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Farmers' awareness and perception of climate change and the various adaptation measures they employ in the semi-arid eastern Kenya

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ABSTRACT

A study was conducted to assess farmers' awareness of climate change and to investigate the various adaptation measures they employ to counter adverse effects of climate change in four selected sub-counties in the semi-arid eastern. The study utilised data collected through face to face interviews of 200 households using a structured questionnaire. The data collected was analysed through descriptive statistics using the Statistical Package for Social Sciences (SPSS) version 20.0. The study showed that drought is the key climate-related shock with 100% of households reporting that they had experienced drought. Erratic rainfall was ranked second in importance, with 99.5% of households experiencing this climate shock. The main effects of climate-related stresses were a reduction in crop yield (96 %) and death of livestock (91 %). Other effects included crop failure (89 %), increases in food price (88%) and loss of income (86 %). Purchasing food was the main coping strategy while the most common adaptation strategies were

growing of drought-escaping crops and water harvesting. The ability of the community to adapt to changing climate is constrained mainly by lack of resources, lack of access to inputs and to some extent lack of information on climate change and appropriate adaptation strategies. Therefore, making inputs and credit facilities more accessible and provision of climate information to communities are some of the desired interventions that can enhance adaptation to climate change in the region.

Keywords: Adaptation, climate change, climate shocks, coping strategies, vulnerability

1. INTRODUCTION

The need to address poverty reduction and climate change can be considered two of the major challenges facing human societies in the 21st Century. The assessments of climate change impacts, adaptation and vulnerability are undertaken to inform decision making in an environment of uncertainty and offers a framework for policy measures that focus on social aspects. While climate change is broadly understood as an increase in global mean temperature leading to changes in regional climate patterns, it appears locally as, *inter alia*, hotter days, more intense storms, less rainfall, or changes in the onset and length of growing seasons (Lobell, 2011). These climatic changes in turn affect local livelihood activities, economic enterprises, health risks, and so on (Beddington *et al.,* 2012). Persistent and widespread drought is a recurrent feature in the semi-arid areas of Kenya and this causes severe hardship, poverty, hunger and even famine to communities living in the region. Although risk and uncertainty dominate the lives of most rural inhabitants in the region, many farmers have been able to develop sustainable farming systems through the use of innovative soil and water management systems and the use of locally adapted crop species and varieties. A logical starting point in the development of new pro-poor agricultural development approaches are the very systems that traditional farmers have developed and/or inherited through generations in areas of limited rainfall. Such complex farming systems, adapted to the local conditions, have helped small farmers to sustainably manage harsh environments and to meet their subsistence needs.

Various reports indicate that when communities adopt appropriate measures, they are better able to adjust to climate change effects and cope with adverse consequences (Rao *et al*., 2011; Speranza *et al.,* 2008; IPCC Report; Edris Alam et al. 2017). Adaptation measures are those strategies that enable the individual or the community to cope with or adjust to the impacts of the climate stresses in the local areas (Nyong *et al.,* 2007; Emmanuel Mavhura et al. 2017). Such strategies include the adoption of efficient environmental resources management practices such as the planting of early maturing crops and selective keeping of livestock in areas where rainfall is inadequate. Climate change creates both risks and opportunities and by understanding, planning for and adapting to a changing climate, individuals and societies can take advantage of opportunities and reduce risks. A better understanding on how local populations have coped with previous droughts has the potential of providing an important guide for addressing current and future climatic events. The objective of this study was therefore to assess farmers' awareness of climate change and to investigate the various adaptation measures they employ to counter adverse effects of climate change in four selected divisions in the semi-arid eastern.

2. MATERIALS AND METHODS

Description of the study area

The study was conducted in four purposively selected sub-counties of Katangi, Ikombe, Ndalani and Yatta in Machakos County where season-to-season variability in rainfall dictates productivity and profitability on smallholder farms (Figure 1). Machakos County stretches from latitudes 0º45´S to 1º31´S from north to south and from longitudes 36º45´E and 37º45´E from east to west. The study sites were selected to represent the various settings throughout the semi-arid region of eastern Kenya in which climate change and variability are having or are expected to have substantial impacts and where people are most vulnerable to such impacts. All sites exhibit low and variable rainfall with a bimodal rainfall pattern, with rains occurring from March to May, and from October to December and experience regular drought-related harvest failures. Mixed crop-livestock production systems are the main enterprises with the major crops being maize, mung beans, pigeon peas and sorghum. Indigenous chickens, small East African goats and zebu cattle are the main livestock species reared. The predominant soils are the Luvisols, Acrisols and Ferralsols derived from the pre-Cambrian 'basement-complex' rocks consisting of mainly granites, gneisses and sometimes sandstones or phyllitic shales and are inherently deficient in N and P and have low organic matter.

