Adapting Agriculture to Climate Change in Kenya: Household and Community Strategies and Determinants

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Abbreviations

AEZ	Agroecological Zone
ARLMP	Arid Lands Management Project
GHG	Greenhouse Gas
NGO	Nongovernmental Organization
PRA	Participatory Rural Appraisal
SWC	Soil and Water Conservation
VCS	Voluntary Carbon Standard

1. Introduction

Climate change is expected to adversely affect agricultural production in Africa. A range of climate models suggest median temperature increases between 3°C and 4°C in Africa by the end of the 21st Century, roughly 1.5 times the global mean response. In East Africa, there are very few places where rainfall means are likely to decrease, however, increases in rainfall are not likely to lead to increases in agricultural productivity as a result of the poor spacing and timing of precipitation. Because of this, coupled with an expected increase in evapotranspiration due to higher temperatures, Kenya is expected to experience country-wide losses in the production of key staples, such as maize (Herrero et al. 2010).

Countries in Sub-Saharan Africa are particularly vulnerable to climate change impacts, because of their limited capacity to adapt. The development challenges that many African countries face are already considerable, and climate change will only add to these. In Kenya, where the poverty rate is 52 percent and 73 percent of the labor force depends on agricultural production for their livelihood, poor farmers are likely to experience many adverse impacts from climate change (FAOSTAT 2010). Because agricultural production remains the main source of income for most rural communities in the region, adaptation of the agricultural sector is imperative to enhance the resilience of the agriculture sector, protect the livelihoods of the poor, and ensure food security.

Adaptation to climate change includes many possible responses, such as changes in crop management practices (e.g., choice of fields, planting dates, planting densities, crop varieties, etc.), livestock management practices (e.g., feeding and animal health practices, transhumance timing and destinations, etc.), land use and land management (e.g., fallowing, tree planting or protection, irrigation and water harvesting, soil and water conservation measures, tillage practices, soil fertility management, etc.), livelihood strategies (e.g., mix of crops or livestock produced, combination of agricultural and non-farm activities, temporary or permanent migration, etc.).

Adaptation can greatly reduce vulnerability to climate change by making rural communities better able to adjust to climate change and variability, moderating potential damages, and helping them cope with adverse consequences (IPCC, 2001). A better understanding of farmers' perceptions of climate change, ongoing adaptation measures, and the decision-making process is important to inform policies aimed at promoting successful adaptation of the agricultural sector. Adaptation will require the involvement of multiple stakeholders, including policymakers, extension agents, NGOs, researchers, communities, and farmers.

This report analyzes these issues for the case of Kenya, using data collected through household and community surveys, and participatory rural appraisals. The next section describes the study sites and presents data collection and analytical methods. Section 3 presents descriptive results on experience of climate shocks and coping strategies. Section 4 reviews climate change perceptions and compares these with actual climate trends, and discusses farmers' perceptions of the impact of climate change on livestock production. Section 5 presents the adaptation strategies reported by households and communities in the study sites, describes the adaptation strategies farmers would like to adopt as well as the constraints to adoption, and analyzes the determinants of adaptation. Conclusions and policy implications are discussed in Section 6.

2. Methodology

2.1 Data collection

To identify and assess ongoing and alternative household-level and collective adaptation strategies available to rural communities, data were collected from 13 divisions within 7 districts in Kenya (see Table 1). The study sites were selected to represent the various settings throughout the country in which climate change and variability are having or are expected to have substantial impacts and where people are most vulnerable to such impacts, with the exception of the coastal area. Selection took into account agro-ecological zones, production systems (crop, mixed and pastoralist systems), agricultural management practices, policy and institutional environments, and the nature and extent of exposure and vulnerability to climate change. The selected sites cover a range of agroecological zones including arid, semi-arid, temperate, and humid areas. Enumerators used to carry out the survey were selected from each district so that they were familiar with local customs and could speak the local language. Figure 1 is a map of the study sites.

Table 1: Study sites

District	Division	Agroecological zone	No. of households
Garissa	Central	Arid	66
	Sankuri	Arid	68
Mbeere South	Gachoka	Semi Arid	76
	Kiritiri	Semi Arid	21
Njoro	Lare	Semi Arid	104
Mukurwe-ini	Gakindu	Temperate	47
	Mukurwe-ini Central	Temperate	46
	Mukurwe-ini East	Temperate	2
Othaya	Othaya Central	Temperate	45
	Othaya North	Temperate	27
	Othaya South	Temperate	16
Gem	Wagai	Humid	96
Siaya	Karemo	Humid	96
Total			**710**

The study included divisions in Garissa, Mbeere, and Njoro which are representative of semi-arid and arid low-potential areas with a predominance of pastoralists and agro-pastoralist systems. The study also included divisions in Mukurwe-ini, Othaya, Gem, and Siaya districts, which are representative of high-potential crop production areas.

Figure 1: Map of study sites

2.1.1 Description of study sites

Garissa is an arid district in the Northeastern province covering 7.5 percent of the country's land mass. The bulk of the area is low lying (100-800 msl) and next to the Tana River. Physiographically, the region consists of plains at various levels with scattered inselbergs and plateaus. Floodplains and low terraces are found along Tana River and the climate is arid to very arid (AEZ V-VIII) (Sombroek et al. 1976). The district borders Somalia to the west and is populated by ethnic Somalis. Most households in the area rely on livestock production for their livelihood. The management of these livestock is by shifting movement of livestock in search of pasture or extensive grazing in the lowlands. Household with access to the riverbank irrigate fruits and vegetables for sale in Garissa town and neighboring towns. Frequent droughts and unreliable rains make it difficult to manage rain-fed food crop agriculture/pastures for livestock rearing. The river has recently been subject to severe seasonal flooding. The administrative division of Central has an area of 863 km^2 and a population of about 71,000 people (1999 estimate). The administrative division of Sankuri, has an area of 1952 km^2 and a population of approximately 12,000 people (1999 estimate).

Mbeere South (formerly under Mbeere District) is a semi-arid district located in the Eastern Province. It is a hilly area with three agroecological zones: at elevations over 1000 msl, maize, banana and fruits are cultivated; at elevations of 750-1000 msl, millet, sorghum, drought resistant maize, and legumes (beans, pigeon peas, black peas, green grams) are grown; and below 750 msl, livestock production prevails (Roncoli et al. 2010). Gachoka division has an altitude of 570 msl to 1560 msl. Rainfall is bi-modal with long rains from March to June and short rains from October to December. Average rainfall varies from 550 mm to 1100 mm, but is highly unpredictable. Most parts receive less than 600 mm of rainfall. Mbeere is the second largest producer of miraa (Catha edulis) or khat in Kenya, a native flowering plant that contains an amphetamine-like stimulant heavily consumed by men in the Somali-speaking areas. Consumption is not illegal in Kenya but highly discouraged because of its negative effects on the youth. Its use and trade are banned in many countries.

Njoro (formerly under Nakuru District) is part of Rift Valley province, near the semi-arid eastern edge of the Mau forest. The main livelihoods of the people of Njoro are saw-milling, cattle-keeping and farming. Njoro's climate allows its population to grow crops like barley, wheat, potatoes, beans and more recently maize. In fact, maize has overtaken wheat in relative importance. Rainfall averages 800-1000 mm (Walubengo 2007). The area experienced a severe drought in 2009.

Mukurwe-ini (formerly under Nyeri District) forms part of the Central Province, in the fertile highlands southwest of Mt. Kenya. The main cash crop is coffee (and to a lesser degree, tea), produced by smallholders organized in semi-private cooperatives that process and market the coffee. The main food crops are maize, legumes (beans and peas), tubers (potatoes), and vegetables (tomatoes, cabbage, spinach, kale).

Othaya (formerly under Nyeri District) also forms part of the Central Province in the fertile highlands of southwest of Mt. Kenya. It is an agricultural area with agricultural potential similar to Mukurwe-ini.

Gem (formerly under Siaya district) is located in the Nyanza Province in the southwestern part of Kenya, bordering the shores of Lake Victoria. The main crops are cotton, coffee, sugarcane, tobacco, green vegetables, beans, bananas, sweet potatoes, and cassava. The area hosts several rivers, streams, and wetlands but they are not widely used for irrigation. Despite the more favorable climate conditions, a recent survey in the Siaya, Vihiga, and Kakamega districts of Western Kenya found that between 58 and 68 percent of the population lived below the poverty line. Local farming systems are characterized by very small landholding size (an average of 0.5 to 1 ha), low external input use and land productivity, declining soil fertility, and exodus of able-bodied men to secure jobs in urban areas (Place et al. 2007;

Roncoli et al. 2010). Population density in Wagai division, where the study took place, is 289 people/km^2 (2001 estimate).

