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Research Article

Role of Rural Institutions in Determining Farmers Adaptation to Climate Change: The case of Kilte-Awlaelo District, Northern Ethiopia

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Abstract

Adaptation to climate change (ACC) is a serious challenge to farmers and pastoralists in Ethiopia. The efforts towards ensuring ACC are highly local, and their effectiveness depends on local institutions. Studying the role of rural institutions in determining households' ACC is vital to developing countries like Ethiopia, where role of rural institutions are seldom recognized in official adaptation strategies. In this study, household data were collected from Kilte-Awlaelo district in order to identify and analyze the relationship among choice of adaptation strategies, household features and rural institutions. Principal component analysis and Multinomial Logit models were used for analysis. Multinomial Logit result showed that education, land size, access to irrigation, farm income, livestock ownership, access to credit were factors that significantly affected farmers' choice of major adaptation strategy at P<0.10. Principal component index of role of rural institutions positively affected the choice of crop diversification and food storage at P<0.10 and P<0.05 respectively; while negatively affected the choice of shifting planting date as major adaptation at P<0.10. Rural institutions were found to be crucial in shaping households' adaptation efforts. Therefore, enhancing the financial and technical capacity of rural institutions could amplify their role in facilitating ACC at household level.

Keywords: Major Adaptation Strategy, Rural Institutions, Multinomial Logit, Principal Component Analysis, Index.

1. Introduction

In Ethiopia, more than 85% of the population depends mainly on agriculture for their livelihoods, rendering them very vulnerable to climate change and variability. The agricultural sector is the largest contributor to the GDP, yet it is dominated by subsistence and smallholder production which made it to be highly exposed to climate variability and weather extremes. In recent times, a significant number of people in Ethiopia are being affected by extended drought and flooding, leading to loss of assets and chronic food insecurity (Gebremicheal and Mebratu, 2009).

Adaptation to climate change and variability poses serious challenges to farmers and pastoralists in arid and semi-arid parts of Ethiopia. The critical problems are not only biophysical or technical problems but also deeply social challenges (Hulme et al., 2001).

Adaptation practices by farmers and pastoralists necessarily occur in particular social and ecological settings. As such, the adaptive dynamics of local social institutions are often critically important because centralized planning or generic, and ready-made technical fixes are of limited utility for the specificities of local practice (Crane, 2013).

Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events (IPCC, 2007). The overall responses to these changes can better be facilitated by active involvement of local institutions (Hulme et al., 2001).

The climatic change in precipitation pattern, variability, and temperature changes are most likely to increase the frequency of droughts and floods in Ethiopia. The poor rural people who do not have access to different livelihood options, infrastructure, and institutional setups are known to be the most vulnerable (MoARD, 2010). In such cases, rural institutional structures become critically important in improving adaptive capacity of the vulnerable social groups.

The efforts towards adaptation to climate change are highly local, and their effectiveness depends on local and extra-local institutions (Agrawal, 2008). However, rural institutions are seldom recognized by the official climate change adaptation programs, and their role in facilitating household's food security and adaptation to climate change has been undermined.

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Figure1: Location map of Kilte-Awlaelo district

Besides, the capacity of rural institutions in supporting large scale adaptation strategies is very limited. This is because, rural institutions face financial, managerial, infrastructural, training, and legal constraints (World Bank, 2010).

Hence, studying the role of rural institutions in determining farmers' adaptation to climate change in the study area is a core component of designing interventions that can positively influence the adaptation practices of small holder farmers (Howard, 2012). In addition, it will fill the gap in scientific knowledge regarding the role of rural institutions in facilitating farmers' adaptation practices.

Therefore, this study was carried out with the main objective of analyzing the role of rural institutions in determining famers' adaptation to climate change and with specific objectives of: (a) identifying farmers' major adaption strategies and (b) studying determinants of farmers' choice of major adaptation strategies.

