Coping with Climate Variability and Adapting 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

Executive Summary

Livelihoods of Kenyan farmers are closely linked to climate conditions. Fifty-two percent of the population is below the poverty line, mostly in rural areas. While the poorest of the poor live in the northern, arid zones of the country, more than 80 percent of the rural poor are located in the high-potential areas of Lake Victoria and Mount Kenya. Almost three quarters of the Kenyan labor force still depends on agriculture for their livelihoods, and almost all farmers depend on timely and adequate rainfall for crop production and husbandry, as only 2 percent of cultivated area is equipped for irrigation. Thus, climate variability and change have and will increasingly impact agricultural livelihoods and food security in the country, making adaptation essential for rural areas in Kenya.

This report uses data gathered through a farm household survey during July 2009 to February 2010 for 710 households from 7 districts and 13 divisions of Kenya spanning the arid, semi-arid, temperate and humid agroecological zones (AEZ) of the country as well as data collected through participatory rural appraisals conducted in each AEZ. One community module was also implemented in each of the districts. These data were used to assess farmers' exposure to climate-related shocks and coping strategies, perceptions of climate change and climate change impacts, adaptation strategies, constraints to adaptation, and the determinants of adaptation.

The findings show that drought is the key climate-related shock—across all districts and AEZs studied, with more than 80 percent of households stating that they had experienced drought over the last 5 years. Erratic rainfall ranked second in importance, with a third or more households experiencing this climate shock in 5 out of 7 study districts over the last five year. Floods affected a small share of households across all AEZs and hailstorms affected some households in three of the study districts. The main effect of climate-related shocks was a reduction in crop yield and in some cases loss of an entire crop. Other effects reported by farmers include increased food shortages, food price increases, death of livestock, and loss of income and assets.

The main coping responses involve the purchase of additional food, reducing consumption, or consuming different foods. Purchasing food was particularly important; between 37 and 63 percent of respondents reported purchasing food in response to climate-related shocks. Livestock is also shown to be an important asset for households facing climate shocks. Between 11 and 24 percent of households reported selling livestock in response to climate shocks, depending on the type of shock. Some households also depended on formal and informal sources of credit, social safety programs, or off-farm employment to cope with climate shocks.

In terms of perceptions of long-term change in climate, 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. Moreover, 91 percent of farmers reported a long-term increase in rainfall variability, across all districts and AEZs. Actual climate data for the period 1957 to 1996 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, other studies have shown

an increase in minimum temperatures, particularly during the wet season. Temperature increases have a significant impact on water availability, thus exacerbating drought conditions. Farmers' climate perceptions are likely based on an observed decline in water availability is are due to temperature increases as well as 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.

Drought and climate change were reported as the two main reasons for the appearance and disappearance of various feed sources for livestock over the past 10 years. However, perceptions of the causes differ by AEZ. The impact of technology seems to be the main perceived reason in Gem and Siaya, while flood is thought to reduce the availability of feed resources 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. Thus, perceptions clearly reflect the agricultural potential of different districts.

Nineteen percent of farm households who perceived long-term climate change responded that they did not implement any adaptation measure. This share is much lower than comparable figures for the Nile Basin of Ethiopia (37 percent) and the Limpopo Basin of South Africa (62 percent). Key adaptation strategies chosen include changing crop variety (33 percent), changing planting dates (20 percent), and changing crop type (18 percent). Other, less important strategies include planting trees, reducing livestock, changing livestock feed, changing fertilizer use, and soil and water conservation (SWC) practices.

In terms of agricultural adaptation options, we find that the range of household-level adaptations implemented is very limited in the arid pastoralist area of Garissa. On the other hand, households in the temperate coffee areas of Mukurwe-ini and Othaya were most likely to adapt. Moreover, households in the project sites of ALRMP and SMS generally listed more adaptation measures than the respective control sites did. In the arid zone, moving animals was the key adaptation measure, while changing planting decisions, including crop variety and type and planting dates were most important in the other zones. In the semi-arid zone, we find more SWC measures in the ALRMP site compared to the control site. Similarly, in the temperate zone, the SMS site shows statistically significant higher use of soil and water management techniques.

Community-based adaptation strategies include development of soil and water conservation structures, sinking boreholes, constructing earthen dams, and protecting springs.

We find significant differences between actual adaptations undertaken and desired adaptations. Almost half of all farm households listed irrigation as the most desired adaptation, followed by planting trees (39 percent). 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); 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 (63 percent) and lack of access to water (26 percent) were considered key constraints for irrigation development; and lack of access to land (6 percent), water (20 percent), inputs (10 percent), and information (5 percent) 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 (36 percent), lack of access to inputs (26 percent), and lack of information (24 percent). 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.

An analysis of the factors influencing adaptation shows that these factors vary widely depending on the adaptation strategy chosen. Access to irrigation is shown to be an important determinant of whether farmers change crop types, suggesting that farmers are switching to high value crops which require irrigation. Access to social safety nets, extension services and climate information influence farmers planting decisions, are important factors influencing whether farmers decide to change planting dates. Farmers with access to food or other aid, extension services, fertile soils, larger land holdings, and with both crop and livestock production, were more likely to change crop variety.

Wealthier households with access to extension services were more likely to plant trees as an adaptation strategy. As with planting trees, farmers that appear to be better off financially are more likely to engage in destocking (reducing the number of livestock). Households that are male-headed that have been involved in farming longer as well as those with access to extension are more likely to changing livestock feeds. Having access to informal sources of credit is an important determinant of both destocking and changing livestock feeds.

Farmers with mixed crop and livestock systems, formal land titles, access to non-farm sources of income, and access to extension were more likely to change fertilizer application. 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.

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 poor spacing and timing of precipitation increase. 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. Figure 1 is a map of the study sites.

Table 1: Study sites

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

*In Garissa, project and control households were selected from within the same administrative units. Project households were identified by project officers.

In addition, survey sites were selected to include areas in which complementary World Bank-funded projects are operating, in order to build on ongoing research and data collection efforts and produce

results that are relevant to these initiatives. In particular, the study included divisions in Garissa and Mbeere which participate in the Arid Lands Management Project (ALRMP) and are representative of semi-arid and arid low-potential areas with a predominance of pastoralists and agro-pastoralist systems. The study also included districts, representative of high-potential crop production areas, where two GHG mitigation projects operate, SMS Ltd. and VI Agroforestry. Control sites were selected with comparable biophysical and socioeconomic characteristics for each of the program district/divisions. 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: 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 Description of the programs

The Arid Lands Resource Management Project (ALRMP) is a community-based drought management project of the Kenya Government (GoK), which operates in 28 arid and semi-arid districts. The project involves four components: drought management, natural resource management, community driven development, and support to local development. Project activities vary from district to district although some main activities include the following:

- Formulate and implement policies and institutions for drought management
- Coordinate the mobilization of resources for drought management
- Coordinate all stakeholders in drought disaster risk reduction and management
- Empowering communities to effectively manage their own development
- Creating an enabling environment for ASAL development
- Monitoring and evaluation of the drought disaster management program

Sustainable Management Services (SMS), Ltd. works in three project areas covering a total land area of 18,000 ha split evenly between homestead (housing, animal sheds), coffee and other crops, mostly subsistence. SMS promotes a package of agricultural activities or “best agricultural practices (BAPs)” aimed at smallholder coffee farmers with the goals of increased productivity, greater resilience to climate change, and soil carbon sequestration.

The practices promoted by the project include the following:

- Cover crops contribute to the fixation of nitrogen, and provision of mulch
- Soil management involving optimal application of fertilizer with emphasis on composting and optimizing the use of natural available organic fertilizer in order to reduce the use of chemical fertilizers harmful to the atmosphere
- Coffee tree management, including pruning, stumping, de-suckering, generates biomass that can be used for mulching and reduces need for chemical spraying to prevent pest and disease
- Proper collection and handling of pulp and organic waste material for use in soil composting, thereby increasing soil fertility
- Trenching and terracing to reduce water runoff and preserve soils
- Improved crop varieties for resistance to disease and climate threats that are otherwise treated with chemical sprays and fertilizers
- Agroforestry involving the planting of shade trees within the coffee area and along boundary lines

Coffee farmers who participate in the project generate carbon credits that will be purchased by the Bio Carbon Fund over a ten-year period; although, the main motivation for farmers to adopt the BAPs is the substantial increase in coffee yields and quality, which will contribute significantly to an increase in farm revenues.

