPA, 2009; Tchinguilou et al., 2012). As agricultural production remains the main source of income for most rural communities on the one hand, and on the other hand is highly vulnerable to climate change, adaptation of the agricultural sector is imperative to enhance the resilience of the agricultural sector, protect the livelihood of the poor and ensure food security (Bryan et al, 2011). Adaptation is an important way for farmers to respond to climate change (Adger et al., 2003; Bradshawn et al., 2004; Barbier et al., 2008; Nam, 2012).

The way in which affected farmers will adapt determines the scale of climate change impacts and hence their farming production and livelihoods. However, achieving substantial adoption and diffusion of adaptation practices and other agricultural innovations in Sub Saharan Africa has been a challenge in recent decades, a trend that authors attribute mainly to insufficient financial capacity, among other factors (Khisa et al., 2007; Pretty et al., 1995; van Rijn et al., 2012; Willy and Holm-Müller, 2013).

This result, combined with the chronic lack of financial resources and the importance of collective action in rural communities in developing countries, raises the question: Can collective action be utilized to facilitate the adaptation to climate change? Some literature has identified that systems which facilitate collective action have reduced vulnerability to climate hazards (e.g., Toni and Holanda 2008; Eakin et. al. 2008; Adger, 2003). However, the potential role of collective action in contributing to adaptation has not been considered sufficiently in the climate change adaptation debate (Ireland et al, 2009).

The objective of this study is to assess the effect of collective action on farmers' adaptive behavior in the Savanna region of Togo. Specifically, we are interested in the indirect role of participation in collective action as a driver for individual efforts on adaptation strategies. Do individuals who participate in collective action acquire certain network externalities which enable them to implement better practices? To explain this, we need to look at how collective action affects adaptation to climate change.

Studies on to what extent collective action determines farm households' choice of adaptation measures may have distinct policy relevance, since available resources such as collective action can be depleted, given chronic problems of human and financial resource constraints.

The next section presents the conceptual framework of collective action and adaptation adoption linkage. Section 3 is devoted to the survey and data collection methods, while section 4 deals with the methodology. The empirical results and discussion are presented in section 5. The paper ends with a conclusion and implications for policy.

2. CONCEPTUAL FRAMEWORK OF COLLECTIVE ACTION AND ADAPTATION ADOPTION LINKAGE

The nature of the impact and the capacity to adapt determine farmers' ability to become resilient to climate change. The magnitude of the impact is influenced by exposure and sensitivity to climatic variability and change (Gbetibouo, 2009). In addition, varied factors determine adaptive capacity, ranging from social networks to the level of access to economic resources. By adaptation, we mean any private investment to reduce potential net damage due to climate change. Farmers use self-insurance efforts to reduce the adverse effects of climate change, if it occurs. An individual's adaptation behavior is triggered by the farmer's recognition of the need to adapt (Fankhauser et al., 1999), perceived climate risk, costs of adaptation, and potential reduction in damage (Kane and Shogren, 2000), all of these enhanced by his access to markets.

Collective action can possibly affect these determinants of individual adaptation behavior. It can facilitate the exchange of information about possible climate change effects, facilitate the diffusion of adaptation innovations, and therefore help reduce adaptation costs. It can also play a significant role in overcoming market failure. Indeed, collective action may contribute to relax labor and credit constraints. For example, providing irrigation as a supplement to rainfall for crop production or implement water and soil conservation practices requires considerable funds, labor and other resources (Scott and Silva-Ochoa, 2001).

Resource limitations and poor infrastructure limit the ability of most rural farmers to take up adaptation measures in response to changes in climatic conditions. With resource limitations, farmers fail to meet the transaction costs necessary to acquire adaptation measures and, at times, farmers cannot make beneficial use of the available information they might have (Kandlinkar and Risbey 2000). By relaxing these limitations, collective action can significantly trigger an individual adaptation process.