2. Methodology

2.1 Description of the study area

The study area Kelte-Awelalo district (Figure 1) is located at13[°] 49' 43" latitude and 43[°]31' 76" longitude of Tigray region, Northern Ethiopia. The average minimum and maximum temperature is 10 $^{\circ}$ C & 28 $^{\circ}$ C respectively and a total rainfall about 565 mm per annum.

It is a typical district in Ethiopia characterized by mixed crop and livestock farming production. Crop

production is mainly dependent on the summer ("Kiremt") rain that fall from June to August.

Current figures indicated that the population of the district has reached 132,000. The estimated total households of the study area were 24,253 (CSA, 2013).

2.2 Data Organization and Analysis

To understand farmers' choice of adaptation strategies, a household survey was conducted in Kilte-Awlaelo district. A semi-structured questionnaire was prepared and interview was conducted among 150 households. Moreover to capture all the qualitative data key informant interview and focus group discussion was also held with local administrators and farmers.

The sample size was limited to 150 households since the number of households in the district is around 24,253 (CSA, 2013), it is believed that 150 households would represent the population sufficiently.

The sample of households covered six administrative kebles of the district. The administrative kebles were stratified based on their rank of climate change adaptation success. The administrative kebles were ranked by the district office of agriculture as better off, moderate and lower performing administrative kebles in the success of climate change adaptation strategies. Following the stratification, two kebles from each stratum were randomly selected totaling to six sample administrative kebles.

The criteria used to select the households from each administrative kebles were by their economic status, i.e.,

high, medium and low-income levels, and by their involvement in rural institutions. Given these criteria, households were then randomly selected in such a way that a representative sample is obtained from the sampling frame.

Based on the above methods, interview was conducted using semi-structured questionnaire from January to April, 2014. The interview questionnaire included household socioeconomic, demographic attributes, households' climate change adaptation strategies, and access & role of rural institutions in households' adaptation strategies.

2.2.1 The theoretical model and econometric specification

The decision on whether or not to adopt an adaptation strategy is considered under the general framework of utility or profit maximization (Norris and Batie 1987; Pryanishnikov and Katarina, 2003). It is assumed that economic agents, including smallholder subsistence farmers, use adaptation strategy only when the perceived utility or net benefit from using such a strategy is significantly greater than is the case without it. Although utility is not directly observed, the actions of economic agents are observed through the choices they made.

To identify factors affecting farmers' choice of major adaptation strategy, the multinomial logit (MNL) model was used. This method is used to analyze factors that affect farmers' choices of major adaptation strategies as methods to adapt the negative impacts of climate change in which the choices are mutually exclusive. The advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Madalla, 1986; Wooldridge, 2010). Moreover, Koch (2007) emphasizes the usefulness of this model by describing the ease of interpreting estimates from this model.

To describe the MNL model, let y denote a random variable taking on the values $\{1, 2, ..., J\}$ for J, a positive integer, and let x denote a set of conditioning variables. In this case, y denotes adaptation options or categories and x contains household attributes like sex, age, education, farm income, and other factors. The question is how ceteris paribus changes in the elements of x affect the response probabilities P (y=j/x),J=1, 2,...J. Since the probabilities must sum to unity, P (y=j/x) is determined once we know the probabilities for J=1, 2,...J.

Let x be a K \times 1 vector with first element unity. The MNL model has response probabilities:

$$P(y = j \mid x) = \exp(x\beta_j) / \left[1 + \sum_{h=1}^{J} \exp(x\beta_h), \ j = 1, \dots, J \right]$$
(1)

Where, β_i is $K \times 1$, J=1,...,J.

For this study, the major adaptation strategies adopted in the area are six, they were mutually exclusive and for statistical convenience, these adaptation strategies were tested for their independence with independence irrelevant alternatives (IIA). Hence the major adaptation strategies are: (1) Livelihood Diversification, (2) Use of Water harvesting and Irrigation, (3) Crop Diversification, (4) Adjusting and shifting of planting dates, (5) Changing Consumption type and number and (6) Food storage.