The number of farmers engaged in the project exceeds 25,000, representing a population in excess of 150,000. Based on coffee acreage of 6,000, the area has a potential to sequester 18-24,000 tCO_2e per year, assuming 3 tCO_2e per ha. Sequestration on land used for other crops, (6,000 Ha), represents a further potential asset for SMS to exploit at a later stage, the immediate focus being on agricultural activities in the coffee production areas.

Vi Agroforestry promotes the adoption of sustainable agricultural land management (SALM) practices among smallholders in Western Kenya as an engine of economic growth and a means to reduce poverty. The project encompasses 116,387 ha, upon which sustainable agricultural land management practices will be adopted on approximately 60,000 ha. Farmers that participate in the project will also earn an income from the carbon trade, as the SALM practices increase soil carbon sequestration.

The package of SALM practices to be promoted fall under the categories of cropland management, restoration of degraded lands, bio-energy, and livestock management in order of importance. Specific activities include the following:

- Cropland management
    - Agronomy involving crop rotation, use of improved crop varieties, and the integration of cover crops Nutrient management including mulch (weed) management (cow pea, beans, sweet potato), improved fallow, green manure undersowing, manure, compost management, replacing inorganic with organic fertilizer, targeted application of fertilizer

- Improved tillage and residue management including practices such as minimum soil disturbance, maize residue management in trash lines, drainage channels, contour lines, ridging, improved fallows
- Agroforestry involving the integration of trees into the existing farming system of intensive cropping of both annual and perennial crops.
- Water management including water harvesting for agriculture (small dams, ponds, half moons), double dug beds, terracing, erosion control, tie-ridges

- Restoration/ Rehabilitation of degraded lands:
  - Organic amendments such as green manuring and composts on agricultural land has been degraded by erosion, excessive disturbance and organic matter loss
  - Area enclosure, riverbank tree planting, gully control, and various types of fallows (grass planting, natural bush vegetation)
- Livestock management
  - Integration of livestock into cropland management systems is of particular importance and plays an important economic role for smallholders.
  - Sustainable management of grazing in combination with fallowing and/ or rehabilitation of degraded lands

2.1.3 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 as well as between program and control sites are drawn.

Econometric analysis was used to examine the factors determining adaptation strategies. Adaptation strategies are analyzed as a function of social, human, and physical capital and assets, and access to services and information.

The qualitative 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. Climatic shocks and coping strategies

3.1 Experience of climate shocks

Households were asked if they had experienced any climate-related shocks over the past five years. Households identified drought, flood, erratic rainfall and hailstorms as the main climate-related shocks in Kenya. As Figure 2 shows, more than 80 percent of all households in all study sites had experienced droughts over the last 5 years, with the highest percentage, 96 percent, in Garissa. The second most important climate shock cited was erratic rainfall; which was mentioned by half the households interviewed in Njoro, by 46 percent in Mukurwe-ini, 47 percent in Othaya, and 48 percent in Mbeere South. About one third of households in Siaya experienced erratic rainfall, 18 percent in Gem, and 1 percent in Garissa. Hailstorms were important in Siaya, where 39 percent of households mentioned it and Gem, where 16 percent of households experienced hailstorms. Floods finally were mentioned again across all sites, but only few households had experienced them directly, with the highest share in Njoro, at 13 percent, followed by Gem, at 5 percent. These results show the importance of drought in Kenyan farm household's livelihoods, which is consistent across all agroecological sites studied.

Figure 2: Climate related shocks experienced over the past five years, by district

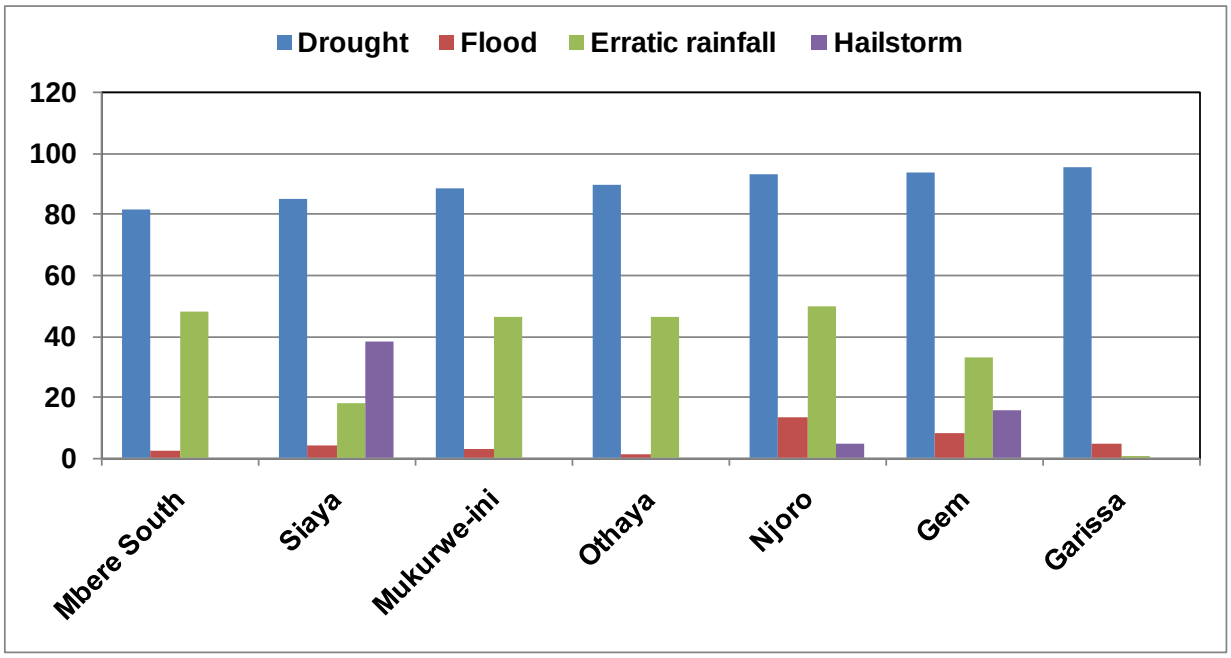
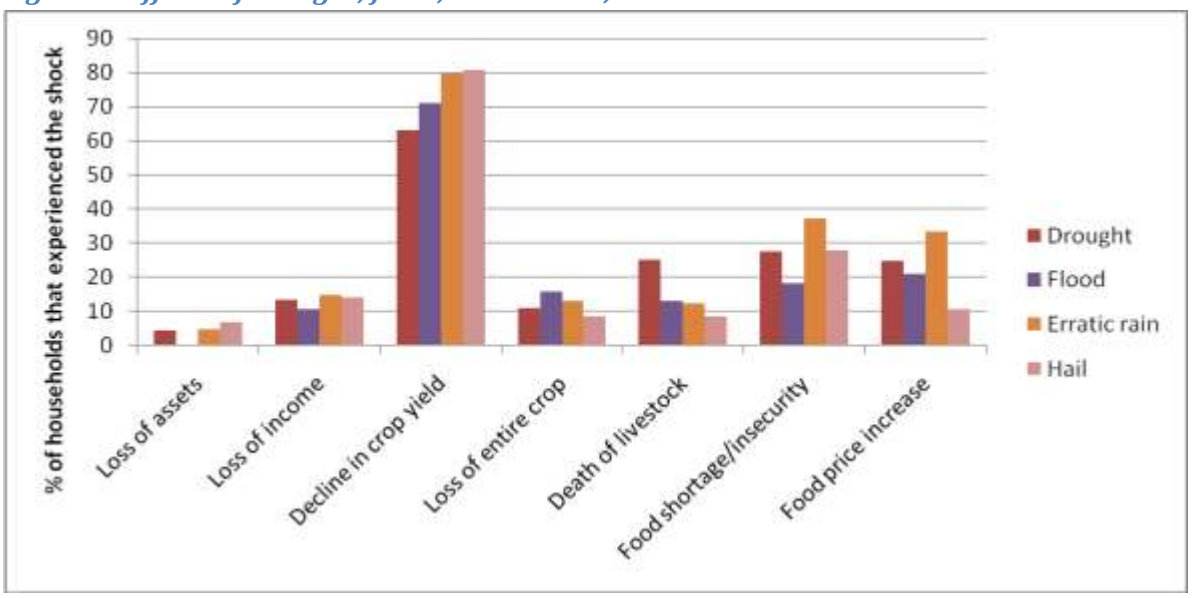