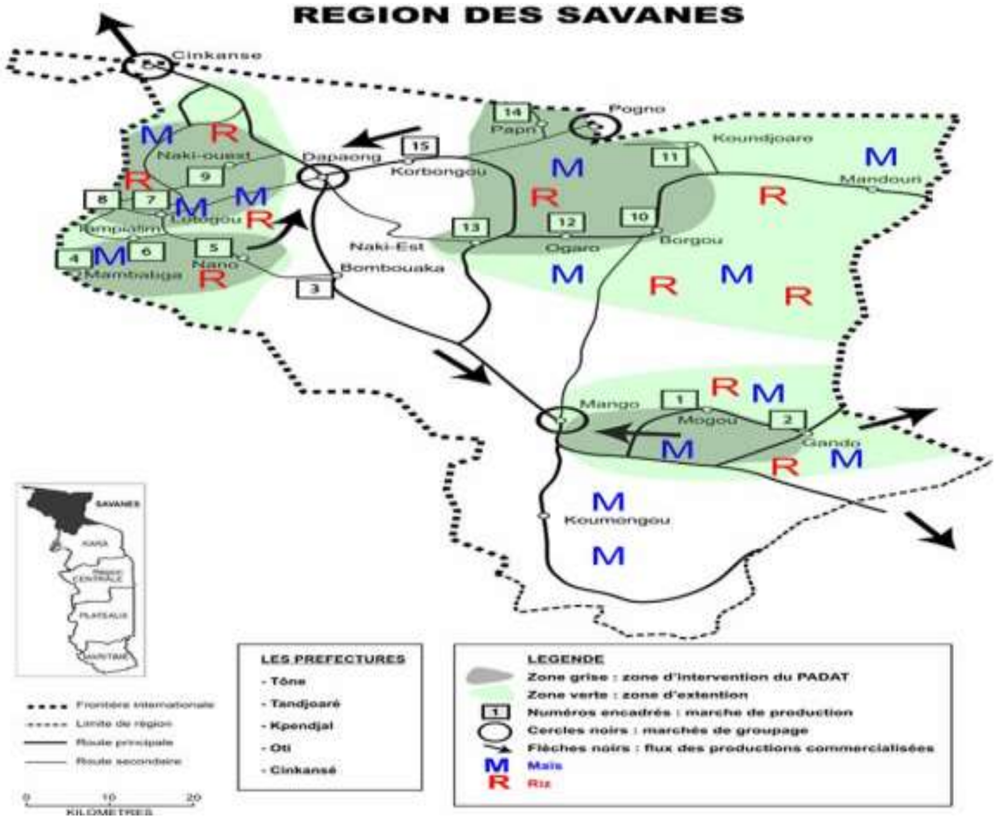
Deressa et al. (2009) showed that informal institutions such as peer networks, which are fostered in collective action organizations, may help increase people's awareness of climate change and its effects and promote sharing of experiences of adaptation options. The authors found that having access to farmer-to-farmer extension; the service in which trained farmers act as the extension agents to the neighboring farmers, can increase the likelihood of using specific adaptation measures such as different crop varieties and planting trees. Thomas et al. (2007) found in their study in South Africa that collective action has emerged as an important way to enhance adaptive capacity. Adger (2000) demonstrated that community collective action in the form of voluntary labor contribution has evolved to facilitate collective adaptation practices, such as sea dike maintenance in the absence of governmental support in Vietnam.

It is, however, not clear how collective action affects farmers' choice of private adaptation measures. Collective action may have negative effects on adaptation in two different ways, through social networks, which is one of its major components: strong social ties may create investment disincentives and strong networks may hinder adaptation through distribution of false information.

Di Falco and Bulte (2009) provided evidence of negative effects of kinship linkages on investment in adaptation. The authors found that the number of kinship links is negatively and significantly associated with the probability to invest in soil conservation. The kin network functions as an informal safety net, thus reduces the need to adapt. The networks also involve a sharing norm and therefore reduce the incentives for adaptation. Also Agrawal et al. (2008) suggest that strong institutional norms, such as the labor sharing norm in farming activities, may attenuate the incentive to adopt individual adaptation measures such as crop diversification or migration. Strong social networks may act as a conduit for the misperception of the climate change effects (false information is easily spread in a strong network). Wolf et al. (2010), for example, suggested that strong bonding networks could potentially increase the vulnerability of elderly people in the UK to the effects of heat waves. Thus, the determination of the effect of collective action on individual adaptive behavior is an empirical matter.

3. SURVEY INSTRUMENTS AND DATA COLLECTION

The analysis for this paper is based on a stratified random sampling survey of farm household heads conducted in the study area. The strata are based on those defined in the Support to Agricultural Development Project (PADAT). PADAT is an ongoing project designed to help improve smallholder food security and incomes. The different zones where PADAT is being implemented were stratified into degrees of vulnerability. Thus, each of Togo's five administrative regions were divided into three clusters: Very vulnerable, vulnerable and less vulnerable zones. The following figure presents the study area with the different zones clustered into degrees of vulnerability.



Dark areas are the most vulnerable zones, green areas are vulnerable zones, while white areas are the less vulnerable zones. In each type of zone, communities were chosen at random and a total of 450 randomly selected farmers, equally distributed in the selected sites, were interviewed. Three communities were selected in each stratum, within each community, two villages were randomly chosen and, within each village, 25 farmers were interviewed randomly.