Unbiased and consistent parameter estimates of the MNL model in equation (1) require the assumption of independence of irrelevant alternatives (IIA) to hold. More specifically, the IIA assumption requires that the probability of using a certain adaptation strategy by a given household needs to be independent from the probability of choosing another adaptation method (that is, P_j/P_k is independent of the remaining probabilities). The premise of the IIA assumption is the independent and homoscedastic disturbance terms of the basic model in equation (1).

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable, but estimates do not represent either the actual magnitude of change nor probabilities. Differentiating equation (1) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial P_j}{\partial x_k} = P_j \left(\beta_{jk} - \sum_{J=1}^{J-1} P_j \beta_{jk}\right)$$
(2)

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Greene, 2000; Koch 2007).

2.2.2 Data Attributes of rural institutions

Being one of the variables of concern that entered into the econometric analysis, the measurements of the role of rural institutions need crucial attention. For addressing this variable number of indicators of rural institutions listed below captured by making use of Likert scaling were used to develop an index variable of role of rural institutions (RURINDEX) and thereby it was used as a proxy to enter the variable it to the model and capture the contribution of rural institutions in determining households' adaptation to climate change. This study follows the work of Robert (2012) in trying to index role of rural institutions with principal component analysis.

To obtain the sum score of an index on the n^{tn} component extracted in a principal component analysis, we used the general form of the formula stated below (Vyas and Kumaranayake, 2006).

 $PC_i = a_1X_1 + a_2X_2 + ... + a_nX_n$

Where;

 PC_i = the subject's score on nth principal component a_i = the regression coefficient (or weight) for observed variable i, as used in creating nth principal component X_i = the subject's score on observed variable i.

Table 1:Items included in indexing role of rural institutions

• Rural institutions create access to household livelihood diversification activities					
•Rural institutions provide farm inputs and credit service					
•Rural institutions provide farming and climate information					
•Rural institutions fulfill households' training and extension service requirements					
•Rural institutions increase households' participation in community adaptation strategy					
•Rural institutions proved leadership in households' adaptation efforts					
•Rural institutions increase households' water use options					
•Rural institutions increase livestock fodder and watering options					
•Rural institutions provide alternative energy source					
•Rural institutions contribute in responding to emergency					
Source: Own adjustment					

A set of indicators considered to be role of rural institutions in determining households' adaptation to climate change were included in the study (As shown in Table 1). Role of rural institutions in terms of creating access to livelihood diversification activities, farm inputs, farming information and credit service were among the items considered. From the above set of indicators adopted to explore the contribution of rural institutions in determining households' adaptation to climate change, role of rural institutions index (RURINDEX) was computed by making use of the 5 point Likert-scaling to all of the statements needed to elicit role of rural institutions. The index was calculated using correlation matrix by equally weighing the indicators of role of rural institutions. In this study, five rural institutions (Rural Cooperatives, Water User Association, Watershed Committee, Farmers Association, and Development groups) relevant to climate change adaptation were only considered in order to better explain role of rural institutions in the study area.

Variable name and description	Mean	Std. Dev.
Household head sex (1=male, 0=female)	0.73	0.44
Age of household head (years of age)	44.77	7.45
Education of household head (year of schooling)	2.38	2.39
Family size (number of family members)	5.2	1.71
Distance of household from village center	3.02	2.25

(Km)			
Household livestock ownership (TLU)	4.27	2.38	
Household farm income per year (Birr) (1U\$\$=18.34 Birr)	8916.67	4549.70	
Total household income per year (Birr) (1US\$=18.34 Birr)	11928.27	5411.25	
Household land ownership (hectares)	0.94	0.55	
Household access to irrigation (1=yes, 0=otherwise)	0.41	0.49	
Household access to credit (1=yes, 0=otherwise)	0.62	0.48	
Household access to extension service (1=yes, 0=otherwise)	0.88	0.32	
Household access to training (1=yes, 0=otherwise)	0.83	0.37	
Index for role of rural institutions (RURINDEX)	1.15	0.73	

3. Result and Discussion

Farmers use multiple adaptation strategies to cope with the impacts of climate change through a range of practices. The major adaptation strategies identified in Kilte-Awlaelo were livelihood diversification, use of water harvesting and irrigation, crop diversification, adjusting and shifting of planting dates, food storage and changing consumption type and number.

