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Climate Change Adaptation in Kenyan Agriculture: Could Social Capital help?

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Abstract

Adaptation is critical since the mitigation efforts to reduce the sources or enhance the sinks of greenhouse gases will take time. The concern in developing countries, particularly in Sub Sahara Africa (SSA) is due to high vulnerability and ability to adapt is low. This study analyses adaptation to climate change in four ecological zones in Kenya. These ecological zones include arid, semi-arid, temperate and humid areas. Climate change adaptation is relatively low in arid areas in comparison to other agri-ecological zones. The study finds that farmers are adapting to climate change and the main strategies includes technologies adoption, crop management, land and water management, livestock management and planting trees. A multinomial discrete choice model was used to analyze the determinants of farm-level adaptation measures. The main factors affecting adaptation is household capital or assets endowment. The study finds that social capital is key driver in adopting new technologies which are crucial in adapting to climate change. Ownership of ICTs devices which are important in dissemination of climate change or agricultural production information also influenced adaption. Other factors influencing adaptation include human, physical and financial capital, climate change perceptions, land size and farming experience. The study discusses recommendations and policy implications.

Keywords: Climate Change; Adaptation; Assets; Social Capital; Kenya

Introduction

Sub-Saharan Africa is highly vulnerable to the adverse impacts of climate change due to low adaptive capacity, heavy dependence on rain-fed agriculture, low levels of human and physical capital, poor infrastructure, and already high temperatures (SEI 2009). An increase in droughts, floods, and other extreme events have impacted the economic sectors that are most vulnerable to climate change, namely crop and livestock production, health, water and energy resources, and forestry among others (SEI 2009). In Kenya, where the poverty rate is 52 percent (World Bank 2010) and 70 percent of the labour force depends on agricultural production for its livelihood (FAO 2010), climate change and climate extreme events have a negative effect on the livelihoods of poor households. Moreover, climate change and variability jeopardizes progress made over recent years in overcoming hunger, reducing poverty (MDG 1), and promoting environmental sustainability (MDG 7). Therefore, efforts to facilitate adaptation are needed to enhance the resilience of the agricultural sector, ensure food security, and reduce rural poverty.

Social capital influences access to climate or agricultural information, ease financial constraints, and build capacity to adapt to climate change. It also shape the ways in which households and communities respond to climate impacts and risk (Deressa et al. 2009) and mediate between local adaptation efforts and the larger process of adaptation at higher scales (Agarwal and Perrin 2008). In particular, local groups and organizations are of fundamental importance to economic, social, and political outcomes (Thorp et al. 2005). Group-based approaches have the potential to increase resilience to climate change by overcoming information barriers and by facilitating access to agricultural knowledge and technologies for adaptation to climate change and responding to climate shocks (Goulden 2005). Therefore, strengthening local organizational capacity and social capital and network, and offering opportunities to expand the social capital of communities are key strategies for enabling and building community adaptive capacity. In this paper social capital and group-based approaches are used interchangeably.

In the recent past, social capital has increasingly gained recognition as important for agricultural development, natural resource management, and rural development in developing countries, especially for those who lack property rights, and have limited access to financial, human or natural capital. However, few studies have focused on the link between group-based approaches to climate change adaptation and livelihood resilience or well-being in developing countries. For instance, recent studies have found that some form of social capital increase the propensity for private adaptation (Nam 2011; Di Falco and Bulte 2011; Di Falco and Bulte 2009b; Anderson 2008). However, these were simple adaptation measures such as changing crop type and planting date but social capital affects the collective adaptation. This paper assesses whether social capital and other assets influence climate change adaptation. The paper is organized as follows; next section discusses theoretical and analytical framework, then data, followed by results and discussion and last section presents the study conclusion.

Theoretical and Analytical framework

This study draws from new institutional economics and focuses on the role of social capital (i.e., group management) in climate change adaptation in kenya. They study hypothesis that social capital with influence private adaptation to climate change.This study also applied principle components analysis (PCA) method to aggregate several binary assets ownership variables into a single dimension. This study followed the recommendation made by Filmer and Pritchett (2001) because relatively easy to compute and understand, and provides more accurate weights than simple summation (Moser and Felton 2007). The factors from PCA were used in econometric analysis. Previous studies have used various assets as stand-alone for instance education, income access to credit (Silvestri et al. 2012; Bryan et al. 2011; Deressa et al. 2008). Assets in this study are categorized according to Behrman et al. (2011) and DFID (2008). The study hypotheses that access to assets (capital) may shape participation in adaptation strategies thus strengthen resilience.