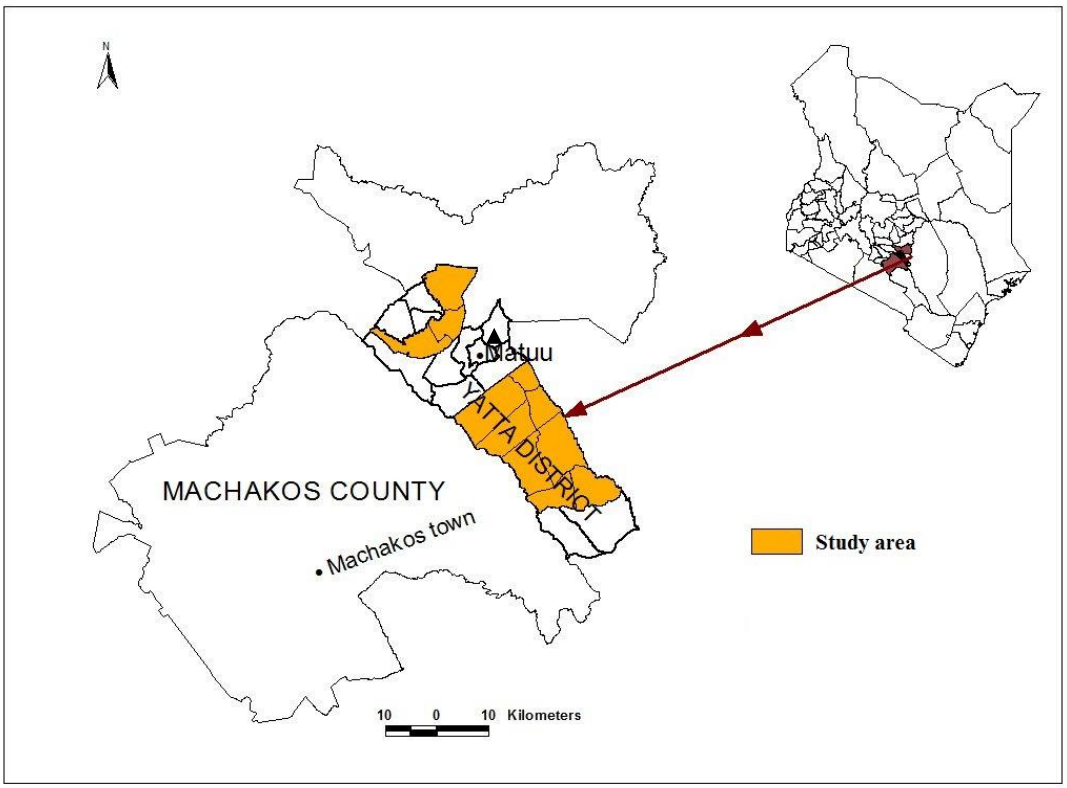

Figure 1 Location of study area

Household interviews

The assessment of the vulnerability and adaptation to climate change and impact on the farming community in the four study areas was assessed using field surveys conducted on individual household interviews using a structured questionnaire. A systematic random sampling was carried out until the desired sample size was achieved and a face-to-face single visit interview, discussion and observations were used to collect the required information. A total of 200 questionnaires were administered in the four locations. Differences in vulnerability and adaptation for different households were assessed based on factors such as sources and diversity of household members' livelihoods, ownership and access to resources, age, gender and level of education. In assessing the capacity to respond, we considered the consequences of short-term seasonal drought at the household level, as this provides direct, experiential evidence. We investigated, in particular, the opportunities and constraints that shape patterns of coping and policy implications that might facilitate adaptation.