Figure 3: Effects of drought, flood, erratic rain, and hailstorms



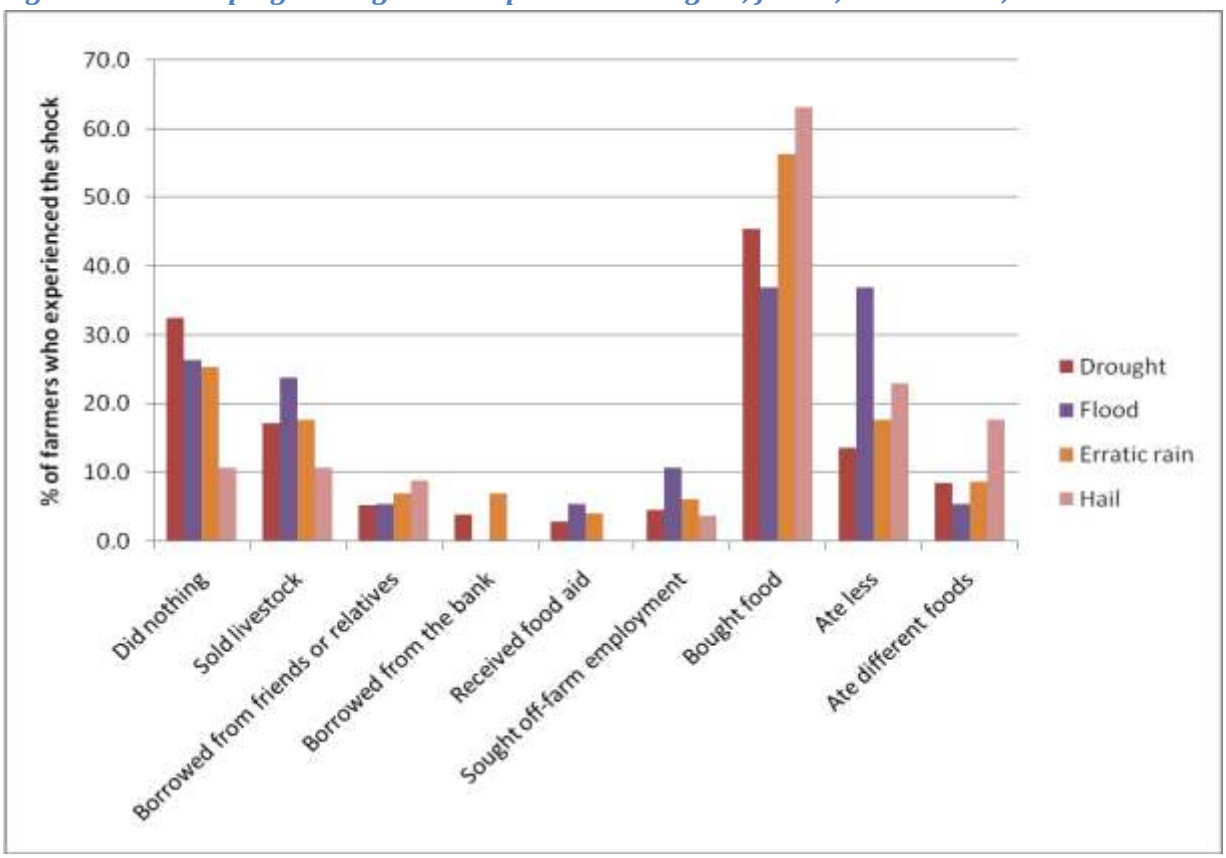
Note: Only those strategies reported by more than 5 percent of farmers are shown

Farmers also reported the main effects of these shocks. Figure 3 shows the main results of shocks reported by farmers. As shown, the main effect of all types of shocks was a reduction in crop yield. Between 63 percent and 81 percent of farmers reported experiencing a decline in yield as a result of climate-related shocks. Some farmers (between 9 and 16 percent) reported losing their entire crop as a result of shocks. Other important effects include increased food shortages, food price increases, death of livestock, and loss of income and assets.

3.2 Coping strategies

Households were asked about the types of coping strategies used to deal with climate shocks. The main coping responses in relation to drought, flood, erratic rain, and hail are shown in Figure 4. Given that the main result of the climate shocks was a decline in crop yield (or in some cases a loss of the entire crop) it is not surprising that the main coping responses involve the purchase of additional food, reducing consumption, or consuming different foods. Purchasing food was particularly important; between 37 and 63 percent of respondents reported purchasing food in response to climate-related shocks, depending on the type of shock. This suggests that access to markets and affordable sources of food are important for households facing climate shocks. However, as was 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 shocks may face difficulties meeting their consumption needs for multiple reasons.

Figure 4: Main coping strategies in response to droughts, floods, erratic rain, and hail



Note: Only those strategies reported by more than 5 percent of farmers are shown

Livestock is also shown to be an important asset for households facing climate shocks. Between 11 and 24 percent of households reported selling livestock in response to climate shocks, depending on the type of shock. Average livestock holdings are shown in Table 2 for the main types of livestock by district. Thirty-one percent of surveyed households owned livestock (sheep, goats, oxen, cattle, other cattle, rabbits, pigs, or poultry). In Garissa none of the households owns any cattle (defined as breeding bulls), oxen, or pigs. Oxen are owned only in Gem, Mukurweini, and Siaya. Pigs are owned in Mukurweini and Siaya, while smaller species like rabbits are owned in Mbeere South, Njoro, and Othaya. In addition to differences in total ownership of livestock, the absolute numbers of each type owned by household members as well as the value of livestock holdings varied widely. Across the different districts, Garissa has the lowest number of livestock holdings together with one of the highest average number of animals per household; in particular this district has the highest number of goats and sheep.

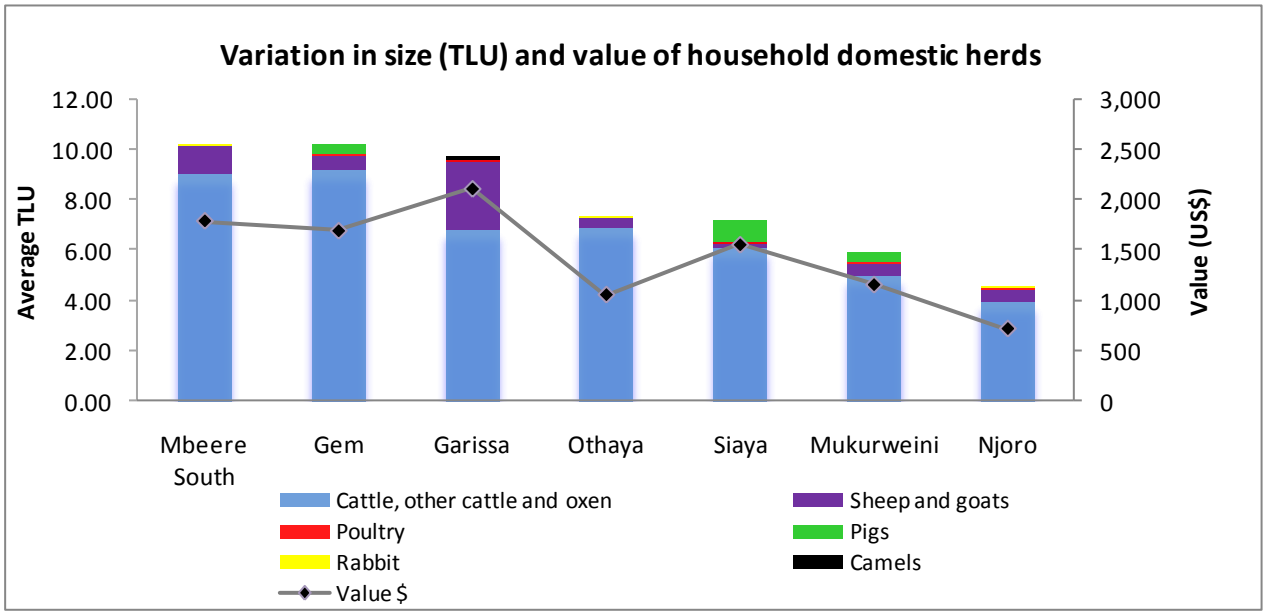
Table 2: Summary of Domestic Livestock Holding per district (average and standard error).