The analytical approaches that are commonly used in an adoption decision study involving multiple choices are the multinomial logit (MNL) and multinomial probit (MNP) models. Both the MNL and MNP are important for analyzing farmer adaptation decisions as these are usually made jointly. These approaches are also appropriate for evaluating alternative combinations of adaptation strategies, including individual strategies (Hausman and Wise 1978; Wu and Babcock 1998). This study used a MNL logit model to analyze the determinants of farmers' decisions because it is widely used in adoption decision studies involving multiple choices and is easier to compute than its alternative, the MNP. The study uses MNL model because of its computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse 1987). It also provides a convenient closed form for underlying choice probabilities, with no need of multivariate integration, making it simple to compute choice situations characterized by many alternatives. In addition, the computational burden of the MNL specification is made easier by its likelihood function, which is globally concave (Hausman and McFadden 1984). Each farmer faces a set of discrete, mutually exclusive choices of adaptation measures. These measures are assumed to depend on a number of climate attributes, social, economic, institutional characteristics and other factors . Let be a random variable representing the adaptation measure chosen by small-scale farmer. The MNL model for adaptation choice specifies the following relationship between the probability of choosing option and the set of explanatory variables as (Greene 2003):

$$P\ r\ o\ b\ (n_i = j) = \frac{e^{\beta'_j x_i}}{\lessapprox_{k=0}^{j} e^{\beta'_k x_i}}, \qquad j = 0,1 \ldots j \quad \ldots\ldots\ldots\ldots\ldots\ldots(i)$$

Where is a vector of coefficients on each of the independent variables. Equation (i) can be normalized to remove indeterminacy in the model by assuming that and the probabilities can be estimated as:

$$Prob\ (n_i = j|x_i) = \frac{e^{\beta'_j x_i}}{1 + \sum_{k=0}^{j} e^{\beta'_k x_i}}, \qquad j = 0,2 \ldots j, \beta_i = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(ii)$$

Estimating equation (ii) yields the J log-odds ratios

$$l\,n(\frac{p_{i\,j}}{p_{i\,k}}) = x_i^{!}(\beta_j - \beta_k) = x_i^{!}\beta_{j,i\,f\,k=0} \qquad (iii)$$

The dependent variable is therefore the log of one alternative relative to the base alternative. The MNL coefficients are difficult to interpret, and associating with the outcome is tempting and misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived as (Greene, 2003):

$$\delta_j = \frac{\delta\ P_j}{\delta\ x_i} = P_j\left[\beta_j - \sum_{k=0}^{J} P_{k\beta_k}\right] = P_j\,(\beta_j - \bar{\beta}\ ) \qquad (iv)$$

The marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable (Long, 1997; Greene, 2003). The signs of the marginal effects and respective coefficients may be different, as the former depend on the sign and magnitude of all other coefficients.

Data

Data collection was through a survey of households from 13 divisions within 7 different districts of Kenya spanning the arid, semi-arid, temperate and humid agro-ecological zones (AEZ). Study sites were drawn from the following districts: Garissa, Gem, Mbeere South, Mukurweini, Njoro, Othaya and Siaya. Such districts have been aggregated according with the agro ecological zone they belong to: Arid (Garissa), semi-arid (Mbeere South and Njoro), temperate (Mukurweini and Othaya) and Humid (Gem and Siaya). The study sites were selected to represent the various agro-ecological zones that will be affected by climate change in Kenya and where people are most vulnerable to such impacts, with the exception of the coastal zones (Herrero et al. 2010). A total of 707 households were used in this analysis. The respondents were distributed based on agro-ecological zones as follows: Arid zone (132), Semi-arid (202), temperate (182) and Humid zone (191). Data was collected through personal interviews using pre-designed questionnaires.

The capture the adaptation strategies, farmers were asked to state their adjustment in farming systems. The strategies mentioned were more than thirsty and difficult to analyze the factors which after decision to choose given strategy. Therefore the choices were grouped into 8 groups because some of the strategies were related. This groups included (i) crop management (change planting dates, increase/reduce land under production, change crop types) (ii) land and water management (implement soil and water management techniques, water harvesting, irrigation, construction of ditches) (iii) technologies adoption (change crop variety, change animal breeds, fertilizer application (iv) Financial (insurance, off-farm jobs), (v) Diversification of enterprises (mixed crop and livestock, change crop to livestock and vise verse, change crop and animal consumption) (vi) livestock management (change livestock feeds, supplement feeds, change animal species etc) (vii) migration (move animals, migrate to other piece of land) (vii) Tree planting (agro-forestry).

Results and discussion

Does group membership increase access to information on climate change and adaptation strategies?