DATA ANALYSIS

Survey data

The data collected was analysed through descriptive statistics using the Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive results of the household survey related to climate change perceptions, coping strategies and adaptation options is presented. Determination of factors influencing farmers' decision to undertake long term measures on crop and livestock production to deal with climate change was carried out using binary logistic regression model. The logistic model was selected for this study because the dependent variable was dichotomous and the model is computationally easier. The model is specified as:

$$\mathbf{Ln\ (P_i/\ (1\text{-}P_i))\ = X_t b + e_I}$$

Where X_t is the index reflecting the combined effect of independent X variables that prevent or promote adoption of adaptation strategies in response to climate change. The index level was specified as:

$$\boldsymbol{X_t = \beta_0 + \beta_1 X_1 + \ldots + \beta_{12} X_{12} + e_I}$$

Where:
X_1 = Hhold_sex (Sex of household head; 1=Male, 2=Female)
X_2 = Hhold_age (Age of household head in years)
X_3 = Hhold_educ (Education level of household; 1=none, 2=Primary, 3=Secondary, 4=Post-secondary)
X_4 = Hhold_occupation (Major occupation of household head; 1=Farming, 2=Non-agricultural casual labour, 3=Formal employment, 4=Agricultural casual labour, 5=Self-employment)
X_5 = Farm_size (Farm size in hectares)
X_6 = Climate_info (Access to climate information; 1=Yes, 0 otherwise)
X_7 = ITK_forecast (Indigenous technical knowledge on weather forecasting; 1=Yes, 0 otherwise)
β_0 = Intercept;
β_i = Coefficient on the independent variables and
e = error term following a normal distribution.

The dependent variable is the natural logarithm of the probability of adopting adaptation strategies (*P*), divided by the probability of not adopting (1-*P*). The model was estimated using the maximum likelihood method of the Statistical Package for the Social Sciences (SPSS) version 20.0.

3. RESULTS AND DISCUSSION

Characteristics of the respondents

Previous research has identified social characteristics such as gender, age, wealth status and education that are associated with vulnerability and has distinguished between vulnerable groups in society (Eriksen *et al*., 2005). Independently or combined, these determinants shape the way in which people are able to reduce exposure to, cope with, and/or recover from negative impacts of climate change or, alternatively, take advantage of the opportunities afforded by climate change. Table 1 shows the characteristics of the households in the study area. The main occupation of households heads was farming (73%) with 93% of them having formal education. The age of household heads varied from 28 to 80 years with a mean of 51 years. Farm sizes varied from 0.8 to 52.2 hectares with a mean of 4 hectares while the mean area under crops was 2 hectares.

Table 1 Socio-demographic characteristics of the household heads

Characteristic	% of households
Gender	
Male	79.8
Female	20.2
Education level of household head	
None	7.1
Primary	48.5
Secondary	33.7
Post-secondary	10.7
Main occupation of household head	
Farming	73.1
Formal employment	11.2
Self-employment/business	15.7
Characteristic	*Mean*
Age (years)	51.3 (9.8)
Farm size (acres)	10.4 (11.1)
Area under crops (acres)	5.8 (4.1)
Area under pastures (acres)	3.9 (2.7)

Number in parenthesis is the standard deviation

Seasonal farming patterns and constraints

Major crops grown in the study area included maize, cowpeas, beans, pigeon peas green grams and sorghum grown under rain-fed conditions. Crops grown under irrigation include French beans, kales, tomatoes and onions. The main factors determining the types of crops grown were season (99%), availability of inputs (82%), food needs (75%) and water availability (71%). Eighty five percent of farmers practised intercropping in both seasons. Major constraints to crop production were unreliable rainfall (93.5%), pests and diseases (65.8%), poor soil fertility (61.6%) and seed availability (53%). Earlier studies by Speranza *et al* (2008) in the neighbouring Makueni County gave unreliability of rainfall as a major constraint to crop production (56% of interviewed households (N=127)), as were poor soils (32%), destruction of crops by pests and diseases (22%) and unavailability of planting seeds (18%). Livestock types kept in the study area include cattle (80% local breeds), shoats (88% local breed) and poultry (97% local breed). The main factors determining the type of livestock kept were feed availability (94%), water availability (84%), food needs (77%), and disease incidences (74%). However, 89% of households reported that cattle was the major livestock in terms of contribution to household food and financial security. Main contraints to livestock production were lack of feed (75%), unavailability of high-yielding breeds (69%), and lack of water during dry spells (58%).