Siaya district is also part of Nyanza Province in the southwestern part of Kenya. Population density in Karemo division is high at 336 people/km^2 (2001 estimate). Smallholder land size is very small. Poverty is high in areas with low rainfall and poor soil fertility, including Karemo division. The long rains fall between March and June, with a peak in April and May. Short rains typically fall from late September to November. Rainfall averages 8000-1600 mm per payer. The humidity is relatively high with mean evaporation being between 1800 mm to 2000 mm in a year.

2.1.2 Data collection methods

Three principal methods of data collection were used in the study: household survey, community survey, and participatory rural appraisals (PRAs). The household survey collected information on demographic characteristics; socioeconomic status (e.g. wealth status, income sources, etc.), social capital (e.g. organizational links), land tenure, crop and livestock management, input use and expenses, productive investments, food consumption patterns and expenditures, access to information, extension, technology, markets, and credit, coping responses to climate shocks, perceptions of climate change, adaptation options undertaken today, and constraints to adaptation. The household survey was conducted from July 2009 until February 2010. Data for Garissa and Siaya was collected at the end due to earlier logistics/climate problems. Data covered the previous production year.

The total number of households interviewed was 710. The number of households interviewed per district is shown in Table 1. While initially 96 households were to be sampled per district, survey teams were unable to complete that number of questionnaires in some districts due to budgetary constraints and, in the case of Garissa, difficulty in locating pastoralist households for interview.

To collect information on the role and impacts of community-based and collective adaptation methods currently undertaken, one additional survey module gathered information at the community level using a standard questionnaire format. The questionnaire mirrored the themes covered by the household questionnaire and can be used to identify collective action mechanisms supporting adaptation to climate change and target interventions geared towards the community level.

PRAs were also conducted in late October-November 2009 in the districts in which the World Bank-funded programs are operating. The PRAs took place in the context of separate groups for men and women, including a total of 69 men and 71 women. Older (over 50) women and men predominated, adding to almost half of the participants, with most of the other half being composed of adult participants between 30 and 50 years of age. Almost half of the participants had primary education, with one fifth having secondary or higher and the rest having had no formal schooling.

A PRA protocol was developed to guide the group discussions based on a thorough review of published literature, online searches, and meetings with experts in Nairobi. The protocol was used flexibly, responding to conditions in the field and to the ways different group of farmers responded, rather than as a rigid framework for eliciting and organizing information.

The PRAs included two phases: a) freelisting, in which participants brought up issues and ideas on a variety of topics (causes, indicators, and effects of climate change, adaptations and needed resources to implement them, and additional fears and worries besides climate); b) scoring and ranking of key adaptive resources and core concerns. Participants also discussed climate predictions and their perceptions of relative reliability.

2.2 Analytical methods

Descriptive results of the household and community surveys related to climate change perceptions, coping strategies chosen and adaptation options employed by farmers, desired adaptation measures, constraints to adaptation, perceptions of the link between agriculture and climate change, the practices that reduce climate change, and the land management practices used by farmers are presented. Comparisons between the various agroecological zones are drawn.

Econometric analysis was used to examine the factors influencing adaptation strategies. Adaptation strategies are analyzed as a function of social, human, and physical capital and assets, and access to services and information. To analyze the factors which influence the decision to adapt to perceived climate changes, a discrete choice model is used. Data from both countries were pooled and the dependent variable for adaptation was created. The dependent variables are dummy variables equal to 1 if the farmer adopted that particular adaptation option in response to perceived climate change and 0 otherwise. The independent variables are presented below.

Analysis of this dependent variable requires a binary response model. These models can be derived from an underlying latent variable model:

$$y^* = \beta_0 + \beta x + \varepsilon$$

where y^* is the unobserved, or latent, variable; x denotes the set of explanatory variables, e is the error term and $1[y^* > 0]$ defines the binary outcome. A probit model is used to determine the factors which influence farmers' decisions to adopt each adaptation strategy.

The information collected through PRAs was written on flipchart sheets, which were then compiled, transcribed, coded thematically, and analyzed quantitatively in an Excel spreadsheet. The data was analyzed in terms of differences between genders and between farmers of different agro-ecological areas (humid/temperate and arid/semi-arid).

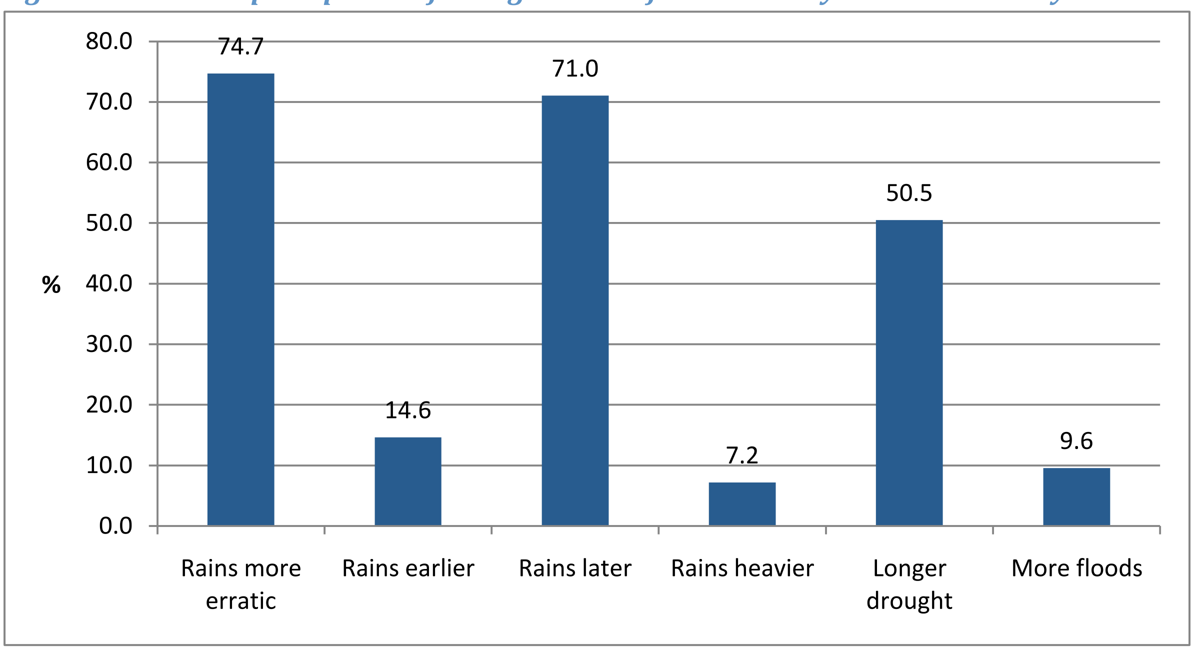
3. Climate change perceptions

3.1 Perceptions of climate changes

Surveyed households were asked about their perception of long-term changes in climate. Specifically, farmers were asked "Have you noticed any long-term changes in the average temperature/rainfall/rainfall variability over the last 20 years?" Farmers that responded positively reported the changes they have observed. The results show that an overwhelming majority of farmers perceived an increase in average temperatures (94 percent) and a decrease in average precipitation (88 percent) over the last 20 years. When asked whether they had perceived a long-term change in rainfall variability, 91 percent of farmers responded positively. These perceptions were consistent across the surveyed districts/divisions despite differences in agroecological zones and expected impacts from climate change.

With regard to rainfall variability, farmers specified which changes they had noticed (Figure 2). Seventy-five percent of farmers reported that rainfall had become more erratic. Eighty-six percent of farmers observed a change in the timing of rainfall with 71 percent reporting that rains are coming later than expected and 15 percent reporting that rainfall was occurring earlier than expected. Farmers also noted increasingly prolonged periods of drought over the past 20 years (51 percent). Changes reported less frequently included an increase in the number of floods (10 percent) and heavier rains (7 percent).

Figure 2: Farmers' perceptions of changes in rainfall variability over the last 20 years



While farmers perceived long-term changes in temperature and precipitation, actual climate data[1] for the period 1957 to 1996 from weather stations closest to the surveyed sites show no significant trends in terms of average yearly temperature or precipitation, with the exception of Mukurweini/Othaya where temperature showed a declining trend. However, Ogutu et al. (2007) show that minimum temperatures rose during 1960-2003, particularly during the wet season. Temperature increases have a significant impact on water availability, thus exacerbating drought conditions. Therefore, farmers' perceptions may be based on a decrease in water availability (which is also affected by other environmental and social drivers such as an increase in population density). Perceptions may also be influenced by more recent climate trends such as the prolonged and severe droughts and rising temperatures during the 1990s (Ogutu et al. 2007).