4.0 METHODOLOGY

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

$$U_i(T'\beta_i + \varepsilon_i) > U_k(T'\beta_k + \varepsilon_k), \quad k \neq i \quad (1)$$

where U_i and U_k are the perceived utility by farmer *j* of adaptation options *i* and *k*, respectively; T is a vector of explanatory variables which influence the choice of the adaptation option; β_i 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, one can relate the observable discrete choice of practice to the unobservable (latent) continuous net benefit variable as Yi = 1 if *Ui*> 0 and Yi = 0 if *Ui*< 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 *j* will choose the adaptation option *i* among the set of adaptation options could be defined as follows:

$$P(Y = 1/T) = P(U_i > U_k/T)$$

$$= P(\beta^* T + \varepsilon^*)$$

$$= F(T'\beta^*), \text{ with } \beta^* = (\beta_i - \beta_k) \text{ and } \varepsilon^* = \varepsilon_i - \varepsilon_k.$$

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, and F(β*T) is the cumulative distribution of ε* evaluated at β*T. Depending on the assumed distribution that the random term follows, several qualitative choice models could be estimated (Greene

2003). For adoption decisions involving multiple choices, analytical approaches commonly used to estimate F(β*T) are the multinomial logit (MNL) and multivariate probit (MVP).

The multivariate probit model simultaneously models the influence of the set of explanatory variables on each of the different adaptation measures, while allowing the unobserved and unmeasured factors (error terms) to be freely correlated (Green 2003; Nhemachena and R. Hassan, 2011). Complementarities (positive correlation) and substitutabilities (negative correlation) between different options may be the source of the correlations between error terms (Nhemachena and R. Hassan, 2011). Another source of positive correlation is the existence of unobservable household-specific factors that affect the choice of several adaptation options, but are not easily measurable, such as indigenous knowledge. The correlations are taken into account in the multivariate probit model. For these reasons, multivariate probit has an advantage over multinomial logit whose attractiveness is limited by the assumption of the Independence of Irrelevant Alternatives (IIA) it requires.

Both techniques suffer from sample selection bias. Indeed, because adaptation to climate change involves a two-stage process: first perceiving change and then deciding whether or not to adopt a particular measure (Maddison, 2007), the decision to adopt a particular measure is likely to be conditional on the perception of climate change and not taking this aspect into consideration can lead to sample selection bias. We account for this bias by the use of the Inverse Mills Ratio in the multivariate probit model.

Following Lin et al. (2005); the multivariate probit econometric approach is characterized by a set of *n* binary dependent variables y_i so that:

$$(1) \quad \begin{cases} Y_i = 1 \; if \; T'\beta_i + \epsilon_i > 0 \\ Y_i = 0 \; if \; T'\beta_i + \epsilon_i \leq 0, \text{ i= 2, 3 …n.} \end{cases}$$

T is a vector of explanatory variables, $\beta_1 \ldots \beta_n$ are vectors of parameters, and $\varepsilon_1 \ldots \varepsilon_n$ are random error terms distributed as multivariate normal distribution with zero means, unitary variance and an $n \times n$ contemporaneous correlation matrix R= $[\rho_{ij}]$, with density $\emptyset(\varepsilon_1, \dots \varepsilon_n; R)$. As adaptation to climate change involves a two-stage process: first perceiving change and then deciding whether or not to adopt a particular measure (Maddison, 2006, 2007), the decision to implement a particular measure is conditional on the perception of climate change and not taking this aspect into consideration can lead to sample selection bias. Let the following equation be the equation of perception:

$$Y_1^* = K'\theta_1 + U_1 \quad (2)$$

Selection bias is a problem if U_1 and any of the ϵ_i are correlated. We intend to account for this correlation through the inclusion of the Inverse Mills Ratio, estimated during the estimation of the perception equation (equation 2) by the probit model in the system (1) as an explanatory variable. This procedure is inspired by Heckman 1979, who shows that selection bias is equivalent to the omitted variable bias; in this case is the Inverse Mills Ratio.

Finally, the likelihood contribution for an observation is the *n*-variate standard normal probability given by the following expression (Nhemachena and Hassan, 2007).

$$\Pr(Y_2, \dots, Y_n / X) = \int_{-\infty}^{(2Y_2-1)X'\beta_1} \times \int_{-\infty}^{(2Y_3-1)X'\beta_2} \dots \times \int_{-\infty}^{(2Y_n-1)X'\beta_n} \emptyset(\varepsilon_1, \dots \varepsilon_n; Z'RZ) d_{\varepsilon_n} \dots d_{\varepsilon_1}$$

Z=diag[$(2Y_2$-1),…, $(2Y_n$-1); and X is the set of explanatory variables, which in our case includes the Inverse Mills Ratio. The marginal effects of explanatory variables on the propensity to adopt each of the different adaptation measures are given by the following expression:

$$\partial P_i / \partial x_i = \emptyset.(X'\beta)\beta_i, i = 1, 2, \dots n$$

P_i is the likelihood of event *i* (that is increased use of each adaptation measure), $\emptyset(\cdot)$ is the standard univariate normal cumulative density distribution function, *x* and β are vectors of regressors and model parameters respectively (Hassan 1996 cited in Nhemachena and R. Hassan, 2011).