District	Cattle	Oxen	Other cattle	Sheep	Goats	Poultry	Camels	Pigs	Rabbits
Garissa			4.8 ± 2.6	6.0 ± 4.0	22.0 ± 12.2	2.0 ± 0	2.6 ± 0.4		
Gem	1.0 ± 0	1.5 ± 0.5	1.6 ± 0.3	2.3 ± 0.9	2.3 ± 0.9	5.2 ± 1.4		2.0 ± 0	
Mbeere South		2.4 ± 0.5	2.8 ± 0.5	3.9 ± 2.5	3.1 ± 2.2	3.9 ± 1.8			1.0 ± 0
Mukurwe-ini	1.5 ± 0.5	1.0 ± 0	1.1 ± 0.1	2.0 ± 0	2.3 ± 0.2	8.4 ± 2.0		2.0 ± 0	
Njoro	1.0 ± 0		1.8 ± 0.3	2.2 ± 0.3	2.0 ± 0	7.8 ± 1.3			
Othaya	1.7 ± 0.7		2.5 ± 0.5	2.5 ± 0.5	1.3 ± 0.3	11.7 ± 3.2			1.5 ± 0.5
Siaya	1.7 ± 0.3	1.2 ± 0.2	1.3 ± 0.1	1.0 ± 0	1.2 ± 0.2	4.0 ± 0.8		4.0 ± 0	

Cattle dominate the value of production in the study sites, followed by sheep and goats (see Figure 5).[1] This suggests that households that own cattle are more resilient to climate shocks. However, during covariate shocks, such as droughts, the price that can be obtained for selling animals is often significantly reduced as many households attempt to sell at the same time (Horowitz and Little, 1987; Blench and Marriage, 1999).

[1] The value of the livestock assets was defined taking into account an average between the price per unit of animal purchased and the average price per unit of animal sold.

Figure 5: Variation in size and value of household domestic herds



Formal and informal sources of credit also appear to be important coping strategies for some households dealing with climate shocks. Some households also relied on social safety programs such as food emergency relief, food subsidies or other farm support during climate crises. Others sought off-farm employment to cope with climate shocks. These findings suggest that social safety nets as well as expanding access to credit are ways in which the public sector can support households vulnerable to climate shocks. Livelihood diversification (in particular off-farm sources of income) also appears to be important for increasing resilience to climate variability.

It is surprising that between 11 and 33 percent of households (depending on the type of shock) reported doing nothing in response to climate shocks. At the very least, these households would be forced to reduce or change consumption as a result of a shock unless the shock was mild requiring no action on the part of the household. Other possible reasons for this response would be that these farmers are already growing crops or keeping animals that are tolerant to some shocks (drought, erratic rainfall, etc.) but they may also do nothing due to lack of information, technology, or credit to counter the shocks.

When we examine the coping strategies reported by households across the different agroecological zones we find that 87 percent of households in the arid areas reported that they did nothing in response to climate shocks (Table 3). This number is significantly higher than in semi-arid, temperate, and humid sites. This may be due to the fact that households in the arid areas are already dealing with more difficult climate conditions and are therefore less likely to respond to climate shocks. A few households in the arid areas did report eating less (4 percent) or selling livestock (2 percent) to cope with climate variability. In the semi-arid areas purchasing food (46 percent), selling livestock (30 percent), reducing consumption (8 percent), and receiving food aid (5 percent) were the main coping strategies reported. Households in the temperate and humid sites reported a wider range of coping strategies. In the temperate areas the main strategies were buying food (48 percent), selling livestock (21 percent), eating

different foods (9 percent), eating less (8 percent), and borrowing from the bank or relatives (6 percent). In the humid areas, the main coping strategies were: purchasing food (69 percent), eating less (28 percent), eating different foods (18 percent), selling livestock (7 percent), and borrowing from friends or relatives (6 percent).

Table 3: Coping strategies by agroecological zone

Coping strategy	Arid	Semi-Arid	Temperate	Humid
Did nothing	87.3	27.7	19.1	11.5
Sold livestock	1.5	30.2	20.8	7.3
Borrowed from friends or relatives	0.0	4.5	5.5	6.3
Borrowed from the bank	0.0	0.0	6.0	0.5
Received food aid	0.5	5.0	2.7	2.1
Sought off-farm employment	0.7	0.7	5.5	4.2
Bought food	0.0	46.0	47.5	68.8
Ate less	3.7	8.4	8.2	27.6
Ate different foods	0.0	4.0	8.7	18.2

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

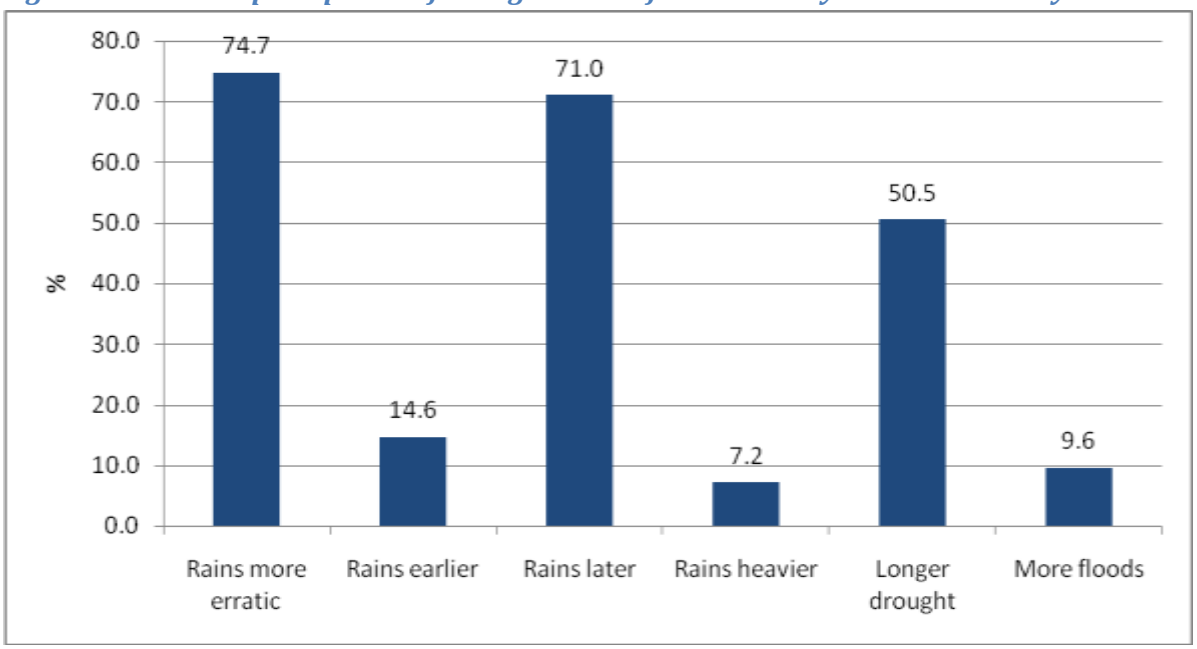
4. Climate change perceptions

4.1 Perceptions of climate changes

In addition to asking households about climate-related shocks, they were also asked about their perception of long-term changes in climate. The results show that farmers are keenly aware of long-term climate change. 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 6). 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 6: 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[2] 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

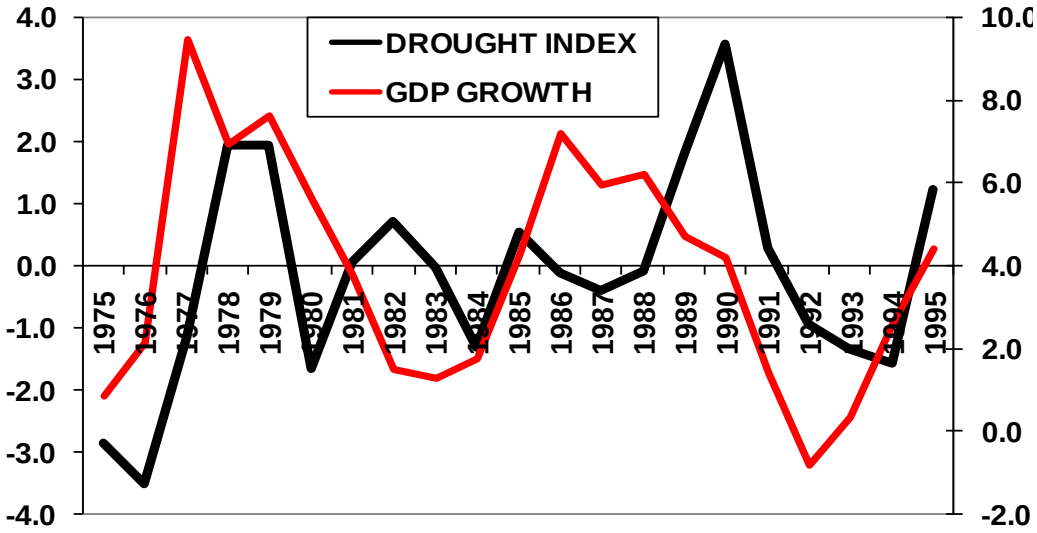
[2] Precipitation data is from the "Global Historical Climatology Network" (GHCN) database available at http://www.ncdc.noaa.gov/ghcnm/. Daily temperature data is from the "Global Surface Summary of Day" data base built based on data exchanged under the World Meteorological Organization, (WMO) World 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.