The study finds that almost 80% of crop and livestock farmers in arid agro-ecological zone are not adapting to climate change. Others are as follows; humid 30%; semi-arid 15% and temperate 10%. The mostly adapted strategies include technologies adoption and crop management. The type of adaptation measures implemented is strongly related with the agro ecological zones the farmers belong to. In arid zone pastoralists mostly adapt livestock management and diversion farming practices. Changes in livestock ownership and the way in which livestock are managed are essential for adapting to long term changes in climate (Deressa et al. 2008). In arid areas, the number of farmers that do not adapt to climate change shocks is significantly higher than in semi-arid, temperate and humid sites. The main reason of low rate of adaptation is households in the arid zones are already dealing with more difficult climate conditions such as drought, therefore less likely to respond to climate shocks. They also have low assets endowments and poverty levels are high with poor infrastructure. The migration strategy is also witnessed and only in this agro-ecological zone.

In semi-arid and temperate agro-ecological zones, farmers are mostly adapting technologies such as fertilizer use and new variety of crops or new breeds of animals. Crop management is also a key strategy in this zone followed by livestock management and water and land management. Farmers are also diversifying their activities beyond their farm, for instance looking for non-farm employment. In humid zone we noted low adaptation of technologies. However, crop or farm management was prominent strategy. Tree planting was a major strategy except in arid areas.

The mostly of the adapted strategy include technologies adoption and crop management followed by livestock management, planting trees and land and water management. Bellow et al. 2010 shows that farm management and technologies (53%) are prominent adaptation strategies. However, adoption of technologies is hindered by many factors. Siebert et al. (2006) show that farmer willingness and ability to accept new practices influence adoption. Kato et al. (2009) suggest that farmers' desire to minimize production risks strongly influences their adoption of new technologies. Thomas et al. (2007) found that during dry spells farmers tended to reduce their investment in crops or even stop planting and focus instead on livestock management.

Table 1: Drivers of climate change adaptation, econometric results

Parameters	Crop management		Land and water management		Technology adoption		Livestock management		Planting trees	
	Coeff	P-value	Coeff	P-value	Coeff	P-value	Coeff	P-value	Coeff	P-value
Land size	0.01	0.800	0.03	0.005	0.01	0.129	0.00	0.841	0.02	0.052
Perception on CC	0.93	0.049	1.300	0.000	1.51	0.015	0.32	0.632	0.82	0.438
Market centre	-0.02	0.358	-0.51	0.028	0.01	0.688	-0.04	0.219	-0.04	0.269
Farming experience	0.02	0.117	0.02	0.283	0.01	0.265	0.02	0.302	0.03	0.054
Household size	-0.01	0.883	-0.24	0.042	-0.11	0.019	-0.13	0.107	-0.02	0.814
Gender of HH head	0.19	0.516	-0.74	0.289	-0.13	0.671	0.82	0.161	0.33	0.563
Access to ICTs	0.18	0.222	1.27	0.016	0.88	0.000	0.05	0.803	0.10	0.739
Physical capital	0.58	0.002	0.74	0.235	0.35	0.027	-0.33	0.098	0.36	0.205
Human Capital	0.02	0.864	1.13	0.000	0.58	0.000	0.08	0.754	0.46	0.038
Financial capital	0.43	0.003	-0.07	0.813	0.16	0.237	0.64	0.007	0.12	0.569
Social capital	0.27	0.324	0.06	0.924	0.51	0.068	0.39	0.388	-0.46	0.322
Constant	-1.20	0.074	-13.9	0.000	-1.50	0.072	-1.99	0.027	-3.08	0.018

**base category, no adaptation*

Table 1 presents the estimated coefficient and P-levels from the multinomial logit model. The chi-square results show that likelihood ratio statistics are highly significant (P<0001) suggesting the model has a strong explanatory power. The results indicated that most of the explanatory variables described above affected the probability of adaptation to climate change, except the gender of the household. Variables that enhance adaptation to climate change included: household assets (human, social, physical and financial), distance from the market centre, and access to information on climate change, farming experience, access to ICTs, land size and perception to climate change.

This analysis uses no adaptation or adjustment as the base category and evaluates the other choices as alternatives to this option. For instance, it compares the choice of crop management to no adaptation where the coefficient and their signs reflect the expected change in probability of preferring manage crop such as change crop type, reduce or increase land under crop production to no adjustment per change in an explanatory variable. The same applies to the remaining choices in the table. The results suggest that perception to climate change, household assets (financial and physical) and household size influence adaptation of crop management strategies. The adaption of land and water management measures is influenced by land size, perception to climate change, market centre, household size, access to ICTs and human capital.