4.2 Indices of collective action at household level

As collective action is not directly observed, we therefore use principal component analysis to recover the underlying latent variables at household level. The extent of action undertaken collectively corresponds to the number of collective actions of the entire household and the frequency of participation of household members in collective action. Thus, the variables that were used in this analysis to recover collective action indicators include two main categories of variables: The density of organizations the household is a member of in the village and the extent of the household's participation in the activities of these organizations (Figure 1).

We recognize that the indices of any one collective action will be influenced by other factors specific to the final goals. Nonetheless, we posit that the aggregation of these indicators at household-level reflects the household's latent, unobservable capacity to act collectively. Both the Kaiser-Meyer-Olkin (KMO)[1] measure of sampling adequacy and Bartlett's test of sphercity (Hair et al. 1998) indicated that all the variables included for the factor analysis were relevant. Two factors which cumulatively explain about 66.66 percent of the total variance of the seven variables were identified. The number of factors has been retained according to Kaiser's criterion, which suggested retaining all factors with eigenvalues greater than 1. Table 1 presents the factor loadings of the different variables. The factor analysis involved Principal Component Analysis as an extraction method and the orthogonal rotation method of Variance Maximizing (Varimax); Kaiser Normalization was used for the rotation method.

Table 1: Definition of indices of collective action

Variables	Factor 1	Factor 2
Membership of farmer organizations (FO)	0.956	0.100
Density of FO membership (percentage of household members)	0.946	0.121
Membership of labor sharing group (LSG)	0.942	0.102
Density of LSG membership (percentage of household members)	0.784	0.082
Average number of days for activities per member of household	-0.041	0.823
Average participation rate in activities	0.070	0.815
Average number of meetings of farmer organization	0.110	0.265

Looking at the first factor in table 1, we note that the scoring coefficients are relatively high and positive for the density and membership variables and relatively low for number and

[1] Kaiser-Meyer-Olkin (KMO) is a statistics method that measures the adequacy of a variable to be included in factor analysis based on correlation and partial correlation. There is a KMO statistic for each individual variable, and their sum is the KMO overall statistic. KMO varies from 0 to 1.0 and KMO overall should be 0.60 or higher to proceed with factor analysis. If it is not, the lowest individual KMO statistic values will be adopted, until KMO overall rises above 0.60.

participation in meetings, activities and number of days worked. Given these scoring coefficients, we hereafter refer to this factor as the Indicator of Cooperative Capacity (ICC). The capacity of the household to cooperate is its underlying ability to create formal and informal frameworks to achieve goals of collective action, no matter what those goals are. This variable reflects the capacity to share information and facilitates the transformation of information into knowledge and action.

In contrast, scoring coefficients for the second factor are strong and positive for most of the variables measuring active participation: Average number of days for activities per member of household, average participation rate in activities, average number of meetings of farmer organizations. Given the heavier weight on variables associated with active participation, we hereafter refer to this factor as the Indicator of Effective Cooperation (IEC). This latter factor reflects resource mobilization, such as labor through labor sharing groups, and activities coordination.

4.3 Analysis of determinants of participation in collective action

In this section, we examine the determinants of the estimated indices of collective action. This is done to test whether the explanatory factors are consistent with the theory. There remains wide disagreement on the theoretical impact of many variables on the participation in collective action. However, there is agreement on the effect of several factors on collective action. We focus on these latter variables.

Education, in general, is hypothesized to favor participation in collective action by increasing farmers' capacity to acquire information and transform such information into knowledge.

Risk perception is usually hypothesized to increase participation in collective action, since it is hypothesized to increase the relative value of collective agreements, particular where these can also serve as mutual insurance (Poteete 2001; McCarthy 1999). In this study, risk perception is captured through four variables: Whether the household has heard about climate change, experienced drought, experienced flood and the household heard experience in terms of climate change.

Reciprocity based on *trust* and trustworthiness is also an important feature that facilitates collective action, since individuals within a social group may engage in informal exchanges with each other in the hope that the counterparts will reciprocate (Willy et al., 2013; Pretty and Ward, 2001). Also game theory literature points out that among players the possibility of cooperation for the provision of collective goods exists under two situations, which highly depend on whether one trusts others (Taylor 1987; Bardhan 1993; Runge, 1986; Axelrod 1968).