Table 3: Farmers' major adaptation strategies

Major Adaptation strategy	Frequency	Percent	
Livelihood diversification	84	56%	
Crop diversification	20	13.33%	
Water harvesting and irrigation	17	11.33%	
Shifting planting dates	9	6%	
Change in consumption	14	9.33%	
Food storage	6	4%	

As indicated in table 3, livelihood diversification (56%) is the most commonly used strategy followed by crop diversification (13.33%). Whereas food storage (4%) is the adaptation least practiced among the major adaptation methods identified in KilteAwlaelo district. Moreover, water harvesting, changing consumption and shifting planting dates are used by 11.33%, 9.33% and 6% respectively.

3.1 Determinants of farmers' choice of major adaptation strategies

The estimation of the multinomial logit model for this study was undertaken by normalizing one category, which is normally referred to as the "base category." In this study, water harvesting and irrigation was the base category. The reason behind taking this strategy as a base category was that, water harvesting and irrigation is the primary strategy Ethiopian government has prioritized to implement as major adaptation strategy and provide farmers with one and above water use options in the period of GTP (GTP, 2010).

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VAR	Livelihood Diversification		Crop Diversification		Shifting Planting Date		Change in Consumption Pattern		Food Storage	
	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z
Sex of household head	1.055559	0.161	0.784595	0.408	-0.270163	0.809	-0.01901	0.987	1.300354	0.467
Age household head	-0.005642	0.948	0.089795	0.379	0.059592	0.588	0.113769	0.338	-0.027908	0.856
Education level of household head	0.349173	0.093*	0.750224	0.002***	0.275377	0.327	0.390752	0.139	0.141834	0.651
Family size	-0.236506	0.503	- 0.167596	0.701	0.124481	0.822	-0.603282	0.265	-0.630993	0.328
Distance from village center	-0.211883	0.233	-0.31874	0.14	-0.304922	0.213	-0.271006	0.318	-0.087213	0.779
Livestock ownership (TLU)	-0.440713	0.067*	- 0.503189	0.104	-0.275582	0.388	-0.65002	0.050**	-0.720927	0.128
Farm Income	-0.000163	0.101	0.000238	0.074*	-0.000149	0.27	-0.000603	0.004***	-0.000142	0.565
Land size	1.935477	0.048**	3.14973	0.004***	1.686665	0.189	1.730991	0.173	3.918113	0.419
Access to irrigation	-2.922773	0.003***	- 2.910722	0.011**	-1.610044	0.095*	-1.670979	0.2	-5.158785	0.007***
Access to credit	-0.724302	0.518	-1.25463	0.334	-0.993958	0.479	-0.28066	0.844	-4.339914	0.041**
Access to extension service	0.420804	0.769	4245171	0.798	15.69704	0.993	2.747981	0.17	-0.784017	0.677
Access to training	-0.04203	0.962	- 0.174408	0.879	14.68695	0.994	-0.201113	0.89	12.98302	0.995
Index for role of rural institutions (RURINDEX)	0.867241	0.241	0.481496	0.059*	-1.856888	0.067*	-1.3446	0.168	1.064818	0.038**
_cons	14.04566	0.041	- 3.823837	0.654	-15.18665	0.995	14.41446	0.083	4.30549	0.998

Table 4: Multinomial logit result of independent variables

Notes: ***, **, * = significant at 1%, 5%, and 10% probability level, respectively Base Outcome = Water harvesting and Irrigation

me = Water harvesting and Number of obs = 150 LR chi2 (65) = 134.56` Prob> chi2 = 0.0000 Pseudo R2 = 0.3300