Type, impact and outcomes of climate shocks experienced by households

There is increasing demand for vulnerability assessments in order to identify the susceptibility of populations to food insecurity, for example, as a basis for Famine Early Warning Systems. Undertaking empirical studies of present-day vulnerability can also play an important role in improving our understanding of the impact of long-term climate change and of measures to facilitate adaptation. Reducing vulnerability is an effective precautionary step towards adaptation (Kelly 2000). Vulnerability assessment offers a framework for policy measures that focus on social aspects including poverty reduction, diversification of livelihoods and strengthening of collective action. Such measures enhance the ability to respond to stressors and secure livelihoods under present conditions, which can also reduce vulnerability for future climate change.

The study showed that drought was the key climate-related shock with 100% of households reporting that they had experienced drought. The significance of drought as a climate related shock in the semi-arid areas is also evidenced in Makueni County where it was perceived as the major cause of famine by 41% of the respondents while 73% mentioned it as a cause of famine (Speranza *et al.,* 2008). Kenya is reported to experience major droughts every decade and minor ones every three to four years (Herrero *et al.,* 2010). In addition, temperature increases due to climate change are anticipated to have a significant impact on water availability, thus exacerbating drought conditions. Erratic rainfall ranked second in importance, with 99.5% of households experiencing this climate shock (Figure 2). Floods affected a small percentage (5%) of households in the study area. The main effects of climate-related shock were a reduction in crop yield (96%) and death of livestock (91%) as illustrated in Figure 2. Other effects reported by farmers included crop failure (89%), food price increases (88%) and loss of income (86%).

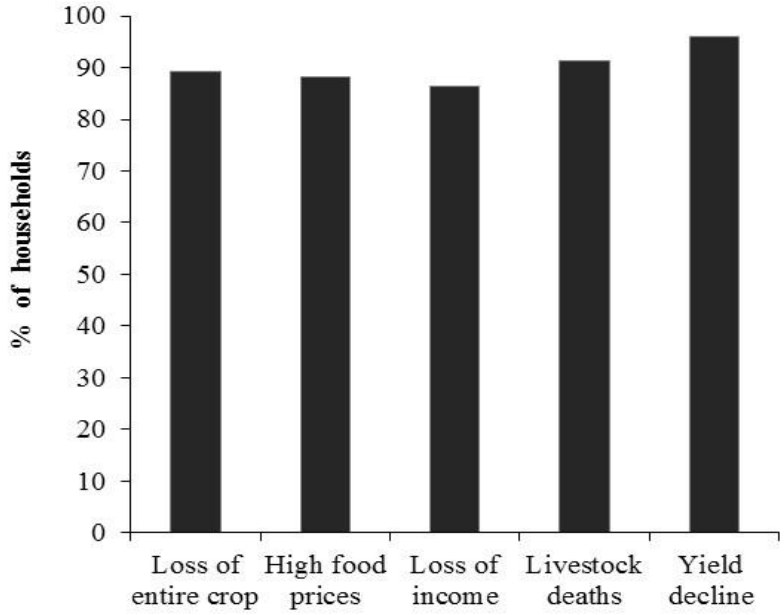

Figure 2 Effects of climate-related shocks on farm enterprices

Potential impacts on world food supply have been estimated for several climate change and socio-economic scenarios. Some regions may enjoy improved agricultural production, whereas others will suffer yield losses (IPCC Report 2008; World Bank 2011), and so a reorganisation of agricultural production areas may be required. In any given region, crops are expected to be affected differently, leading to the need for adaptation in related support industries and markets, farm-level strategies and rural development schemes. Households reported increased sales of livestock, especially cattle and goats, so as to purchase food. This results in depletion of household resources, thereby increasing their vulnerability. This is in agreement with the IPCC analysis of climate change impacts that indicated a general reduction of potential crop yields and a decrease in water availability for agriculture and populations in many parts of Africa (IPCC Report 2008; IPCC Report, 2011; World Bank 2011). Individuals particularly vulnerable to environmental change are those with relatively high exposure to changes, high sensitivity to changes, low coping and adaptive capacities, and low resilience and recovery potential. Often, poor communities as those found in the area of study are dependent on low input agricultural activities that are sensitive to the climate changes and therefore would be more vulnerable to environmental change. In addition, women and girls are typically the ones to care for the home and fetch water, fodder, firewood, and often food. During times of climate stress, they must cope with fewer resources and a greater workload.