Literature on collective action often posits that households with non-farm income have less likelihood of participation in collective action initiatives in rural communities. This means that dependence on farm income is positively linked to participation in collective action. Dependence on farm income is captured in our analysis through the share of farm income in the total income. The regression results are summarized in Table 1 below:

Table 1: The determinants of participation in collective action (Results of OLS)

Variables	Indicator of Cooperative capacity (ICC)	Indicator of Effective Cooperation (IEC)
Risk perception		
Heard about CC	**0.24*** (0.13)	**0.97*****(0.12)
Experienced drought	0.13 (0.11)	**0.31*******(**0.09)
Experienced flood	**0.23**** (0.10)	0.01(0.9)
CC experience	0.00 (0.01)	**0.16*****(0.06)
Social capital		
Degree of trust	**0.06***** (0.01)	0.05(0.05)
Close friends	0.02(0.02)	**0.03*****(0.01)
Dependence on CA		
Dependence on farm income	**0.06******(**0.014)	**0.14*****(0.05)
Off-farm income	**-0.11*** (0.06)	**0.25*****(0.09)
CA experience		
Age	0.01 (0.04)	0.02(0.03)
Farming experience	0.03 (0.05)	**0.07***(0.04)
Others		
Education	0.00 (0.01)	0.00(0.01)
Gender	0.02 (0.13)	0.09(0.11)

Constant	0.25 (0.29)	**1.12*****(0.25)
R-squared	**0.11**	**0.29**

***Significant at 1% level; ** significant at 5% level and * significant at 10% level. Between parentheses are assigned standards errors.

The estimated equations for cooperative capacity and effective cooperation have fairly good explanatory power, with many of the significant coefficients being in line with the positivity or negativity predicted by the theory. Overall, the estimated equations provide evidence that these indices capture different aspects of collective action at household level. One interesting point to note from these results is that households that have experienced flood and/or drought in the past are more willing to participate in collective action. This placed in the climate change context seems to indicate that climate change enhances collective action initiatives. To examine the robustness of these results we further used Tobit model to model collective action determinants in the following section.

4.4 Collective action initiative and climate change

Previous results indicate the possible positive climate change effect on collective action initiatives. To test the robustness of these findings, in addition to the OLS regression, we use Tobit model to model the degree of collective action on its determinants. The results are shown in the table 5.6.

Table 5.6: Determinants of collective action (Results of Tobit model regression)

Variables	Indicator of Cooperative capacity (ICC)	Indicator of Effective Cooperation (IEC)
Risk perception		
Heard about CC	**0.21*** (0.12)	**1.04*****(0.11)
Experienced drought	0.13 (0.10)	**0.26***(**0.09)
Experienced flood	**0.22**** (0.09)	0.03(0.8)
CC experience	0.00 (0.01)	**0.15*****(0.06)
Social capital		0.04(0.05)
Degree of trust	**0.05***** (0.01)	**0.02****(0.00)
Close friends	0.02(0.02)	

Dependence on CA		
Dependence on farm income	**0.06**(**0.014)	**0.14*****(0.05)
Off-farm income	**-0.54*** (0.28)	**0.25*****(0.09)
CA experience		
Age	0.01 (0.04)	0.02(0.03)
Farming experience	0.03 (0.05)	**0.07***(0.04)
Others		
Education	0.00 (0.01)	0.00(0.01)
Gender	0.02 (0.12)	0.09(0.11)
Constant	0.26 (0.27)	**1.11*****(0.24)
R-squared	**0.04**	**0.12**

***Significant at 1% level; ** significant at 5% level and * significant at 10% level. Between parentheses are assigned standards errors.

Source: *Authors from the estimation under STATA 12*

The results of Tobit regression confirm the positive effect of climate change extreme event on collective action. Indeed, as previously shown in OLS regression, households which experienced flood are more willing to join collective action initiative. Similarly, Drought and information about climate change enhance households' participation in collective action.

These results can be easily understood. Perception of risk is usually hypothesized to affect positively collective action because of its potential positive effect on the relative value of cooperative agreements (Poteete 2001; McCarthy 1999). More frequent climate extremes increase the likelihood that a household will perceive climatic risks, hence will join collective action initiatives. Another reason could be that in the context of climate change many risks involve intervention which goes beyond individual action (Adger, 2003). The next sections, we examine how these indices impact on the use of private adaptation strategies observed at the household level in the study area.