The PRA discussions of climate change perceptions centered on changes in rainfall variability over the long term. Farmers often expressed concern about greater variability and seasonal changes which hindered their ability to predict rainfall patterns and plan their farming activities accordingly. In addition, many farmers reported that the shortening of the rainy seasons have led to longer dry periods in between which result in greater pressure on food supplies. In Siaya and Garissa, farmers reported an increase in rainfall intensity has exacerbated the problems of flooding and soil erosion. While farmers focused on changes in rainfall variability (partly a function of the timing of the PRAs, which coincided with the delayed onset of the rainy season), many also acknowledged increases in temperatures over the long term (Roncoli et al. 2010).

While the PRA results do support the findings of the household survey, they also show that farmers place greater emphasis on rainfall variability when making decisions about their farming activities. Furthermore, they suggest that farmer's perceptions of long term decreases in rainfall from the household survey are actually based on their experiences with rainfall variability, and particularly changes in timing and distribution of rainfall, rather than average quantity of annual rainfall. This again explains why farmers' perceive a decrease in rainfall associated with climate change despite the fact that actual climate data have not shown a decreasing trend.

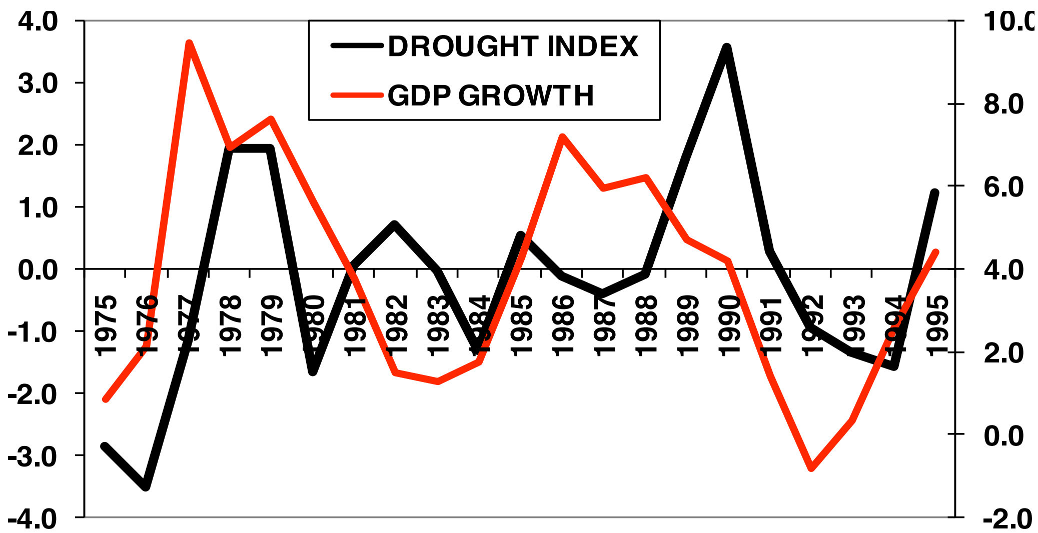
Farmers' concerns about changes in rainfall variability are warranted given that rainfed agriculture is the dominant source of staple food and cash crop production and livelihood for the majority of the rural poor. Climate variability, in particular the occurrence of drought,[2] is a robust determinant of agricultural performance as well as general economic performance in the country (Herrero et al. 2010). As shown in

[1] Precipitation data is from the "Global Historical Climatology Network" (GHCN) database available at http://www.ncdc.noaa.gov/ghcnm/. Daily temperature data is from the "Global Surface Summary of Day" data base built based on data exchanged under the World Meteorological Organization, (WMO) World Weather Watch Program, which is made available online through the National Climate Data Center of the United States (NCDC), available at http://lwf.ncdc.noaa.gov/cgi-bin/res40.pl?page=gsod.html.

[2] Note that, for farmers in Kenya, "drought" has different meanings, it may mean a rainy season below average, but also the dry periods between rainy seasons and prolonged dry spells within rainy season (pers. Comm. Carla Roncoli).

Figure 3, there is a strong association between drought and GDP growth, with growth dipping dramatically following each severe occurrence of drought.

Figure 3. Linkage between the Palmer Drought Severity Index (PDSI) and GDP growth, Kenya, 1975-1995



Source: IFPRI (2006).

3.2 Perceptions of climate change and climate variability impacts on livestock production

Farmers and pastoralists also perceived changes in their environment as a result of climate change. In particular, households reported on the impact of climate change with regard to the availability of feed sources for livestock. Figure 4 shows in which periods of the year households declared they have experienced shortages of feed for the species for which data are available from the survey (cattle, sheep, and goats). In general, feed availability is not constant during the whole year and moderate deficits are affecting all species considered, in particular at the beginning of the year and between August and October. Sheep are the less affected, while goats and cattle experience a significant change in feed availability during the year.

The major production constraints are shown in Figure 5, although some of these are connected. Figure 10 shows production constraint by district. According to 36 percent of households, the feed resources appeared and disappeared because of drought and in a broader sense as a consequence of system changes and climate change impacts. Land use change was identified by almost 18 percent of households as one of the main reasons for the change in feed availability, but mostly in districts where the possibility of multiple land use forms is available (i.e. Othaya).

Figure 4: Level of severity of shortage of feed during one year of period for cattle, sheep and goat.

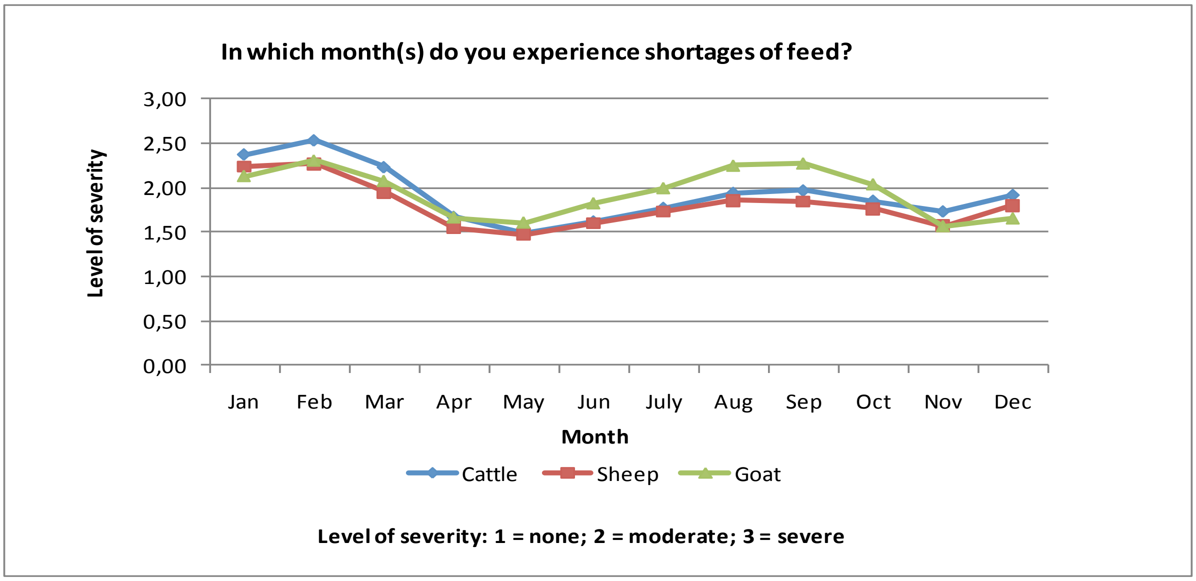
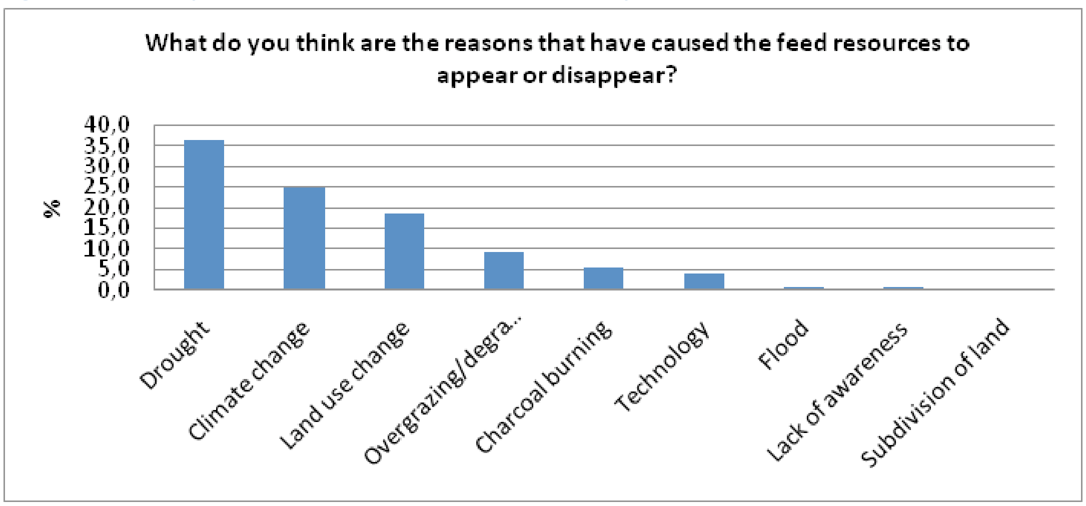
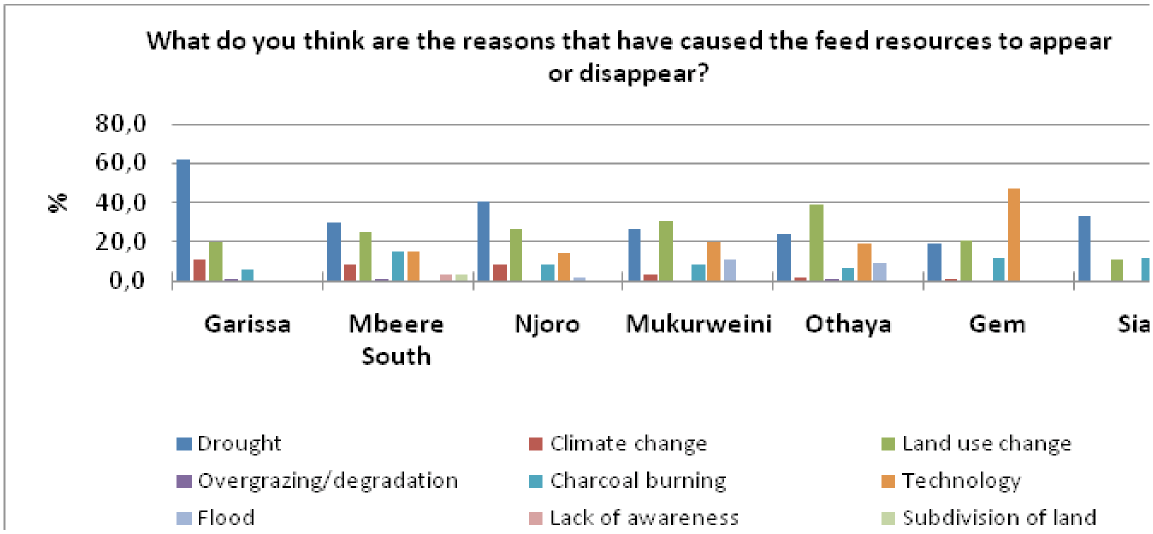