Adaptation and copping strategies

Adaptation measures are those strategies that enable the individual or the community to cope with or adjust to the impacts of the climate in the local areas (Nyong *et al.,* 2007; IPCC Report, 2011; Levine et al., 2012). Adaptation has the potential to reduce the negative impacts of climate change. However, the ability to adapt is particularly related to socioeconomic factors such as wealth status, income sources, social capital, land tenure, input use and cost, food consumption patterns and expenditure, access to information and technology, market, and credit. By understanding, planning for and adapting to a changing climate, individuals and communities can take advantage of opportunities and reduce risks (USAID, 2007; Levine et al., 2012). Some suggested adaptation practices include choice of disease-/drought-resistant crops and their arrangement in sequential cropping systems (Bello *et al.*, 2013; Waha *et al.*, 2013), diversity in cropping activities (Muller *et al.*, 2013), improved farm management practices such as use of high levels of nutrients, increased area under irrigation, and high-yielding cultivars (Calzadilla *et al.*, 2013), and livelihood diversification (Bryan *et al.*, 2013). Since adaptive capacity is dependent on individual resource endowment (Turner and Rao, 2013), rights of land tenure and technological changes (Yegbemey *et al.*, 2013), low-income farmers are more vulnerable to the impacts of climate change. Thus the complexity and heterogeneity in socio-economic and climatic conditions require adaptation options that consider multiple factors, impacts, vulnerabilities, and potentials. Identifying which areas and populations are at greatest risk from climate change can help in setting priorities for adaptation.

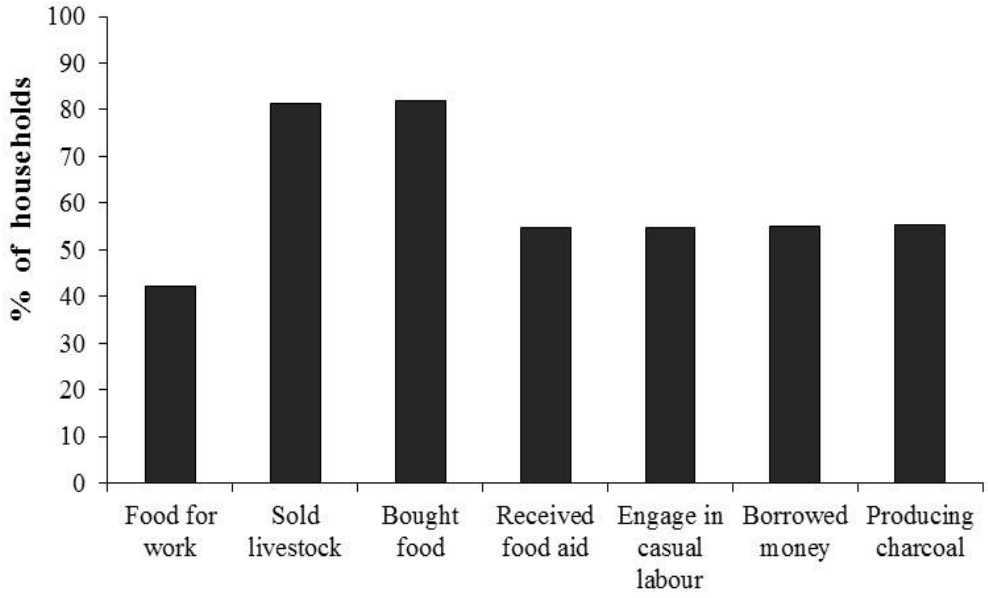

Figure 3 Coping strategies employed by households in response to climate change

The fact that the communities living in the area covered by this study had survived droughts for many years is an indication that they had developed indigenous mechanisms and strategies to cope with these droughts. The households interviewed had developed various coping strategies that had enabled them to reduce their vulnerability to past climate variability and change. Figure 3 illustrates the coping strategies used to deal with climate shocks. Given that the main result of the climate shocks was a decline in crop yield and in some cases a loss of the entire crop, it was not surprising that the main coping strategy involved the purchase of additional food, reducing consumption, or consuming different foods. Purchasing food was particularly important; 82% of households reported purchasing food in failed seasons (Figure 3). This suggests that access to affordable food sources is important for households in this region. However, as mentioned above, food shortages and price increases are other common effects of climate shocks heightening the situation of food insecurity. This indicates that households affected by the climate shocks may face difficulties meeting their consumption needs. Given that in order to buy food households must afford it somehow, we looked into what other coping strategies these households employed. Among those households that reported buying food as a coping strategy, 86% sold livestock, 6% borrowed from relatives, 61% sought off-farm employment, 62% received aid, and 61% were engaged in producing charcoal (Figure 3).