Log likelihood = -136.57426

As result revealed, the choice of livelihood diversification as households' major adaptation strategy is affected by the level of education, livestock ownership (TLU), land size and access to irrigation at 10%, 5% and 1% level of significance respectively (see Table 4). Households that have higher schooling and land size are likely to have higher probability of adopting livelihood diversification as major adaptation strategy as compared to use of water harvesting and irrigation. On the other hand households with access to irrigation are likely to have lower probability of adopting livelihood diversification as major adaptation strategy. This implies that irrigation not only alleviates water stress but it also expands the opportunities of increasing crop harvest, as well as increasing returns on investments such as fertilizer and other inputs (see also Newsham and Thomas, 2009).

Another adaptation strategy taken by farmers is crop diversification and use of improved crop varieties that has proven to be one of the most popular farm level adaptations to climate variability and change.

Education of household head and size of land owned were found to have positive impact on use of crop diversification at 1% level of significance. Households with better education level are likely to have higher probability of using crop diversification as major adaptation strategy as compared to use of water harvesting and irrigation (see Table 4). This is attributed to farmers' information and awareness regarding the advantages of using improved and drought crop varieties.

Farm income was found to have positive impact on use of crop diversification as compared to use of water harvesting and irrigation. With increasing farm income, households are more likely to use crop diversification as major adaptation to climate change. The reason behind is that, different crop varieties have different input requirements and costs associated with their access, production, different responsiveness to local stressors and can face very different output prices in ways that affect farmers' profitability (see also Deressa et al. 2009). On the other hand, access to irrigation was found to have negative impact on the use of crop diversification as compared to water harvesting and irrigation. This was found to be statistically significant at 5% level. This implies that farmers with access to irrigation tend to focus on cash crops instead of adopting different crop varieties which might be costly and have associated profit uncertainties.

Outcome of the study shows that, rural institution (*Index*) was found to have positive impact on the use of crop diversification as compare to water harvesting and irrigation. This was found to be statistically significant at 5% level (see Table 4). This implies that rural institutions play big role in promoting crop diversification and use of drought resistant and short growing varieties through organizing training and farmer to farmer experience sharing programs. Besides, rural institutions play great role in supplying short growing and drought tolerant crop varieties as well as other farm inputs adopted by farmers.

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One of the most straightforward adaptations strategy is the option to shift the time of crops to be planted. According to this study access to irrigation was found to have negative impact on the adoption of adjusting and shifting planting dates as major adaptation strategy compared to the use of water harvesting and irrigation. This was found to be statistically significant at10% level of significance (see Table 4). This implies that access to irrigation reduces farmers' dependence on rainfall availability and planting can be granted on the preferred dates.

Most importantly result shows that rural institutions are the major factors that negatively affect the choice of shifting planting dates as a major adaption strategy. This means that the variable rural institutions (Index) have a negative and significant effect on households' choice of shifting planting dates as a major adaption compared to the use of water harvesting and irrigation (see Table 4). This indicates rural institutions discourage the use of shifting planting dates as major adaptation strategy. This is because for rain fed agriculture where planting is typically dependent on the onset of rainfall, it is clear that shifts in planting date will result in reduced crop harvest. Hence, local institutions tend to promote households' to use other alternative adaptation strategies (such as use of drought tolerant crop varieties) rather than shifting planting dates.

Even if households adopt multiple adaptation measures, households' food requirement may still not be fully shielded from the negative impacts of a changing climate. As a result, households are forced to change their consumption type and number to deal with climaterelated shocks to agriculture when they unavoidably occur.

The decision to adopt changing consumption type and number as a major adaptation strategy is negatively affected by the amount of farm income at 5% level of significance (see Table 4). This implies households with higher income are less likely to adopt change in consumption as a major adaption to climate change as compared to use of water harvesting and irrigation. Farm income of rural households typically declines in bad climate years due to productivity shortfalls. Hence, households' with lower farm income tend to get knocked by rising food price. Therefore, households compensate their food requirements by changing their consumption pattern.