Figure 5: Rank for reasons that have caused the feed resources to appear and disappear.



When considering the causes of feed shortages by district we can see that perceptions of causes differ by agroecological zone. The impact of technology seems to be quite high in Gem and Siaya, flood is thought to reduce the availability of feed resources in particular in Mukurwe-ini, Othaya, and Siaya. Drought is identified as the key reason for feed constraints in Garissa district and as one of the major drivers of feed availability in Mbeere South, Njoro and Siaya. These reasons reflect the agricultural potential of different districts.

Figure 6: Rank for reasons that have caused the feed resources to appear and disappear per district



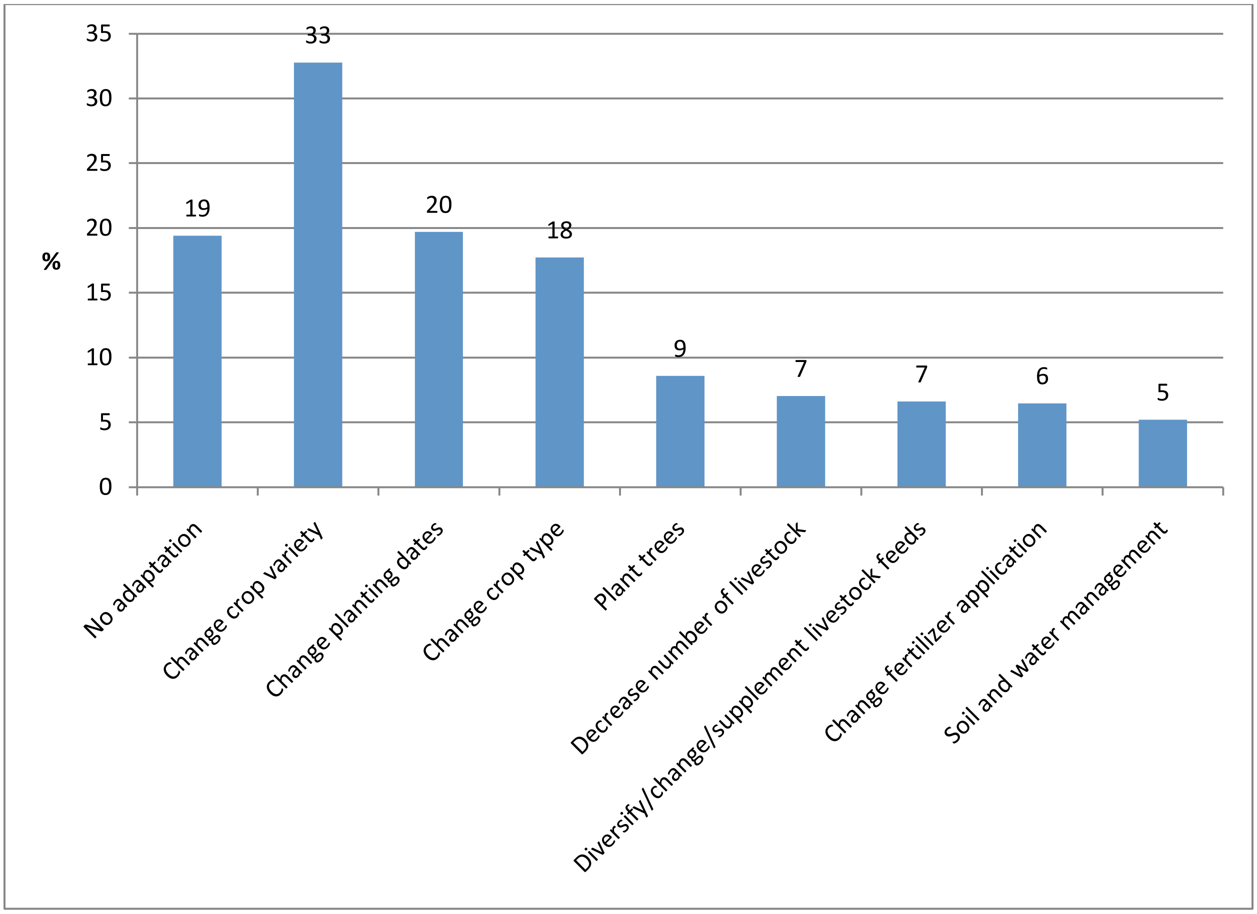
According to the household sample, some feed resources available 10 years ago are no longer available, among these are: kikuyu grass (*Pennisetum clandestinum*), marer (*Cordia sinensis*), allan (*Lawsonia iner* or *Terminalia brev.),* deka (*Grevia tembensis*), haiya (*Wrightia demartiniana*). On the other hand, some new feed resources appeared in the last 10 years, in particular: mathenge (*Prosopis juliflora*), napier grass (*Pennisetum purpureum*), desmodium (*Desmodium intortum*) and caliandra (*Caliandra calothyrsu*).

4. Adaptation to climate change

4.1 Household-level adaptation

Surveyed farmers adopted a range of practices in response to perceived climate change (Figure 7). The most common responses included changing crop variety (33 percent), changing planting dates (20 percent), and changing crop type (18 percent). Other responses included planting trees (9 percent), decreasing the number of livestock (7 percent), diversifying, changing, or supplementing livestock feeds (7 percent), changing fertilizer application (7 percent), and soil and water conservation (5 percent). While the number of farmers that did not adjust their farming practices in response to perceived climate change (19 percent) may seem high, this figure is relatively low compared to similar data collected from Ethiopia and South Africa, where 37 percent and 62 percent, respectively, did not adapt to perceived changes in climate (Bryan et al. 2009).

Figure 7: Changes in agricultural practices reported by farmers in response to perceived climate change



Note: Above adaptations only include options reported by more than 5 percent of farmers.

While most of the surveyed farmers did report adaptations to perceived climate changes, apart from planting trees, the adaptive responses reported frequently require little investment to implement—e.g. purchasing new varieties or crop types, receiving training or information on soil and water conservation, etc. When farmers' actual adaptations are compared with those changes that farmers would like to implement (Figure 11), we find that farmers would like to make more significant changes to their farming practices but are unable to due to a number of constraints such as lack of money or resources needed for the investment.