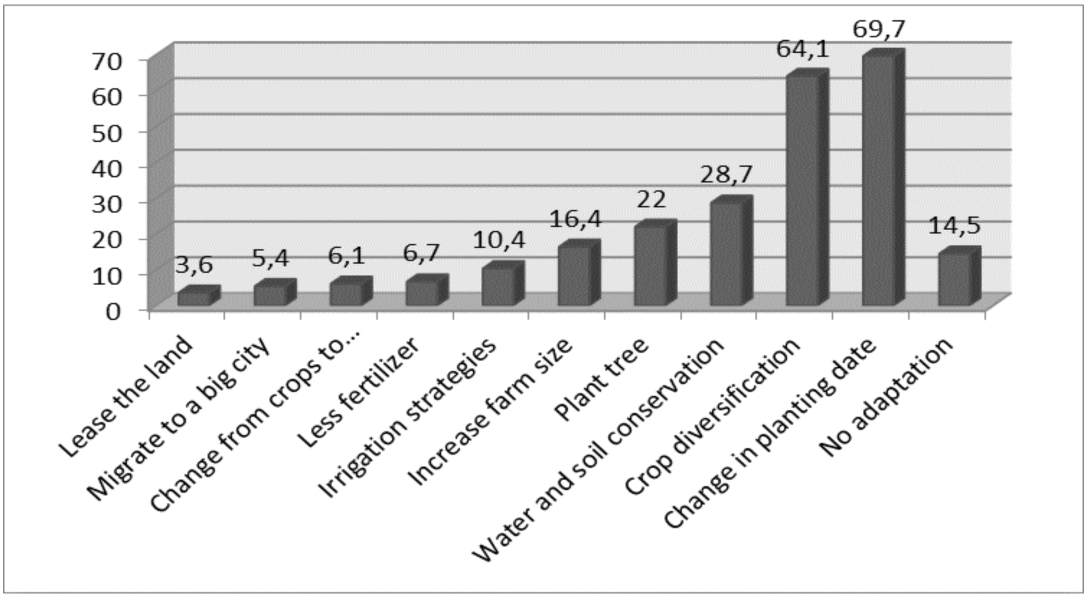
5. EMPIRICAL RESULTS AND DISCUSSION

5.1 Actual adaptation strategies of farmers in the Savanna region of Togo

Based on the data of our agricultural household survey in the Savanna region of Togo, this section presents brief summaries of farmers' perception of climate change and which strategies they use for adapting to those changes. The study focuses on private adaptation measures adopted in farming practices. In our survey farmers were asked questions about their perceptions of long-term climate changes as well as about which measures and practices they have typically adopted in order to cope with such changes over the years. The question asked was "What have you done to reduce the impact of the changes in weather patterns on your farm or crop yield/livelihood?" Interviewers had a list of possible adaptation options, but to avoid framing bias, they did not present it to the respondents. Instead, the respondents verbally described their adaptation measures and the Interviewers checked the corresponding options in the list. The results show that the majority of farmers correctly perceive that long-term temperatures are rising (72.4%) and precipitation is declining (76.3%).

Farmers' adaptation strategies in responding to the changing climate include crop diversification, changing planting dates, use of irrigation, use of soil and water conservation techniques (stone bunds use), farm to livestock shift, increase in farm size, off-farm activities (Figure 1)

Figure 1 Adaptation strategies used by farmers in the Savanna region (% of respondents)



5.2 Two-step multivariate probit

5.2.1 Perception of climate change equation (Selection model)

We first applied the climate change perception equation. This equation allows us to estimate the Inverse Mills Ratio, which was used as an explanatory variable in the multivariate model to encounter the problem of selection bias. Here, the climate change perception variable (dependent variable) takes the value 1, if the farmer notices at least one facet of climate change (changes in temperature and/ or rainfall), and 0 otherwise. For the perception equation, it is hypothesized that education, the age of the head of household, off-farm activities, extension services, information on climate change, degree of trust, degree of cooperation, membership of a labor sharing group, credit access, membership of farmers' organizations influence farmers' awareness of climate change.

More education is believed to be associated with access to information on improved technologies and higher productivity (Norris and Batie 1987); here, it is hypothesized that farmers with a higher level of education will have more information on climate change. The age of the head of household is assumed to represent farming experience. More experienced farmers are more likely to observe the change in climatic conditions over time. Higher income (both farm and off-farm) is often associated with access to information, lower discount rates, and a longer-term planning horizon by farmers (CIMMYT 1993). Therefore, it is hypothesized that off-farm activities and credit access which increase income increase awareness of climate change.

Obviously, access to information on climate change from either extension agents or any other organization is likely to create awareness of climate change. The degree of trust represents one facet of social capital. In technology adoption studies, social capital plays a significant role in information sharing (Isham 2002), and hence, it is hypothesized that a higher degree of trust is associated with greater awareness of climate change. The results of the selection model are displayed in table 2.

Table 2: Selection model results

Explanatory variables	Coefficients	P-values
Age	0.0003	0.489
Sex	0.0114	0.550

Education	0.0004	0.826
Heard of CC	**0.0100*****	0.002
Off-farm activities	0.0145	0.327
Extension services	**0.0636*****	0.010
Credit access	**-0.0847*****	0.003
LG membership	-0.0094	0.450
FO membership	0.0009	0.956
Degree of trust	0.0023	0.783
Degree of cooperation	-0.0031	0.643
Irrigation	**-0.0342****	0.024
Number of relatives	0.0000	0.993
Log likelihood		-86.584208
Number of observation		434
Prob > chi2		0.0000