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,[3] is a robust determinant of agricultural performance as well as general economic performance in the country (Herrero et al. 2010). As shown in Figure 7, there is a strong association between drought and GDP growth, with growth dipping dramatically following each severe occurrence of drought.

Figure 7. Linkage between the Palmer Drought Severity Index (PDSI) and GDP growth, Kenya, 1975-1995



Source: IFPRI (2006).

[3] 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).

4.2 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 8 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 9, 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 8: Level of severity of shortage of feed during one year of period for cattle, sheep and goat.

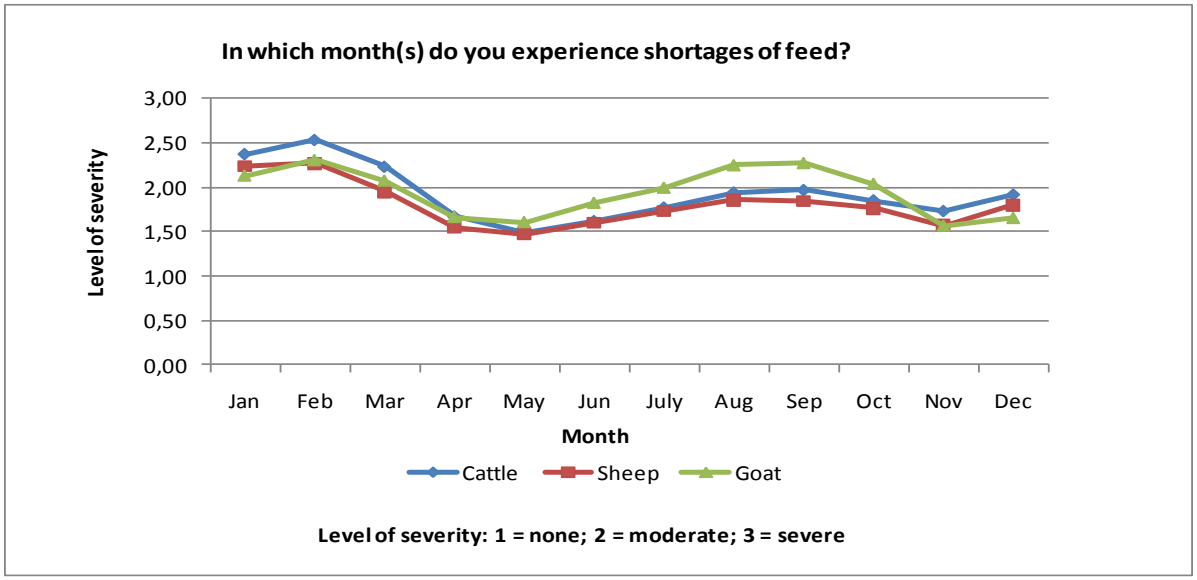
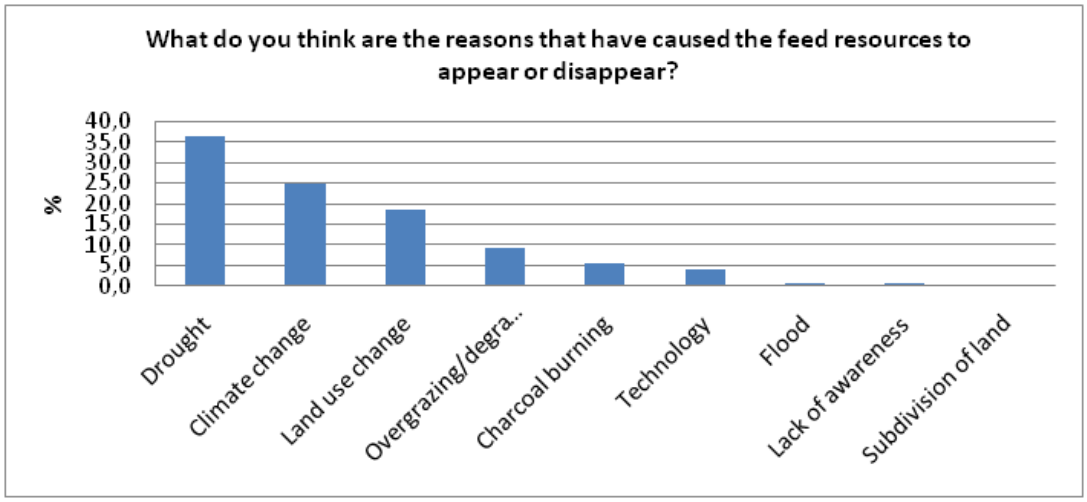
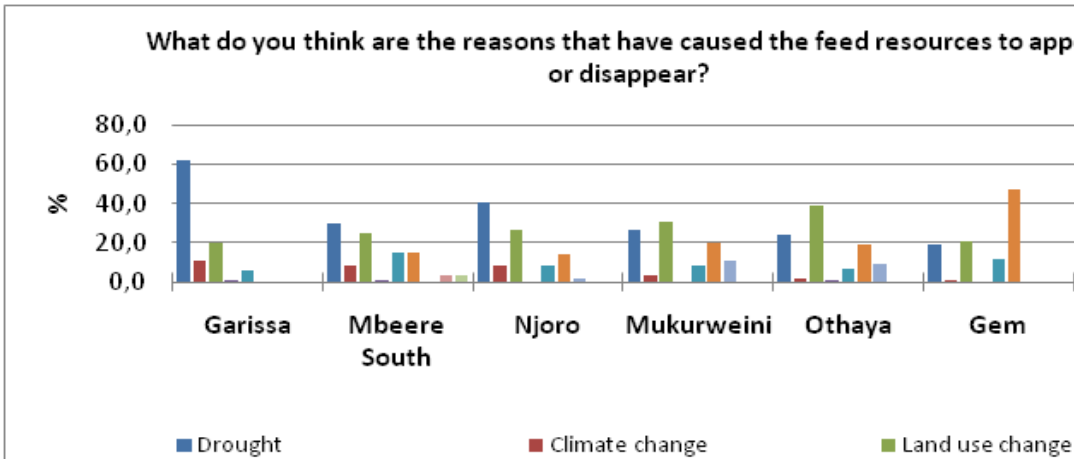


Figure 9: Rank for reasons that have caused the feed resources to appear and disappear.



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 10: 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