Figure 8 presents the share of households in the various study sites that mentioned that they adapted to perceived long-term change in temperature and precipitation (climate change). A key finding is that households in the arid district of Garissa are least likely to adapt to climate change, whereas households in the temperate coffee areas of Mukurweini and Othaya were most likely to adapt. The low probability of adaptation in Garissa may be partly due to the fact that they are already coping with difficult climate conditions. For example, farmers in Garissa have to irrigate in order to grow most crops, therefore they would be less likely to report irrigation as an adaptation strategy because they are already doing this. The low level of adaptation is also an indication of limited adaptive capacity in this district as well.

Figure 8: Share of households reporting adaptation to perceived long-term changes in temperature and precipitation

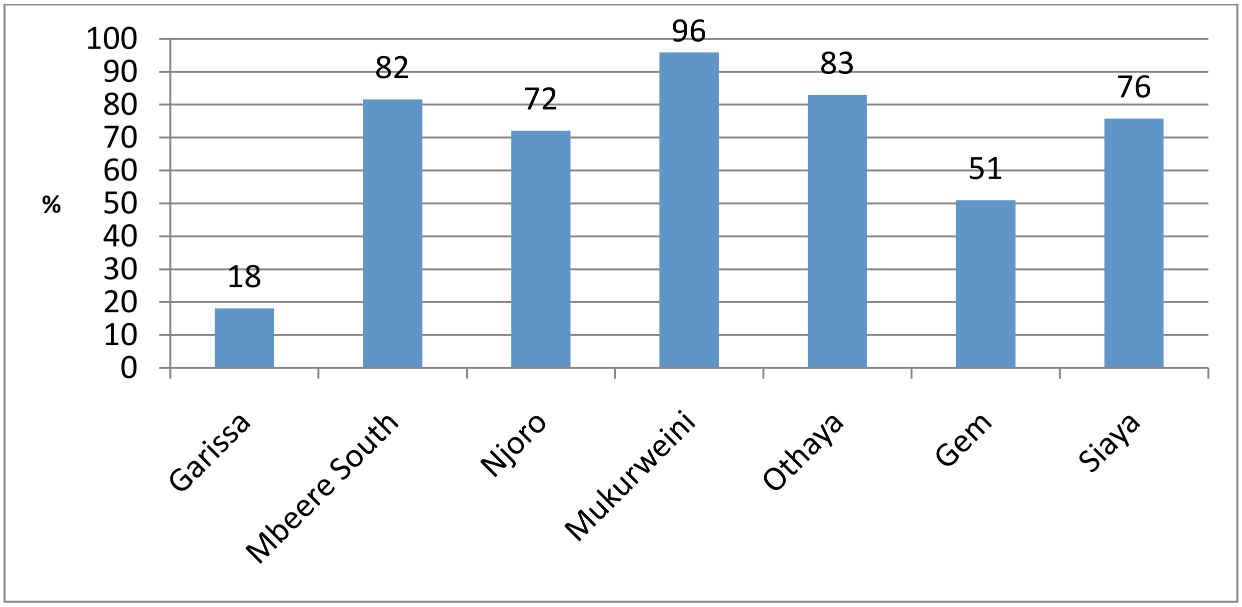
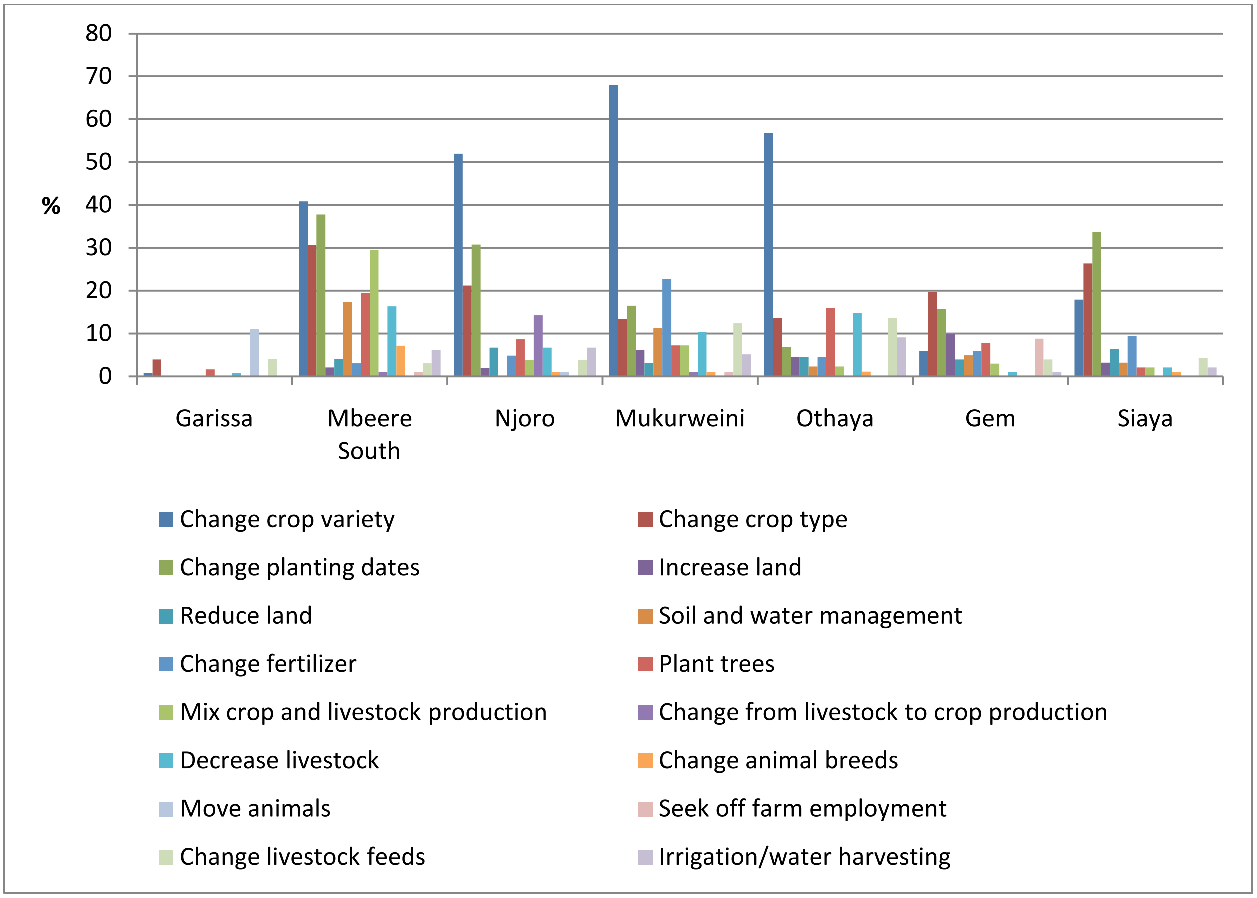


Figure 9: Adaptation strategies by district



Moreover the range of adaptation strategies employed by farmers in the various sites differed (see Figure 9). While households in Garissa only applied 10 different adaptation strategies, households in the semi-arid and temperate zones used 27 and 26 different adaptation measures, respectively, and 22 different measures were used in the humid zone. These results show that households in the arid district are not only dealing with tougher climate conditions to begin with but also have a more limited range of adaptation options available to them.

To summarize, Table 2 presents the top three adaptation measures by agroecological zone (grouping districts in the same AEZ together). Changing planting decisions, including crop variety and type and planting dates, was the key adaptation measure in all but the arid zone. In this zone, moving animals, presumably to regions with lower temperature and more rainfall to support grazing was the key adaptation strategy, followed by changing the crop variety and type (but not planting date). Changing livestock feed was the third most important adaptation measure. In the semi-arid zone, farmers have also increasingly switched from cropping systems to mixed crop/livestock systems and have planted trees to adapt to climate change. In the temperate zone (coffee production area), farmers have also changed fertilizer applications and livestock feed. In the humid zone, finally, farmers have also changed fertilizer applications and increased land under production.