Source: *Authors from the estimation under STATA 12*

5.2.2 Multivariate probit model

The econometric analysis on the effect of collective action and other factors on farmers' climate change adaptation strategies is carried out below. The data were tested for multi-collinearity using a technique known as Variance Inflation Factor (VIF) As a result, the data used in the estimation of the regression equations in table 3 have values of VIFs less than 5[2], indicating that the data have no problem with multi-collinearity. Results from the multivariate probit model of determinants of adaptation measures are presented in table 3. The results of the correlation coefficients of the error terms are significant (based on the t-test statistic) for

[2] Multi-collinearity is said to be a problem when the variance inflation factors of one or more predictors becomes large. However, large appears to be a subjective judgement. According to Haan (2002), some researchers use a VIF of 5 and others use a VIF of 10 as a critical threshold. These VIF values correspond, respectively, to R_i values of 0.80 and 0.90.

most of the pairs of equations, indicating that they are correlated. These results suggest that there are complementarities (positive correlation) between the different adaptation options being used by farmers.

This supports the assumption of interdependence between the different adaptation options. This may be due to complementarity in the different adaptation options and also to omitted household-specific and other factors that affect uptake of all the adaptation options. Another important point to note from the results is that there are substantial differences in the estimated coefficients across equations that support the appropriateness of differentiating between adaptation options.

The univariate probit models can be viewed as a restrictive version of the multivariate probit model with all off-diagonal error correlations set to zero (i.e. = 0 ρ_{ij} for $i > j$), (Lin et al. 2005; Belderbos et al. 2004). A likelihood ratio test based on the log-likelihood values of the multivariate model indicate significant joint correlations chi2 (21) = 244.995 (Probability > chi2 = 0.0000), justifying estimation of the multivariate probit, which considers different adaptation options, as opposed to separate univariate probit models, and consequently the lack of suitability of aggregating them into one adaptation or no adaptation variable, as was the case with Maddison (2006).

The Inverse Mills Ratio coefficients are significant (based on the t-test statistics) in some of the equations (in three out of seven), justifying its inclusion. Consequently, the absence of the Inverse Mills Ratio among the explanatory variables would have led to misleading results as a result of sample selection bias. The following table summarizes results from the two-step multivariate probit model.

Table 3: Results of multivariate probit analysis

Variables	**Water and soil conservation**	**Irrigation**	**Plant trees**	**Crop diversification**	**Change in planting date**	**Increase in farm size**	**Change in crops**
Age	-0.0070	0.0039	-0.0017	-0.0022	0.0007	0.0001	0.0067
Sex	0.1463	-0.2228	0.1028	0.2063	0.0463	-0.3452	0.1550

Education	**-0.0499****	0.0120	0.0028	**-0.0583****	0.0387	-0.0407	0.0241
Household size	-0.0007	-0.0212	0.0121	**0.0432***	-0.0390	**-0.0517***	-0.0138
Water access	-0.1156	**1.2205*****	**0.2918***	-0.0519	-0.2037	-0.1009	**-0.4436****
Off-farm	**0.4326****	-0.2023	-0.2061	-0.1149	-0.3502	0.3585	0.1877
Extension services access	0.0485	-0.2418	**0.2943***	**0.3519****	0.2523	-0.2681	**0.2952***
Credit access	0.2547	**0.6119****	0.0333	**-0.3488***	0.0356	**0.5923****	**0.5332****
Own-fund	**0.0000*****	-0.0000	**0.0002*****	**0.0000*****	0.0000	0.0000	**-0.000*****
CC experience	-0.0117	0.0127	-0.0068	0.0380	0.0565	**-0.0877****	0.0497
Asset value	0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000
Farm size	0.0239	0.0210	-0.0065	-0.0015	-0.0207	**-0.0062**	**-0.0456****
Close friends	**0.0785****	-0.0254	-0.0115	-0.0402	-0.0645	**0.1467*****	**0.0754***
Temperature	-0.2078	**0.01754***	-0.1714	0.3161	**0.8547****	0.2532	**0.7563*****
ICC	0.0543	**0.3004****	0. 0913	**0. 3315*****	-0.0230	-0.1010	**0.1664***

IEC	**0.2705*****	0.0681	0. 0716	0.0082	0.1082	**0. 2292****	0.0476
Inverse Mills Ratio	**4.1076****	-1.3680	1.2826	1.1640	**4.6063***	**11.1314*****	3.8261
Intercept	**-4.5382****	-0.4539	-1.6737	**-**15797	**-4.7517****	**-10.820*****	**-4.5254****
	Rho1	Rho2	Rho3	Rho4	Rho5	Rho6	Rho7
Rho1	1						
Rho2	**0.2280****	1					
Rho3	0.0999	**0.2412****	1				
Rho4	**0.2489*****	0.1211	**0.3710*****	1			
Rho5	**0.3260*****	0.1608	0.1387	**0.5342*****	1		
Rho6	0.0465	**-0.3177****	-0.0041	**0.2743****	**0.1897***	1	
Rho7	**0.3693*****	0.1190	**0.3960*****	**0.8203*****	**0.6448*****	**0.2928*****	1