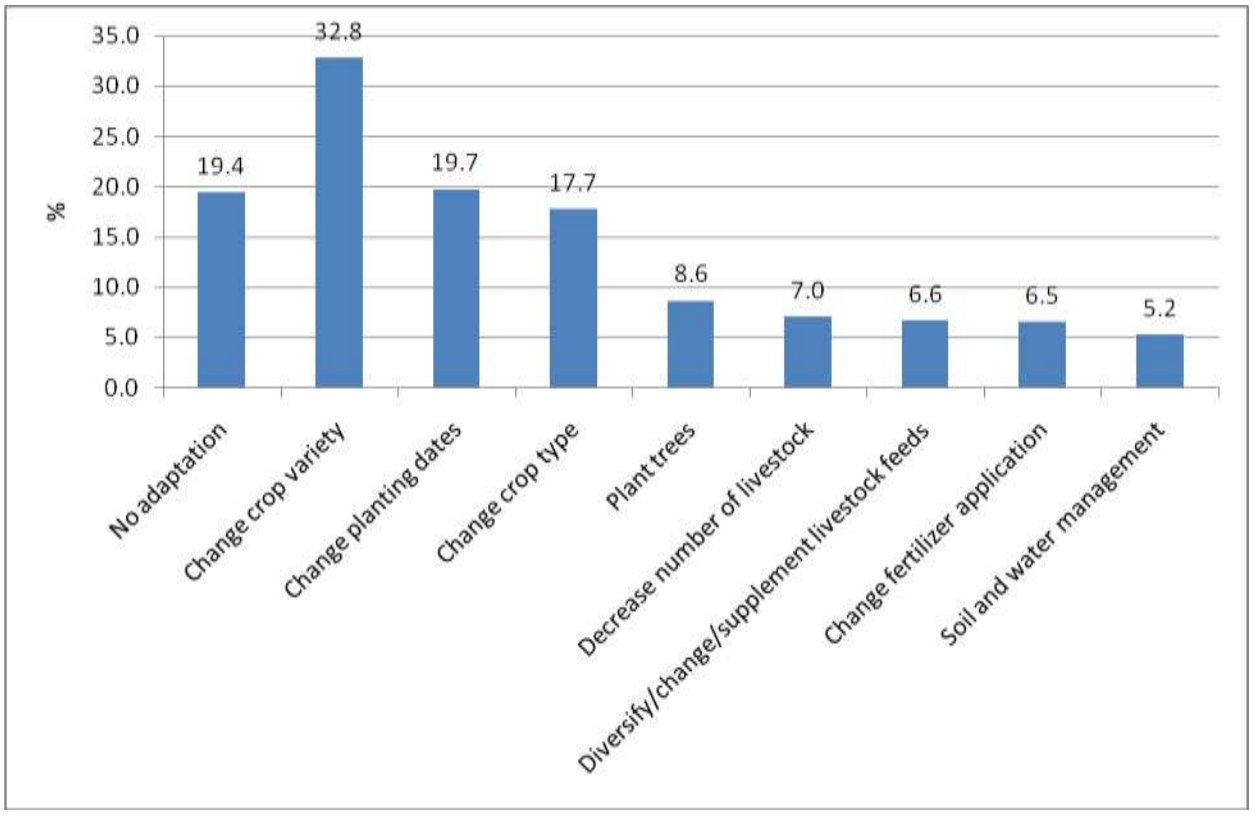
new feed resources appeared in the last 10 years, in particular: mathenge (*Prosopis juliflora*), napier grass (*Pennisetum purpureum*), desmodium (*Desmodium intortum*) and caliandra (*Caliandra calothyrsu*).

5. Adaptation to climate change

5.1 Household-level adaptation

Surveyed farmers adopted a range of practices in response to perceived climate change (Figure 11). 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 11: Changes in agricultural practices reported by farmers in response to perceived climate change

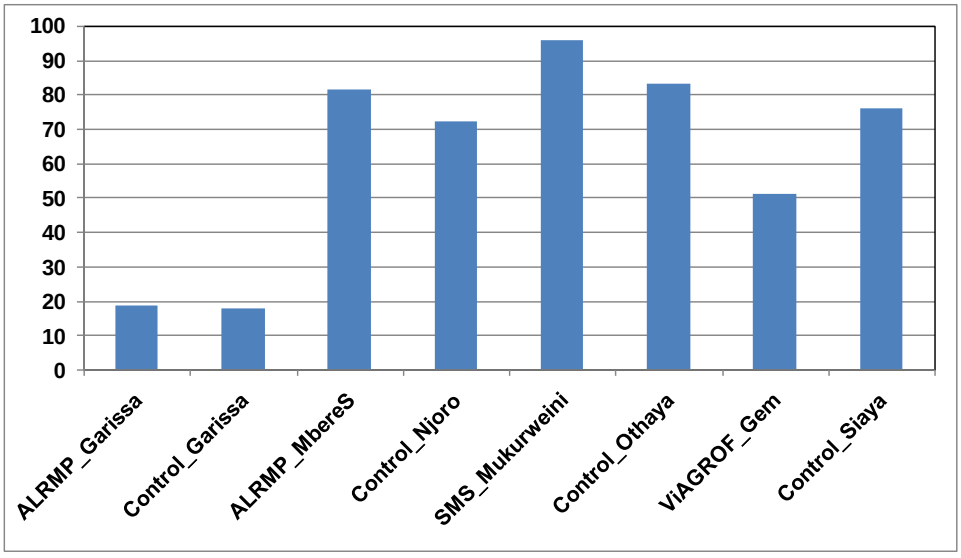


Note: Above adaptations only include options reported by more than 5 percent of farmers.

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 14), 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 12 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. Second, households in the project sites of ALRMP and SMS generally listed more adaptation measures than the respective control sites did. However, farm households in the Vi Agroforestry site listed significantly fewer adaptation measures than those in the control site. Results are similar for the variety of adaptation options undertaken. 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 still 22 different measures in the humid zone.

Figure 12: Share of households reporting adaptation options to perceived long-term change in temperature and precipitation



Source: Authors.

Table 4 presents the top three adaptation measures by agroecological zone. Changing planting decisions, including crop variety and type and planting dates, was the key adaptation measure in all but the arid zone. In the arid 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 4: 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 ALRMP and control site; 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.

Table 5 presents statistically significant differences between adaptation methods used in World Bank supported project and control sites, respectively.[4] There were no significant differences between adaptation measures chosen by project and control households in Garissa. While ALRMP provided services related to climate change adaptation, similar activities are likely to have been provided to control households by the many other NGOs and government agencies that operate in the district. Moreover, it appears that, generally, the range of adaptation options in the arid zone is limited. In the semi-arid zone, households in the ALRMP project site are significantly more engaged in soil and water conservation measures, tree planting, and changes in livestock production (both decreasing the number of livestock and changing animal breeds) than their counterparts in the non-ALRMP site.

In the temperate, coffee-growing zone, the SMS site shows statistically significant higher use of soil and water management techniques, changing planting dates, and a reduction in meat consumption. For the carbon project and the Voluntary Carbon Standard (VCS), SMS was proposing increasing tree cover and

[4] These numbers are suggestive only. In order to demonstrate whether the programs had an impact on the likelihood of adapting, we would need to control for other confounding factors using econometric methods such as propensity score matching.

composting of coffee husks with manure prior to use for coffee systems; composting of crop residues and manure prior to use for maize systems; and composting of manure prior to use for napier grass systems. The manure management activities supported by SMS might be part of the soil and water conservation techniques that show significant higher mentioning in the SMS site. On the other hand, tree planting was significantly higher in the control site.

Table 5: Adaptation measures with significant differences between WB project and control sites

AEZ	**SEMI-ARID**		**TEMPERATE**		**HUMID**	
Adaptation method	ALRMP Mbeere South	Control Njoro	SMS Mukurweini	Control Othaya	Vi AGROF Gem	Control Siaya
Change crop variety					**5.88**	**17.89**
Change planting date			**16.49**	**6.82**	**15.69**	**33.68**
Increase land area					**9.80**	**3.16**
Soil and water management	**17.35**	**0.00**	**11.34**	**2.27**		
Plant trees	**19.39**	**8.65**	**7.22**	**15.91**	**7.84**	**2.11**
Eat less meat			**3.09**	**0.00**	**0.00**	**3.16**
Increase number of livestock	**0.00**	**1.92**				
Decrease number of livestock	**16.33**	**6.73**				
Change animal breeds	**7.14**	**0.96**				
Off-farm employment					**8.82**	**0.00**