Table 2: Top three adaptation measures used by agroecological zone

Rank	Arid	Semi-Arid	Temperate	Humid
1	Move animals	Change planting decisions (variety/type/date)	Change planting decisions (variety/type/date)	Change planting decisions (variety/type/date)
2	Change planting decisions (variety/type)	Change to mixed crop/livestock systems	Change fertilizer applications	Change fertilizer application
3	Change livestock feed	Planting trees	Change livestock feed	Increase land

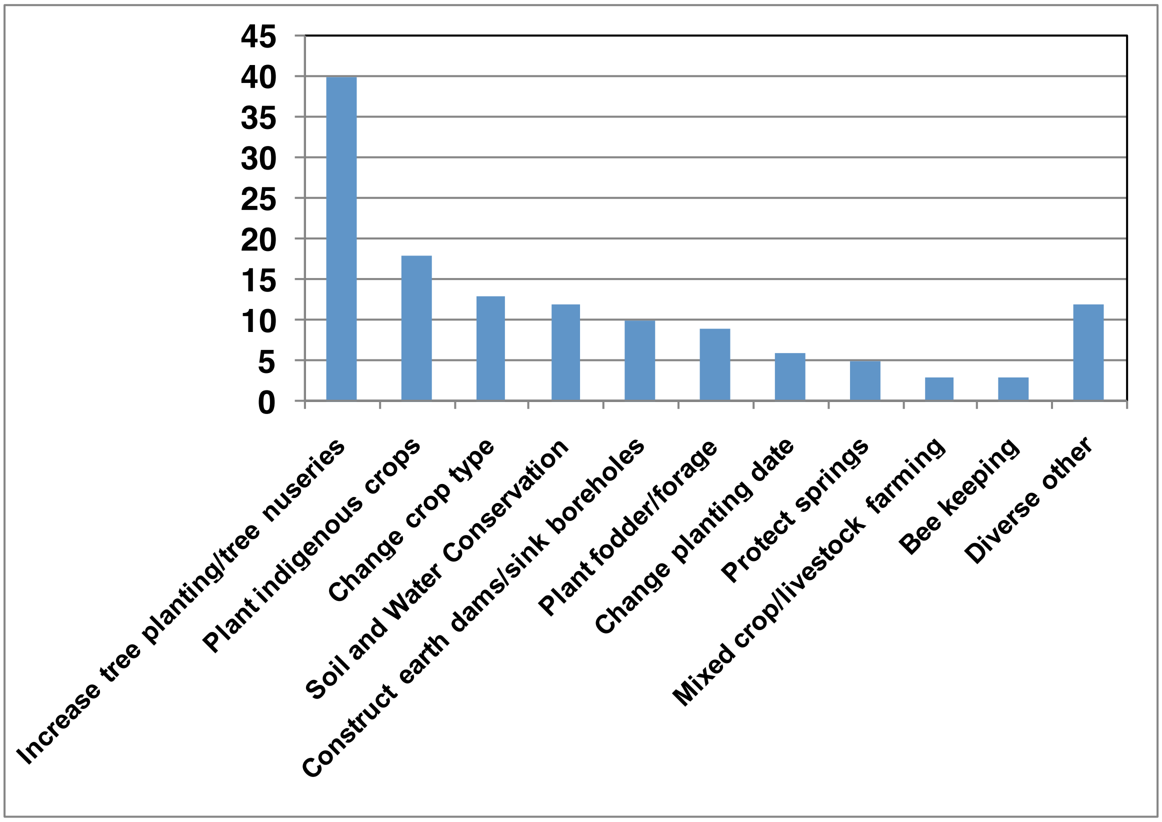
Note: Arid includes Garissa; semi-arid includes Mbeere South and Njoro; temperate includes Mukurweini and Othaya; and humid includes Gem and Siaya.

It might be surprising that irrigation was not one of the key adaptation options implemented. We believe there are several reasons for this: First, in Garissa, rainfed agriculture is not an option, and crop farmers are already irrigating. In the temperate and humid areas, rainfall is generally plentiful. Irrigation or water harvesting was mentioned in both the semi-arid and temperate areas as selected adaptation options, but not among the top three. The main reason is that irrigation is generally considered a costly investment that cannot be implemented by individual farm households alone.

4.2 Community-level adaptation options

In addition to household surveys, we also implemented a community module in each of the study sites where the household survey was implemented. Participants selected for the community survey are influential and informed members of their communities including village elders, chairmen, village chiefs, assistant chiefs and church leaders. Figure 10 presents the adaptations that communities have taken in response to long-term climate change. Planting trees and tree nurseries was the adaptation strategy mentioned most often. This corresponds with government and media reports that both identify lack of trees as a key cause of climate change. Moreover, the government provides financial support for tree plantings. The temperate district of Othaya listed tree planting and nurseries most often. While some of the adaptation measures mentioned, such as planting indigenous trees, changing crop type and changing planting dates do not require the effort of the entire community, other adaptation strategies, such as development of some soil and water conservation structures, sinking boreholes, construct earthen dams, and protect springs do require the support by the entire community. Construction of earthen dams was mentioned most often in Njoro, protection of springs was an important adaptation strategy in Mbeere South and Othaya, and sinking boreholes was mentioned in Mukurwe-ini, Njoro, Othaya and Siaya. Garissa listed mixed crop/livestock farming and planting trees and tree nurseries as communal adaptation strategies.

Figure 10: Community-identified adaptations to climate change

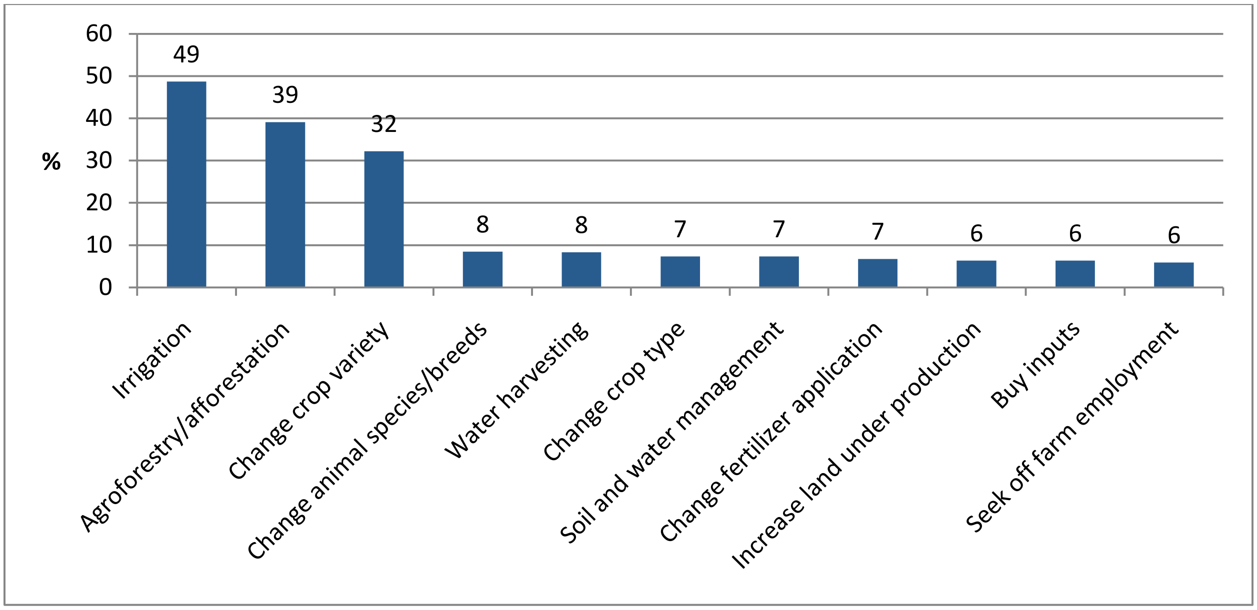


4.3 Desired adaptations and constraints to adaptation

When asked what changes they would like to make to adapt to changing climate variables 49 percent of farmers responded that they would like to invest in irrigation and 39 percent said they would plant trees. These changes require a more significant initial investment by farmers; and, in the case of irrigation, access to water is also crucial. In fact, when discussing constraints to implementing these measures farmers reported lack of money or access to credit (63 percent) and lack of access to water (26 percent), in the case of irrigation; and lack of money/credit (55 percent), lack of access to land (6 percent) and water (20 percent), lack of inputs (10 percent), and lack of information (5 percent), in the case of agroforestry/afforestation, as significant impediments to adoption.

Despite the relatively lower cost of implementation, a large number of farmers (32 percent) also responded that they would like to change crop variety. These farmers reported no money/credit (36 percent), lack of access to inputs (26 percent), and lack of information (24 percent) as the most major constraints to adopting new varieties. Desired adaptations mentioned less frequently by farmers included changing animal species or breeds, water harvesting, changing crop type, soil and water management, changing fertilizer application, increasing the amount of land under production, purchasing inputs, and seeking off farm employment (see Figure 11).