Households consider livestock an important asset that can be turned into money in response to adverse climate shocks. Access to assets is closely related to adaptation options available to food-insecure people (Rocheleau *et al.,* 1995; Brown, 2011). With respect to crop production, surveyed households took a range of adaptation strategies (long-term measures in response to perceived climate change (Figure 4a). The most common responses were growing of drought-escaping crops (87%), water harvesting (67%), changing crop variety (63%) and improvement of soil fertility (52%). Other responses included changing crop type (48%), soil conservation practices (43%) and changing planting dates (39%). On livestock production, farmers also undertook several adaptation strategies (Figure 4b). The most common strategies included decreasing the number of livestock kept (52%), mixing of crop and livestock production (38%) and changing of animal breeds (27%). Other strategies included diversifying livestock feeds (22%) and supplementing livestock feeds (22%) as illustrated in Figure 4b.

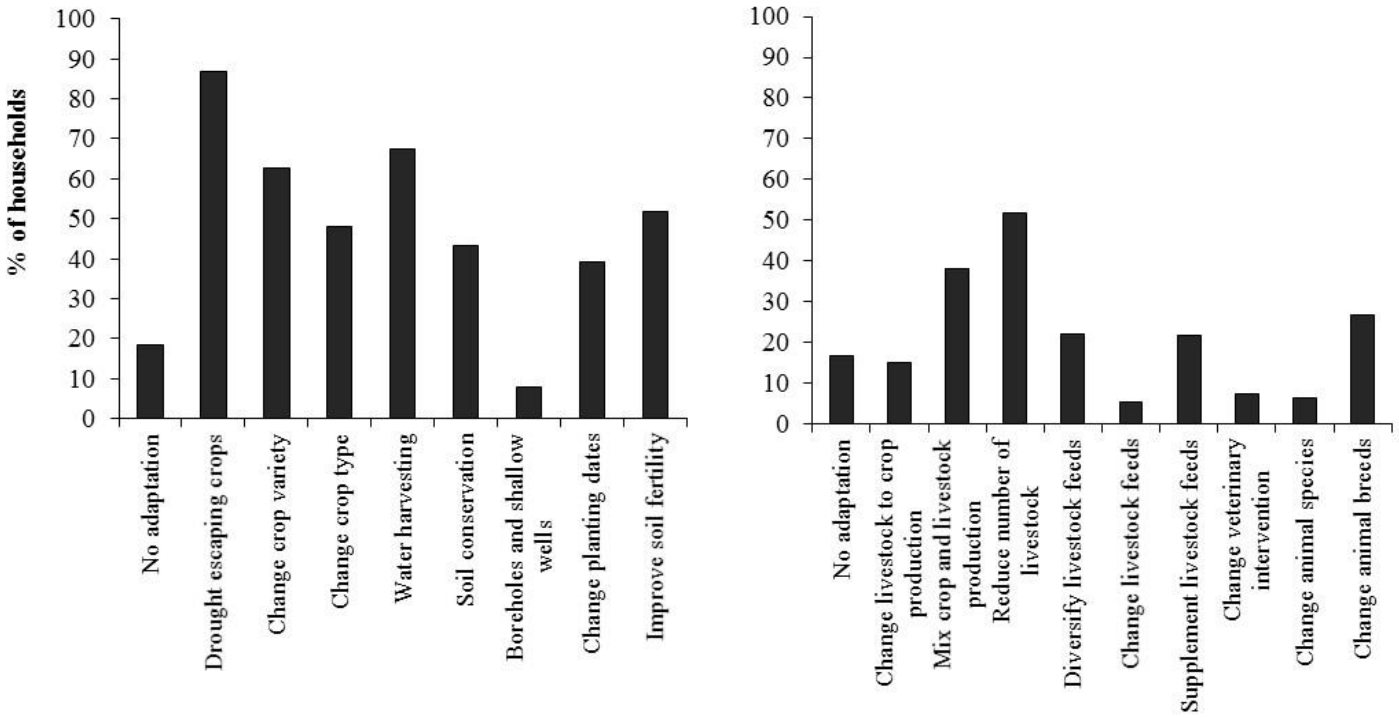

Figure 4 Adaptation strategies employed by households in a) crop production b) livestock production