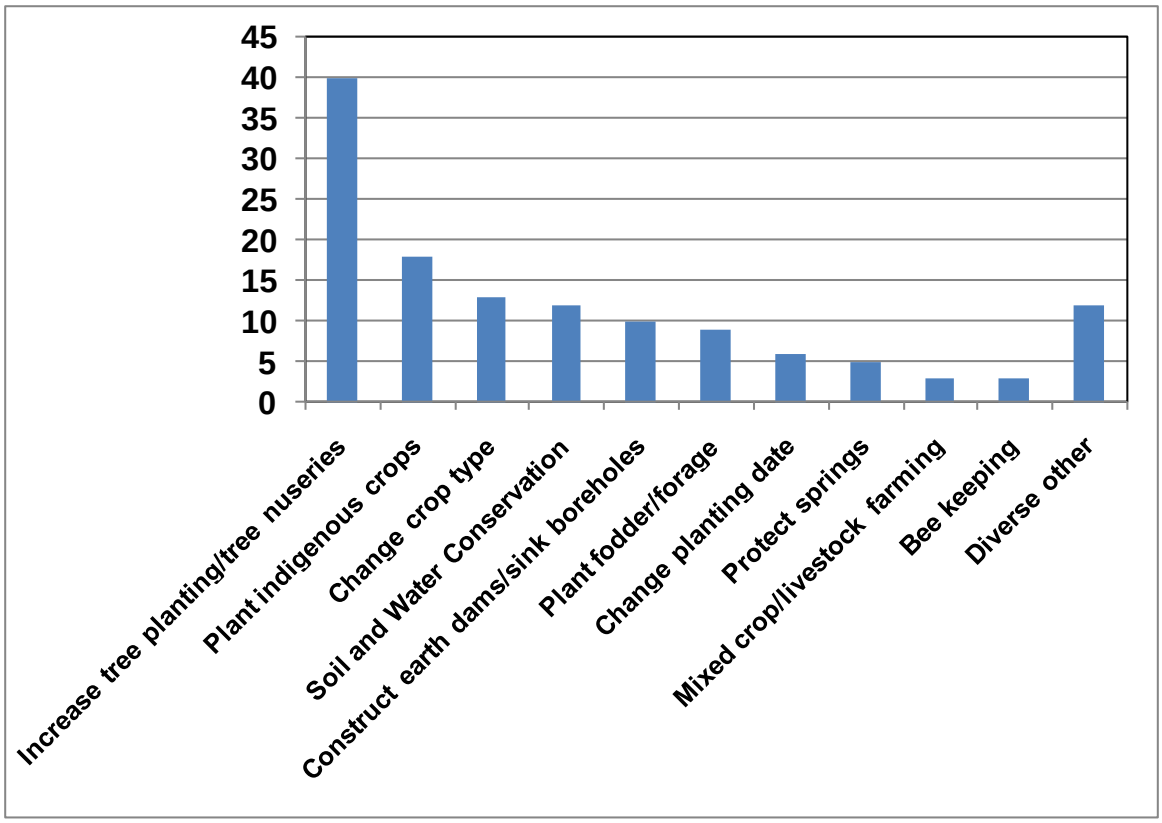
In the humid site, the project site of Vi Agroforestry showed significantly higher use of expanding land area, planting trees, and off-farm employment, whereas the control site showed higher use of changing crop variety and planting date and eating less meat as adaptation strategies. The BioCarbon fund supported project introduced sustainable agricultural practices such as manure management, use of cover corps, and returning composted crop residuals to the field, and the introduction of trees into the landscape as methods for increasing the carbon stocks on the land. However, only planting trees was shown to be used significantly more as an adaptation strategy in the project site.

5.2 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 13 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 13: Community-identified adaptations to climate change



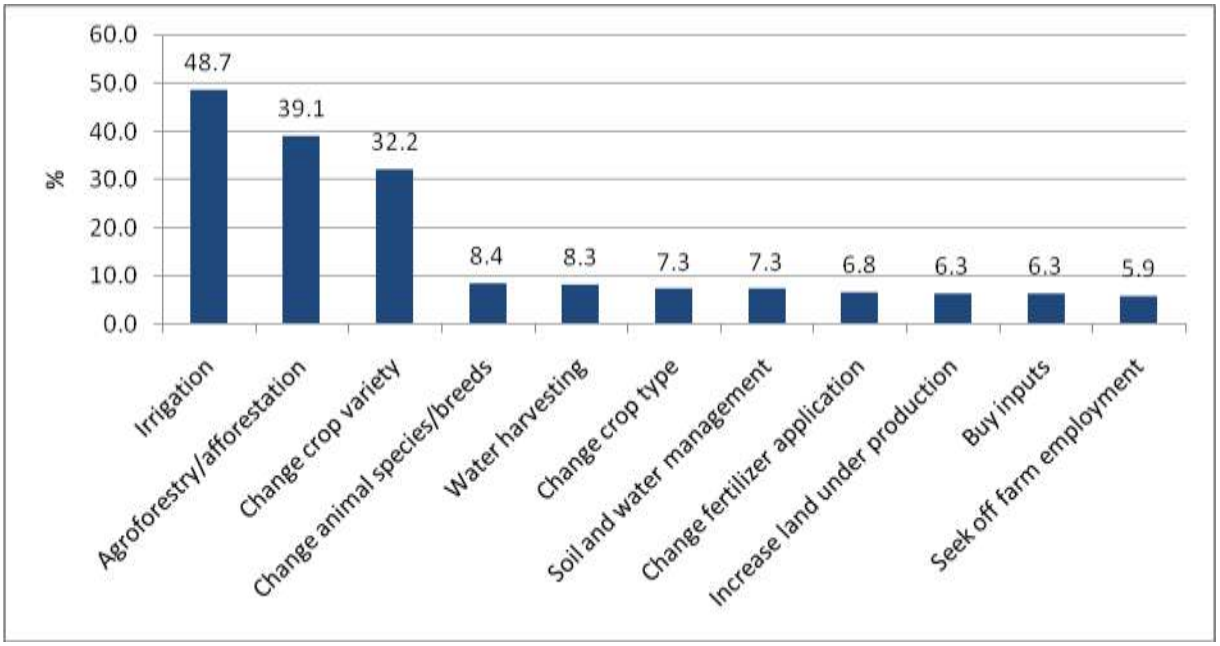
5.3 Desired adaptations and constraints to adaptation

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 14).

Figure 14: Adaptations farmers would like to implement in response to climate change

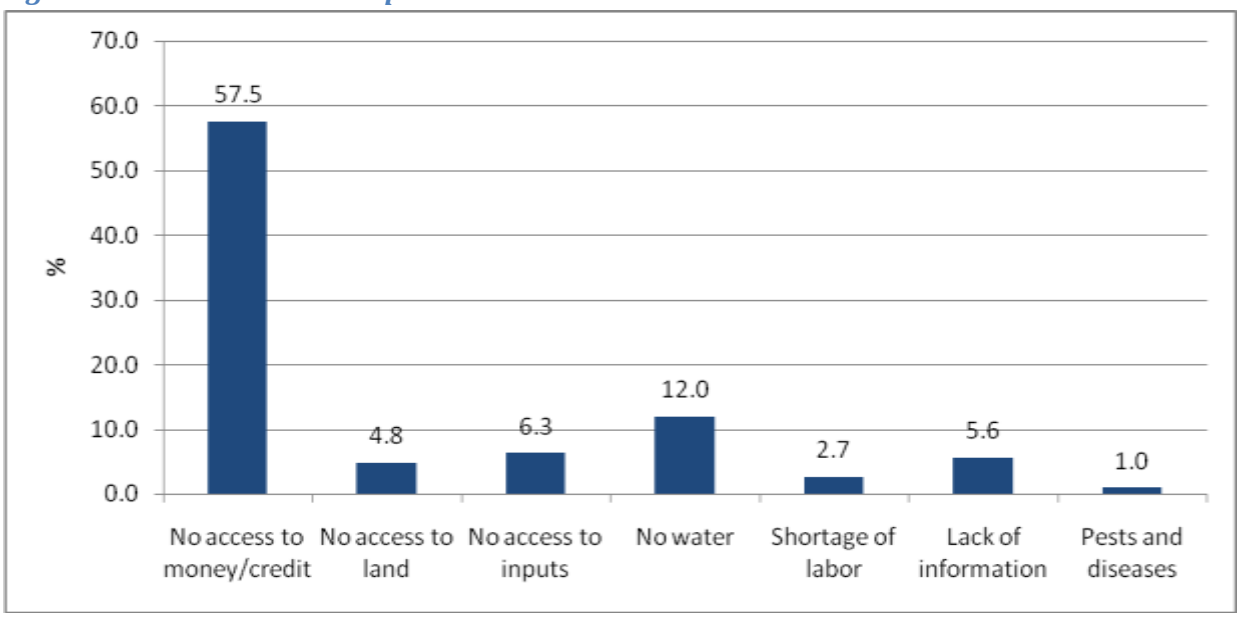


Note: Above figure includes only those responses reported by more than 5 percent of farmers

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 15. 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[5] or cash earning opportunities would enable farmers to meet the initial costs of more considerable investments, such as irrigation.

Figure 15: 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

[5] 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.

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).

5.4 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 11 above). We also analyzed the decision to adapt any adaptation strategy using a dummy variable for whether the household adapted or not.

The results (marginal effects) are presented in Table 6. 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. However, 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[6]), 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.

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

Table 6: 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 6 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.[7]

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).