Figure 11: Adaptations farmers would like to implement in response to climate change

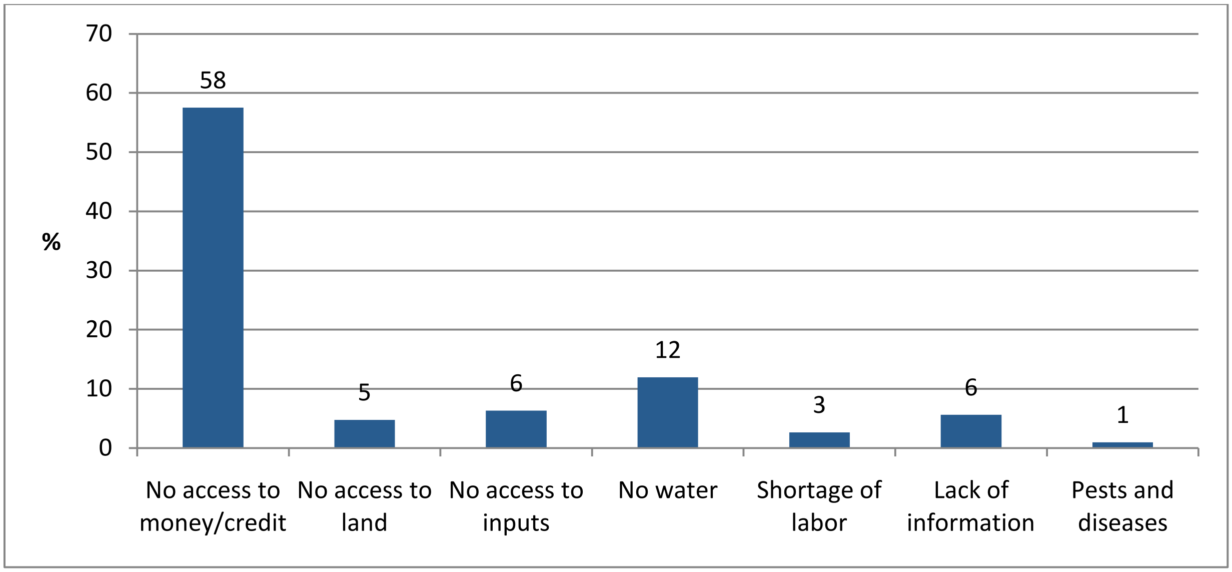


Note: Above figure includes only those responses reported by more than 5 percent of farmers

Farmers were also given the opportunity to rank the most important constraints to adaptation across all of the desired adaptation options. Responses are shown in Figure 12. No access to money/credit was reported to be the most significant constraint by a majority of farmers (58 percent). Twelve percent responded that lack of water was the most important constraint. Others ranked lack of access to inputs, lack of information, lack of access to land, shortage of labor, and pests and disease as the most significant constraints. These data suggest that expanding access to credit[3] or cash earning opportunities would enable farmers to meet the initial costs of more considerable investments, such as irrigation.

[3] However, lack of money does not necessarily translate into need for credit. In the companion PRA study some women emphasized income (training for value added, group formation for better markets) rather than credit, as they had bad experiences with lenders.

Figure 12: Constraints to adaptation



Note: Above figure includes only those constraints that were reported by more than 1 percent of farmers

During the PRAs, participants discussed potential adaptation strategies to climate change. These included both actual as well as desired adaptations, given that it was difficult to distinguish between the two in group settings, where actual adaptations for some farmers may be desired, but unfeasible, adaptations for others. The discussions revealed that livelihood diversification (including integrating crop and livestock production and seeking off-farm income sources, such as jobs, trade, food-for-work, and even illegal activities, such as smuggling, commercial sex, theft, etc.) is the most common adaptation strategy. Livelihood diversification received less attention during the household survey most likely because of the emphasis on changes in farming practices as a result of climate change, rather than the whole range of possible adaptations. However, separating actual adaptations and desired adaptations in the household survey revealed that while farmers are interested in finding off-farm employment (6 percent) few have actually been able to diversify their income sources (2 percent). Conversely, more farmers reported mixing crop and livestock production in response to climate change (4 percent) compared to those who only expressed an interest in making this change (1 percent).

The second most often mentioned adaptation strategy during PRA discussions, especially by the women, pertained to planting decisions. This includes planting more drought resistant crops (ex. cassava, sweet potatoes, pigeon peas, dolichos, etc.) and early maturing varieties, as well as using improved hybrid seed for greater productivity. Farmers also reported planting more napier grass than maize, shifting towards more livestock production and adopting more drought resistant livestock breeds (ibid). As shown above, changing crop varieties or types and changing planting dates were also common adaptations to climate change among farmers in the household survey. However farmers in most of the PRA sites complained about the poor quality of seed and inputs, which they attributed to lack of quality controls by government and fraudulent business practices by traders.

Irrigation and water harvesting schemes were ranked at the top among priority adaptations during the PRAs regardless of gender or agro-ecological area (although in most cases it referred to desired rather than actual adaptations). The household survey indicated that while many farmers are interested in irrigation and water harvesting (49 percent and 8 percent respectively), only 4 percent actually made either investment. PRA participants also stressed soil and water conservation measures to improve soil fertility, such as nutrient management (manure, compost, and fertilizer), cover cropping, and agroforestry. Furthermore, livestock owners in Mbeere and Garissa mentioned zero-grazing and sustainable pasture management as adaptation strategies (Roncoli et al. 2010).

In both freelisting and ranking exercises, PRA participants placed considerable emphasis on improved human and organizational capacity, including access to literacy and technical training, access to information, and support for group formation. In particular, participants expressed an interest in technical training on entrepreneurship, income generation activities, processing for value added, marketing, drought-resistant varieties, tree planting, and waste disposal (ibid). Only 6 percent of household survey respondents mentioned lack of information regarding climate change and appropriate adaptations as the biggest constraint to adaptation.

Echoing survey respondents, PRA participants identified lack of money or credit as the most significant resource needed for adaptation among the top priority constraints. Farmers also highlighted the need for better market infrastructure; better quality, affordability, and distribution of inputs; and livestock and veterinary services (ibid).

4.4 Determinants of adaptation

To further explore the constraints to adaptation as well as potential entry points for public action we used a discrete choice model to analyze the factors that influence the adoption of the main adaptation strategies. Using the same set of explanatory variables we analyze the decision to change farming practices, focusing on those adaptations reported by more than 5 percent of households (shown in Figure 7 above). We also analyzed the decision to adapt any adaptation strategy using a dummy variable for whether the household adapted any adaptation strategy or not.

The results (marginal effects) are presented in Table 3. We find that, based on our household survey, only a limited number of factors influence the decision to adapt or not. Only access to food or other aid and weather forecasts increase the likelihood of adaptation while all other factors are not statistically significant. It is difficult to draw any conclusions from these results given that the individual adaptation choices underlying this aggregate variable for adaptation are vastly different. Therefore, it is unlikely that the factors that influence one adaptation strategy, say changing crop variety, will be the same or similar for an entirely different strategy, such as tree planting. In fact, when we look at adoption of individual adaptation strategies, it appears that the analysis of farmers' decision to adapt or not masks important factors influencing the adoption of particular strategies. These factors vary widely depending on the adaptation strategy chosen.

Only a few factors influence whether farmers change crop type or change planting dates. This is not surprising given that planting decisions are more likely to be autonomous adaptations taken by farmers. However, there are some noteworthy findings with respect to planting decisions. Access to irrigation is a significant determinant of changing crop type. This suggests that farmers are switching to high value crops which require irrigation. With regard to changing planting dates, having access to social safety nets (i.e. food emergency relief, food subsidies, or other farm support[4]), access to extension services (in particular farmer research groups or common interest groups), and climate information (specifically seasonal forecasts or early warnings) were important determinants.

Similarly, food or other aid and extension services (farmer research or common interest groups) were significant determinants of changing crop variety. In addition, farmers with access to fertile soils, larger land holdings, and with both crop and livestock production, were more likely to change crop variety. It is interesting that membership in associations (i.e. the number of associations to which members of the household belong) negatively influences the likelihood of changing crop variety. This is likely due to the fact that most of the associations reported by households were women's associations. These networks are often responsible for the storage of seeds as an important source of biodiversity and therefore may be less likely to use improved varieties developed for adaptation purposes.

Given that planting trees is bigger financial investment than changing planting decisions, wealthier households are more likely to adopt this practice—households with access to electricity (an indicator of wealth), non-farm sources of income, and larger land holdings are more likely to plant trees as an adaptation strategy. Accordingly, access to food emergency relief and other sources of aid (which are usually targeted to the poorest, thus providing an indicator of those that are particularly vulnerable climate change) is shown to negatively influence the decision to plant trees. Access to extension services of all types is also a significant determinant of whether a farmer plants trees in response to perceived climate change. Membership in associations also increases the likelihood of planting trees.

[4] Only a few households reported receiving aid from food for work or cash for work programs.