The percentage of farmers that did not adapt any strategies on crop production was 19 while the percentage that did not adapt any strategies on livestock production was 17. This compares well with a similar study conducted in seven other areas of Kenya where 19% of farmers did not take any adaptive strategies (Bryan *et al.*, 2011; Cooper *et al.,* 2008). Farmers were also asked what measures they would like to implement to adapt to changing climate variables such as variable rainfall pattern and amount, longer

droughts and hot temperatures. The most common responses were water harvesting (35%) through building of water pans and dams, and digging of shallow wells, planting fruit trees (30%) and construction of soil and water conservation structures (5%). This is supported by the fact that enhanced resilience to future periods of drought stress may be supported by improvements in existing rain-fed farming systems such as water-harvesting systems and supplementary irrigation practices in semi-arid farming systems (Rockström, 2003). As climate change increases the potential for climate related risk, it is also important that risk management and risk reduction is incorporated into adaptation planning at all levels. We argue that coping is a distinct component of vulnerability and that understanding the dynamism of coping and vulnerability is critical to developing adaptation measures that support people as active agents.

Further analysis indicated that the logistic model explained 65% of the total variation in the adoption of adaptation strategies on livestock production in response to climate change (Table 2). The chi-square statistic showed that the parameters included in the model were significantly different from zero at the 1% level for adoption of adaptation strategies. The maximum likelihood estimates of logistic regression are also shown in the table. Farmer's age, major occupation, farm size, access to climate information and indigenous technical knowledge on weather forecast significantly influenced the adaptation strategies on livestock production in response to climate change. The odds in favour of adaptation strategies increased by a factor of 1.04 for older farmers, possibly because older farmers have long experience on climate change in the area. Major occupation significantly and negatively influenced the likelihood of adopting long term strategies by a factor of 0.46 at the 10% level. Farmers whose major occupation is farming would possibly not feel the effect of climate change and would probably not adopt adaptation strategies on livestock production. Farm size significantly and negatively influenced the likelihood of adopting adaptation strategies by a factor of 0.96 at the 10% level for farmers with large farms (Table 2), possibly because these farms provide enough feed for livestock. Access to climate information significantly and positively influenced the likelihood of adopting adaptation strategies by a factor of 3.87 at the 5% level.

Table 2 Parameter estimates for factors influencing farmers' adoption of adaptation strategies on livestock production in response to climate change

Explanatory variable	B	Wald	Exp (B)
Household sex (1)	-0.110	0.072	0.896
Hhold age	0.041**	4.857	1.042
Hhold education		1.203	
Hhold education (1)	0.129	0.040	1.138
Hhold_education (2)	-0.249	0.129	0.780
Hhold_education (3)	0.170	0.038	1.185
Hhold_occupation		3.765	
Hhold_occupation (1)	-0.787*	2.892	0.455
Hhold_occupation (2)	0.075	0.012	1.078
Farm_size	-0.043*	3.182	0.958
Climate_information	1.353**	4.421	3.870
ITK_forecast	-0.945***	6.679	0.389
Intercept	-1.534	1.280	.
Model χ^2	24.57***		
Overall cases correctly predicted	64.9%		
Sample size	200		

Note: H = Household * = significant at p<0.1; ** = significant at p<0.05; *** = significant at p<0.01

Access to climate information

The main type of climate information that farmers reported having access to were daily weather forecasts, advisories and alerts/early warning. Daily weather forecasts were accessed through radio (97%), while advisories and alerts were accessed through *barazas* (gatherings convened by local administrators) (56%). Though not reliable as reported by 65% of farmers, daily weather forecasts were the most easily accessible and timely climate information. Alerts/early warning was more relevant as reported by 72% of farmers and was easily accessible. Seventy two percent of farmers indicated that they had indigenous knowledge and skills (ITS) on weather forecasting and could predict a wet and a dry season based on the behaviour of animals and plants. Indigenous knowledge

on weather forecasting was reported by 81% of farmers to be helpful in farming decision making especialy on the types of crops to be planted.