Adoption of technologies such as new variety of crop, new breed of livestock is influenced by social capital. Through cooperation and exchange, farmers increase their social capital, access information, and learn about new technologies/strategies for increasing productivity under climate change (Ngigi et al. 2012). This corroborate with previous studies that found that social capital influence farmers' choices of adaptation and climate change perception in Ethiopia (Deressa et al. 2008). Farmers in social association may adapt more technologies than farmers who are not affiliated to social groups. Ownership to ICTs devices such as cell-phones, radios also influenced adoption of technologies. Physical and human capital influences adoption of technologies. New technologies are essential for climate change adaptation.

Livestock management is also important in CC adaption. This may include changing livestock feed, seeking veterinary advice, supplementing feeds among others. Livestock management is mainly influenced by financial capital. Financially well-being also allows household to change or supplement livestock and to move animals to an alternative site to reduce the risk of animal loss during climate shocks (Silvestri et al. 2012). Despite the limitations of climate information, providing weather and seasonal forecasts and early warnings does promote household adaptation to climate change. When farmers are aware of possible change in weather conditions, they are more likely to respond by moving animals to a different site and reducing the size of their herd. Adaptation involves making decisions under a great deal of uncertainty. Even with the best information from meteorological data, climate forecasts or local observations, households are still faced with a considerable degree of uncertainty (Crane et al. 2011; Roncoli et al. 2010).

Land size, farming experience and human capital influence adoption of agro-forestry or tree planting which is mitigation strategy. Tree planting is one way of climate change adaptation and recommended in climate SMART adaptation or agriculture. The more experienced in farming the farmer is, the more likely to adapt than the less experienced. These results suggest that it is experience rather than age that matters for adapting to climate change (age and farming experience was highly correlated, age was dropped).These results suggest that assets (capital), ownership of ICTs devices, perception to climate change serve as important factors for coping with and adapting to climate change. The choice of the suitable adaptation measure depends on factor or asset endowments (i.e. family size, land area and capital (social, financial, physical and human resources) at the disposal of farming households.

Conclusion and policy implication

Kenya's National Climate Change Response Strategy elaborates the need for adaptation to reduce vulnerability to climate change, including in priority sectors such as agriculture. Building institutional and human capacity to respond to climate change (including demand-driven knowledge management and mobilization) is paramount. Local organizations contribute to capacity building and information dissemination, which is vital for farmers' adaptation to climate change. For instance, rural groups increase the probability that members will receive information on climate change and adaptation strategies, such as new plant varieties and water harvesting options. Membership in groups also increases the likelihood that members will have access to agricultural inputs, technical advice, output markets, and risk management mechanisms, which also help farmers adapt to climate change. Therefore, local groups may increase individual, household, or community resilience to climate change. However, local collective action is less effective in response to shocks that affect many people in a community; for severe and widespread shocks, national or even international assistance is needed

This study finds that farmers are adapting to climate change and the main strategies includes technologies adoption, crop management, land and water management, livestock management and planting trees. A multinomial discrete choice model was used to analyze the determinants of farm-level adaptation measures. The main factors affecting adaptation is capital or assets endowment. The choice of the suitable adaptation measure depends on factor or asset endowments (i.e. family size, land area and capital (social, financial, physical and human resources) at the disposal of the farming households. Social capital is key driver in adopting new technologies which are crucial in adapting to climate change. This suggests that social groups can be used to help farmers share knowledge and technologies and in turn adapt to climate change. Human capital such as education, training in crop and livestock production and access to extension services also affect adaption. This suggests that education to improve their awareness of the potential benefits from adaptation is an important policy measure for stimulating farm-level climate adaptation. Financial capital such as income, food aid, access to formal or informal credit influenced adaptation. Ownership of ICTs devices which are important in dissemination of climate change or agricultural production information also influenced adaption. The results of the empirical analyses confirmed the role of improved access to information (climate and production) which is crucial for adaptation decision making and planning.

More farming experience was found to promote adaptation especially in tree planting. Experienced farmers usually have better knowledge and information on climate change and agronomic practices that they can use to cope with changes in climate and other socioeconomic conditions. Combining access to extension and credit ensures that farmers have the information for decision making and the means to take up adaptation measures. Policies aimed at promoting farm-level adaptation need to emphasize the critical role of providing information (through extension services and use of ICTs or social groups) and the means to implement adaptations through affordable credit facilities. This study suggests that group participation can contribute to "buffer capacity" (the ability to deal with risks, shocks, and uncertainty) and by extension enhance environmental, economic, and social resilience. Access to climate change information, adaptive responses through local groups may be a powerful tool for increasing farmers' adaptive capacities and resilience. Given the importance of local groups for information dissemination and capacity building, which are essentials for climate change adaptation and mitigation, efforts to support the development and work of local groups need to be mainstreamed into Kenya's climate change policies.

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