Table 3: Determinants of adaptation

	Adaptation	Change variety	Change type	Change planting dates	Plant trees	Destocking	Change feeds	Change fertilizer	Soil and water conservation
Gender of household head	-0.079	-0.156	-0.089	-0.229	0.096	-0.025	**0.630***	0.082	-0.259
Education of household head	0	0.002	0.031	-0.021	-0.015	0.017	-0.022	0.016	-0.035
Years involved in farming	-0.001	-0.007	-0.001	0.001	0.01	0.003	**0.017****	0.001	**0.014***
Household size	-0.006	0.027	-0.005	-0.019	0.022	-0.027	-0.052	0.009	**0.076***
Access to electricity	0.222	-0.053	0.009	0.172	**0.422***	0.155	**-0.458****	**0.438***	0.01
Food or other aid received	**0.321*****	**0.239****	0.139	**0.295*****	**-0.287***	**-0.304****	**0.354****	0.031	-0.005
Associations membership	-0.162	**-0.348****	-0.121	0.034	**0.356***	-0.176	-0.294	-0.213	0.073
Soil fertility high	0.217	**0.431****	-0.08	0.053	0.064	-0.175	-0.006	0.188	-0.432
Soil fertility moderate	0.244	0.081	0.025	0.082	0.239	-0.093	-0.309	0.081	-0.067
Land title	-0.032	0.176	0.116	-0.057	-0.012	0.18	**-0.678*****	0.395	0.286
Land area	0.018	**0.035***	-0.003	0.023	**0.030***	-0.008	0.002	0.022	**0.032***
Mix crop and livestock production	-0.072	**0.428****	0.251	-0.223	-0.022	-0.032	0.214	**0.984****	0.384
Irrigation	0.21	0.521	**1.022*****	-0.841		-0.282	-0.174		-0.075
Extension field visits	0.189								
Extension (ffs and ffe)	-0.049								
Extension (frg and cig)	0.156								
Crop extension field visits		0.051	0.122	0.051	**0.489*****			0.024	**0.636*****
Crop extension (ffs and ffe)		-0.148	-0.218	-0.26	**0.576*****			**0.383***	0.274
Crop extension (frg and cig)		**0.530*****	0.112	**0.372****	**0.408***			0.247	0.404
Livestock extension field visits						-0.237	0.410*		
Livestock extension (ffs and ffe)						0.097	-0.11		
Livestock extension (frg and cig)						-0.011	0.029		
Weather forecasts	**0.324****	0.189	0.118	0.107	0.232	0.138	0.079	-0.292	0.113

Table 3 continued									
	Adaptation	Change variety	Change type	Change planting dates	Plant trees	Destocking	Change feeds	Change fertilizer	Soil and water conservation
Seasonal forecast and/or early warning	0.013	-0.193	0.018	**0.257***	-0.092	-0.157	0.135	0.031	-0.064
Formal credit	0.055	-0.027	0.128	0.065	-0.05	0.037	-0.034	-0.06	0.137
Informal credit	0.031	**-0.242***	0.152	0.23	-0.091	**0.345***	**0.475****	-0.111	-0.188
Nonfarm income	0	0	0	0	**0.000***	0	0	**0.000****	**0.000****
N	653	601	653	541	562	541	653	530	541

legend: * p<.1; ** p<.05; *** p<.01

Abbreviations: farmer field schools (ffs), farmer-to-farmer exchange (ffe), farmer research group (frg), and common interest group (cig)

Several factors influence farmers' decision to adjust their livestock practices in response to perceived climate change. As with planting trees, farmers that appear to be better off financially are more likely to engage in destocking (reducing the number of livestock) as an adaptation strategy. That is, farmers that do not rely on food or other sources of aid are more likely to reduce the number of livestock. Changing livestock feeds is influenced by a number of individual and household characteristics. Male-headed households are more likely to change livestock feeds as are households that have been involved in farming longer. Livestock extension, specifically field visits, encourages farmers to change livestock feeds. As opposed to the case of destocking, it appears that poorer households (those without access to electricity and those that depend on food aid) and households without a formal land title are more likely to change livestock feeds. Having access to informal sources of credit is an important determinant of both destocking and changing livestock feeds.[5]

Farmers with mixed crop and livestock systems, access to non-farm sources of income, and access to extension (specifically farmer-to-farmer exchange programs or farmer field schools) were more likely to change fertilizer application. Wealthier households (as suggested by their access to electricity) also are shown to be more able to invest in fertilizer in response to climate change.

Finally, the results show that the households that are more likely to implement soil and water conservation measures in response to perceived climate change are larger (with more household labor for construction of the measures), more experienced, have sufficient land area, and have access to non-farm sources of income and extension services (specifically field visits).

5. Conclusions and policy implications

The above results show that households face considerable challenges in adapting to climate change. Coping with climate 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 while many households have made more minor adjustments to their farming practices in response to climate change (in particular, changing planting decisions), few households are able to make large investments to improve their farming practices, for example in agroforestry or irrigation, although there is a desire to invest in such measures. Lack of money and credit 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 future well-being.

The fact that few farmers in the arid site adapted to climate change and that the range of adaptation strategies employed was much more limited than in other areas, suggests that households in Garissa are

[5] Access to credit is captured by a dummy variable for whether the household has borrowed from formal or informal sources over the previous year. This is an imperfect proxy for access to credit—not all households that did not borrow are necessarily credit-constrained. Rather some households may chose not to borrow because they feel it is too risky or for other reasons.

in particularly precarious situation. Not only are these households already facing difficult climate conditions, but they also have less capacity to adapt and limited options to increase resilience to future climate change. Numerous NGOs and government agencies are already operating in these areas. Much assistance is provided in the way of emergency relief, such as food aid. However, in addition to providing a safety net following major climate shocks, more should be done to build the resilience of these communities to withstand future climate crises. In particular, drought management and drought preparedness plans should be integrated into rural development efforts. Other public actions that would increase resilience to climate shocks include developing early warning systems and expanding access to weather insurance.

In the semi-arid, temperate, and humid sites the rate of adaptation is far higher and a range of different adaptation strategies are being adopted. However, there is still a major gap between what households have already implemented and what they would like to implement to increase resilience to climate change. Many households reported irrigation as the most desired adaptation, followed by planting trees. Irrigation, and to some extent, tree planting require government and private sector/NGO support.

Government support will be important in terms of enabling conditions (governance of water use, basic investments, including roads leading to and from irrigation systems, and extension); while private sector support will be important for the design/construction of irrigation systems, as well for making irrigation technologies available and for knowledge development. NGOs, the private sector and the government have roles to play in providing other rural services supporting irrigation development and tree planting, such as credit, education, and health services. In fact, lack of money or access to credit and lack of access to water were considered key constraints for irrigation development; and lack of access to land, water, inputs, and information were key constraints cited for adoption of agroforestry/afforestation.

Another important adaptation strategy that one third of farmers would like to implement is changing crop varieties. Even this relatively modest (in terms of cost) adaptation strategy faces obstacles, including lack of money/credit, lack of access to inputs, and lack of information. Again, the government, the private sector, and NGOs all have important roles in addressing these obstacles, ranging from development of desirable crop traits adapted to the various agroecological zones of Kenya to capacity building and knowledge dissemination through public, private, and NGO extension services, to making better seeds available in remote rural regions.

The analysis of the determinants of adaptation further suggests that there are effective policy levers to support the adoption of adaptation strategies. The results show that different strategies are needed to encourage the adoption of particular adaptations options. However, in general, access to social safety nets, extension services, credit, and climate information appear to be important mechanisms as they support the adoption of several adaptation strategies. Access to irrigation is shown to be an important determinant of whether farmers change crop types, suggesting that investments in irrigation infrastructure would help farmers switch to higher value crops, thereby increasing farm revenues.
In addition, access to land is important for changing crop variety, planting trees, and constructing soil and water conservation measures.

During the PRAs, participants also placed considerable emphasis on investments and adaptations outside of agriculture such as increasing human and organizational capacity, including access to literacy and technical training on entrepreneurship, income generation activities, processing for value added, marketing, etc. Analysis of the determinants of adaptation also showed that increasing access to off-farm sources of income also enables farmers to make agricultural investments in agroforestry, fertilizer, and soil and water conservation measures. Moreover, livelihood diversification (in particular off-farm sources of income) is important for increasing resilience to climate variability. Therefore, the government should not only focus on investments in agriculture to improve livelihoods, but also focus on providing options for livelihood diversification to support adaptation to climate change.

Communities should also work collectively to adapt to climate change. Communities are already working together to develop soil and water conservation structures, sink boreholes, construct earthen dams, and protect springs. Additional measures that communities may consider include raising awareness of climate change impacts and potential adaptation strategies, sharing information about the effectiveness of different strategies, sharing technologies such as seeds, community-based weather monitoring and forecasting, informal credit schemes, and collective income-generating schemes.

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