Contraints to adaptation of superior technologies

Droughts could have numerous socio-economic impacts, which may include reduced farm labour because some households engage in alternative means of livelihood such as working as farm labourers elsewhere and as casual employees in urban centres. Additional labour would also be required because animals have to be moved to distant locations for grazing. Surveyed households reported a range of constraints that hinder implementation of adaptation strategies to climate change (Figure 5). Many households had limited access to the favoured adaptation options due to a lack of skills, labour and/or capital. The households instead carried out a multitude of less favoured and frequently complementary activities. Even a relatively modest (in terms of cost) adaptation strategy faces obstacles, including lack of money/credit, lack of access to inputs, and lack of information (Figure 5). The most common responses included lack of resources (88%), inadequate water supply (75%), lack of access to inputs (71%) and lack of information on climate change and appropriate adaptation (62%). Other responses included lack of access to credit (50%), declining land sizes (43%) and shortage of labour (40%).

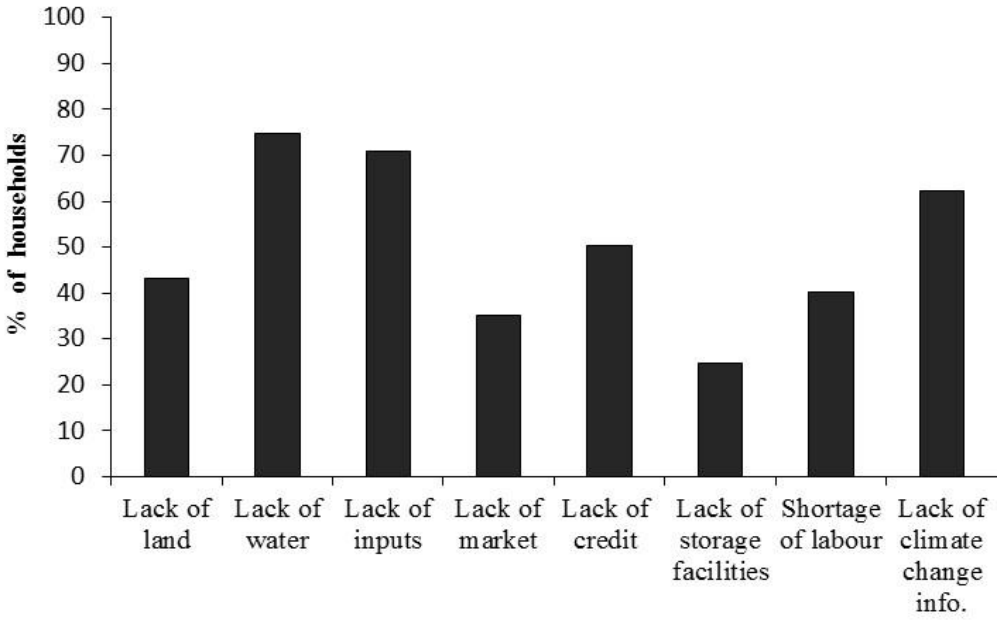

Figure 5 Constraints to adaptation of superior technologies

Households with access to means of financing credit or off-farm sources of income are more likely to adapt to changing climatic patterns. In particular, access to credit would support the adoption of new livestock practices (changing feeds) and off-farm sources of income would enable farmers to plant fruit trees, construct soil and water conservation structures, change crop variety, change planting dates, and change livestock feeds (Bryan *et al*., 2011; Bahadur, *et al.,* 2013; Sattler and Nagel, 2010). Surveyed households proposed a number of government incentives/policies that they thought would enhance appropriate adaptation to climate change. The most common desired adaptation strategies proposed included development of water systems for irrigation (92%), making inputs more accessible (89%), provision of climate information and capacity building on appropriate adaptation strategies (89%) and provision of credit (80%).

Given the difficulties of averting global warming, adaptation to climate change is essential to counter the expected impacts of long-term climate change (IPCC Report, 2011; Lipper *et al*., 2010; Wilby and Dessai 2010). An effective way to address the impacts is by integrating adaptation measures into sustainable development strategies so as to reduce the pressure on natural resources, improve environmental risk management, and increase the social well-being of the poor. Critical interventions includes; improved forecasting for farming, extreme events and disaster management; disseminating climate information to farmers; developing policies that make credit and inputs more accessible among others to encourage both short- and long-term adaptations. In addition, capacity-building to integrate climate change into development plans and involving local communities in adaptation activities is important.

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