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho61 = rho71 = rho32 = rho42 = rho52 = rho62 = rho72 = rho43 = rho53 = rho63 = rho73 = rho54 = rho64 = rho74 = rho65 = rho75 = rho76 = 0: chi2(21) = 244.995 Prob > chi2 = 0.0000; *; **; *** Significant at 10%; 5% and 1% respectively

6. RESULTS AND DISCUSSION

The multivariate probit estimation results show that collective action in the forms of cooperative capacity and effective cooperation does explain adaptation to climate change adoption at household level. Higher cooperative capacity and effective cooperation are associated with choosing most of the adaptation strategies (five out of seven). Indeed, the collective action in the form of cooperative capacity does increase the likelihood that the household will adopt practices such as irrigation, crop diversification and change in crops. Whereas collective action in the form of effective cooperation does enhance the probability that a given household in the study area will use water and soil conservation practices and increase farm size.

Collective action in both forms facilitates the exchange of information about possible climate change effects, facilitate the diffusion of adaptation innovations, and therefore help reduce adaptation costs. This is in line with the work of Deressa et al. (2009), who showed that informal institutions such as peer networks may help increase people's awareness of climate change and its effects and promote sharing of experiences of adaptation options. Also the fact that households act collectively provides a channel to informal financial sources that relax farmers' credit and labor constraints on investments in adaptation. Farmers work together to develop labor intensive adaptation measures such as soil and water conservation practices and increase in farm size in the study area. This explains the positive effect of effective cooperation on the probability of these measures.

Perceived increase in temperature has also quite a significant effect in the likelihood of employing climate change adaptation strategies. Perceived change in temperature did seem to explain growing more crop varieties, changes in planting dates and irrigation practice adoption. Households that perceive the change in temperature can link their perception with decreases in water resources (surface and ground), and high evapo-transpiration rates. This leads to them taking various responses. For instance, farmers tend to use drought resistant crops or varieties; so use quick-growing crops to conserve the little rain. They also tend to adopt irrigation strategies, if possible.

Access to free extension services significantly increases the probability of taking up adaptation options, except for stone bunds use, irrigation, increase in farm size and change in planting dates. Extension services provide an important source of information on climate change as well as agricultural production and management practices. Farmers who have significant extension contacts have better chances of being aware of changing climatic conditions and of the various management practices that they can use to adapt to changes in climatic conditions. Improving access to extension services for farmers has the potential to significantly increase farmers' awareness of changing climatic conditions as well as adaptation measures in response to climatic changes.

Farmers with access to credit have higher chances of adapting to changing climatic conditions. Access to affordable credit increases the financial resources of farmers and their ability to meet transaction costs associated with the various adaptation options they might want to take. With more financial and other resources at their disposal, farmers are able to change their management practices in response to changing climatic and other factors. They are better able to make use of all the available information they might have on changing conditions, both climatic and other socioeconomic factors. For instance, with financial resources farmers are able to buy new crop varieties, new irrigation technologies, and other important inputs they may need to change their practices to suit the forecasted and prevailing climatic conditions.

Having more close friends in the village is also positively related to the likelihood of adoption of the use of irrigation, increase in farm size and change in crops. The implication of this result is that social networks increase awareness and use of climate change adaptation options.

7. CONCLUSION AND POLICY IMPLICATION

The above results show that households face considerable challenges in adapting to climate change. Coping with climate change and variability and meeting subsistence needs often means that households are unable to make productive investments in their farming operation to adapt to climate change or improve long-term productivity. The results show that many households have made minor adjustments to their farming practices in response to climate change, in particular, crop diversification and change in planting dates. However, few households are able to make large investments to improve their farming practices, for example, irrigation or water and soil conservation practices, although there is a desire to invest in such measures. Lack of funds or credit and lack of information on innovation technologies were reported as the main constraints to adopting these practices.

This further emphasizes the need for greater investments in rural and agricultural development to support the ability of households to make strategic long-term decisions that affect their well-being. However, given chronic financial constraints, this study highlights the crucial role of collective action in the adaptation process. Collective action in the forms of cooperative capacity and effective cooperation facilitate the exchange of information about possible climate change effects, facilitate the diffusion of adaptation innovations, resource mobilization (mainly labor), and therefore help reduce adaptation costs. Consequently, Collective action could circumvent financial constraints. Policies that facilatate collective action could therefore help climate change adaptation.

Another important result of this study is that climate change could enhance collective action initiatives. Two reasons might be the source of this last finding. Firstly, perception of climate risks affects positively collective action because of its potential positive effect on the relative value of cooperative agreements. Secondly, in the context of climate change many risks involve intervention which goes beyond individual action. Given that farmer groups are not always successful, there is a need to better understand under what conditions collective action is useful and viable. This should be the target of future researches.

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