Similar to farm income, livestock ownership have negative impact on the adoption of change in consumption pattern as major adaptation strategy as compared to water harvesting and irrigation. This was found to be statistically significant at 1% level. This implies that households with higher livestock ownership tend to sell their livestock in response of fulfilling their home consumption requirements. Hence, they are less likely to adopt change in consumption as major adaption strategy to climate change. Major changes in consumption patterns in Kilte-Awlaelo district include, change from *Teff*dominated meal in to Barley and Millet dominated meal. And also households' tend to use cactus (*Beless*) vastly in meal during scarce seasons.

Food storage combined with saving is one of the most practical, immediate and cost-effective ways to respond to climate induced food scarcity. The choice of adopting food storage as major adaptation strategy is negatively affected by access to irrigation and access to credit at 1% and 5% level of significance respectively (see Table 4). Households' with access to irrigation are less likely to adopt food storage as major adaptation strategy compared to use of water harvesting and irrigation. This is attributed to the fact that households with access to irrigation are less likely to face food deficit as they can produce up to three times per year even in slack-off season. And, hence they will have less probability of adopting food storage as their major adaptation to climate change.

Besides, households with access to credit are less likely to adopt food storage as major adaptation to impacts of climate change as compared to water harvesting and irrigation. This implies that households with access to credit can fulfill their food requirements by making use of their better purchasing power gained through credit and hence they will less likely store food to adapt to the impacts of climate change.

Rural institutions (*Index*) have positive impact in households' decision to choose food storage as a major adaption strategy to climate change compared to use of water harvesting and irrigation. This was found to be statistically significant at 5% level (see Table 4). Many rural households across Kilte-Awlaelo improperly use their resources through extravagant celebrations of social ceremonies. These extravagant celebrations of social ceremonies are highly reduced by the contribution rural institutions through training and awareness creation programs. This implies that food storage options are highly promoted by the rural institutions and is believed to contribute to major increase in households' adaptive capacity.

Conclusion

Analyses in the literature that focus on the role of rural institution in determining adaptation to climate change are limited, mainly in developed countries. This study contributes to the literature by examining the role of rural institution in adaptation to climate change from the perspective of developing countries. While multinomial logit model is used to examine the determinants of choice of adaptation strategies, the role of rural institutions was indexed with principal component analysis, so that it could be a proxy to enter the variable into the model.

Result shows that taking water harvesting and irrigation as a reference, level of education, land size, and access to irrigation were factors that affect the choice of

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livelihood diversification as major adaptation. Similarly, level of education, farm income, land size and access to irrigation were found to be factors that affect the choice of crop diversification as households' major adaptation strategy. The result further indicated farm income and livestock ownership are factors that negatively affect the choice of change in consumption as households' major adaptation. Likewise, access to irrigation and access to credit are factors that significantly affect choice of food storage as households' major adoptions in the district.

More importantly the principal component index of rural institutions was found to promote the choice crop diversification and food storage as households' major adaptation strategies. Adjusting and shifting planting date was however discouraged by rural institutions.

Rural institutions were contributing towards households' adaption to climate change through providing farm inputs, extension service, and farming information. Besides, rural institutions provide leadership and increase households' participation in communal adaption strategies. Results are consistent with the findings of Agrawal (2008), World Bank (2010) and Crane (2013).

The adverse affects of climate change on agriculture have become a major concern for rural households. The length of the growing season and the type of crop grown are both affected by climate change. Climate change also modifies the availability of water, which have an intense effect agricultural productivity. on Livelihood diversification is one of the major adaptive approaches to minimize the adverse effects of climate change. However, the role of rural institutions in creating access to livelihood diversification activities was insignificant. This is due to the limited financial and technical capacity as well as infrastructural and legal constraints.

Adaptation to the predictable impacts of climate change is necessarily local, and rural institutions have a critically important role in promoting effective adaptation by rural households. Therefore, development efforts should emphasize in enhancing the financial and technical capacity of rural institutions to amplify their role in facilitating adaption to climate change.

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