6. Conclusions and policy implications

The above results show that households face considerable challenges in coping with and adapting to climate variability and change. Many of the coping responses to climate-related shocks, such as drought and erratic rain, reported by households are the sort of "last-resort" decisions that households are typically reluctant to make, such as selling livestock (particularly when they are not likely to get a good price), reducing consumption or changing consumption patterns. This suggests that the surveyed households are in a very precarious situation and that climate shocks can have a particularly devastating effect on household well-being. Greater effort is needed to increase the resilience of households to cope with climate variability, through the accumulation of assets and wealth.

In addition, given the effect of shocks, such as drought and erratic rain, on crop yields, food availability, and food prices; public action is needed to ensure households meet their consumption needs. This may take the form of food aid, food subsidies or other programs that offer a social safety net to households

[7] 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.

vulnerable to climate shocks. Other public actions that would increase resilience to climate shocks include expanding access to weather insurance and increasing food stockpiles to be used during poor production years.

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 indeed 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 cited 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 analysis of the determinants of adaptation suggests that there are effective policy levers to support the adoption of adaptation strategies. The results also 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.

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Appendix: Additional data on livestock production

Livestock provide many benefits to pastoral families in the form of milk, meat, leather, manure and socio-cultural capital. At the same time they represent a considerable asset that can be traded or sold in hard times or for purposes such a paying food, school fees, medicine expenses or providing a dowry. Households analyzed in the study took the form of a cluster of families living within a homestead and utilizing a single domestic herd.

1. Domestic herd Size and Composition

1.1 Conversion of livestock number to Tropical Livestock Unit (TLU)

The size of the domestic herd was measured on absolute numbers and on tropical livestock units (TLU). A conversion factor has been applied to transform livestock numbers into standardized TLU, see table 1 for the conversion factors. This last factor permitted calculation of per household TLUs.

Table 1. Conversion of livestock number to Tropical Livestock Unit (TLU)

Livestock species	TLU
Cattle	1.43
Oxen	1.43
All other cattle	1.43
Sheep	0.10
Goats	0.10
Poultry	0.01
Camels	1.00
Pigs	0.20
Rabbit	0.02

Source: ILRI, 1995.

ILRI (International Livestock Research Institute). 1995. *Livestock Policy Analysis.* ILRI Training Manual 2. ILRI, Nairobi, Kenya. pp. 264.

1.2 Wealth in Livestock

Minimum subsistence thresholds of 4.5 TLUs per household can be used to identify households in poverty (Herren, 1990). Table 2 shows the absolute number of each type of animal owned per household. When only the domestic herd is counted as an indicator of household wealth, the majority of

households are classified between poor and sufficient: for 181 households the average TLU is below 3.5, for 20 of them is between 3.5 and 7, while for 16 is higher than 7. However none of the households in our sample uses its land uniquely for livestock and in general tends to do a mixed use of the land, combining crop production with livestock and grazing/pasture land.

Table 2. Summary of Domestic Livestock Holdings.

	Mean ± SE	Range
Camels	2.6 ± 0.4	1 -5
Cattle	1.5 ± 0.2	1-3
Oxen	1.8 ± 0.3	1-5
All other cattle	2.1 ± 0.2	1-12
Sheep	3.1 ± 0.6	1-16
Goats	8.0 ± 2.2	0-120
Poultry	8.5 ± 0.9	1-50
Pigs	2.7 ± 0.7	2-4
Rabbit	1.3 ± 0.3	1-2

1.3 Livestock keeping reason

For local communities in these semi-arid districts, livestock is the main source of wealth, and income is derived from the sale of livestock and its products. The sale of animals during dry season to purchase food is a way to reduce the vulnerability of households to severe food scarcity, playing an important role in local food security (Nyariki, 1997). Table 3 shows the rank of reasons for purchase and exit of cattle, sheep, goats, poultry, and pigs. Table 4 shows the different ranks for livestock keeping reasons.

The average ranking of reasons for keeping cattle indicated that farmers attached greater importance to milk production for feeding the family and for cash income and to production of manure than any other stated reason. 40% of the farmers declared they may sell cattle to financing food, school fees and medicines expenses. Income generation was mentioned as key reasons to keep pigs, for most of the farmers pigs were comparable to operating a bank account. Pigs were also thought to be good sources of manure. The main reason farmers keep cattle is the provision of draft power to cultivate the land and

manure to fertilize the soil. Traction and manure are both valuable and saleable products especially in agro-pastoral areas. Cattle are also kept to financing future expected expenditures.

Sheep, goats, poultry, rabbit, duck and camels formed the bulk of animals kept for provision of meat for feeding the family. Goats are rarely milked but their meat is preferred. Poultry are also kept for production of manure and eggs. Camels are important sources of milk.

Table 3. Rank of reasons for purchase and exit of cattle, oxen, other cattle, sheep, goats, poultry, pigs and rabbit.

Reason for purchase and exit	Cattle		Oxen		Cattle		Sheep		Goats		Poultry		Pigs		Rabbit	
	RP	RE	RP	RE	RP	RE	RP	RE	RP	RE	RP	RE	RP	RE	RP	RE
Insurance	10.3			10.10	4.5	2.4	2.1	1.9	1.4	1.2	5.9	5.8				
Store of wealth			4.3	10.0	16.2	2.4	27.7	3.8	25.7	1,2	25.5	25.0	100.0			
Financing future expected expenditures	20.7	27.8	26.1	5.0	15.1	34.8	21.3	60.4	12.2	46.9	25.5	25.0		50.0	33.3	
Increase social prestige					1.1		4.3		1.4		1.0	1.0				
Replacing old stock	6.9	16.7	8.7	20.0	7.8	6.1	4.3		9.5	3.7	2.9	2.9				
Obtain more manure	31.0			15.0	21.8	0.6	12.8		20.3		7.8	7.7			33.3	
More milk production	3.4				27.9		14.9		18.9		17.6	17.3				
For animal draft	20.7			35.0	1.1											
Replace animale that died	6.9			5.0	2.8		10.6		4.1		2.9	2.9				
Financing food, school fees, medicine expenses		44.4	43.5		0,6	40.2		22.6	5.4	33.3	6.9	6.7		50.0		
Lack of enough feed			4.3		1,1	5.5				6.2						
Breeding							2.1	3.8								
Death			4.3			2.4		3.8	1.4	2.5						
Diseases		11.1				0.6				2.5	2.0	1.9				
Meat			4.3							6.2	2.0	1.9			33.3	100.0
Too expensive to maintain			4.3			0.6						1.9				
To buy animal feed						0.6				1.2						
Drought						1.8		1.9		1.2						
Dowry payment						0.6										
To pay a credit						1.2		1.9								
Total	100	100	100	100	100	100	100	100	100,0	100	100	100	100	100	100	100

RP= Reason for purchase (%)
RE= Reason for exit (%)

Livestock also plays an important socio-cultural role and cattle, other cattle, goats and donkeys are still used as the primary means for the payment of a dowry or for supporting funerals. Farmers declared prestige may derive in raising pigs, sheep, goats, poultry and bees.

Table 4. Rank for livestock keeping reasons.

Livestock keeping reasons (%)	Cattle	All other Cattle	Camels	Sheep	Goats	Poultry	Donkeys	Pigs	Duck	Bees	Rabbit
Milk for food		28.6	26.7	1.6	19.1		4.2				
Milk for Sale (income)		20.2	17.8	1.2	8.8		1.1				
Meat for food	3.9	4.1	17.8	18.3	15.3	27.4	1.1	6.3	33.3		37.5
Meat for Sale (income)	6.6	2.2	4.4	12.7	4.7	6.2		18.8			
Eggs for Sale						16.7					
Draft power (traction)	18.4	0.1				0.2	11.6				
Insurance	4.7	2.0	4.4	2.9	2.7	2.1	1.1	6.3			
Financing of expected (planned expenditure)	13.7	8.2	13.3	17.5	13.6	12.5	14.7	12.5		33.3	12.5
Savings	8.3	5.3	4.4	10.3	9.1	9.9	5.3	18.8	33.3		25.0
Dowry payment	2.0	1.1		0.8	2.8	0.1	2.1				
Manure	29.2	24.1	2.2	25.1	18.6	13.7	4.2	25.0	33.3		25.0
Prestige (social status)	1.0	0.9		2.7	1.1	2.4	1.1	6.3		33.3	
Hides/skins	0.5	0.1		0.6	0.5	0.1					
Breeding	8.8	3.0	2.2	6.4	3.6	3.9	5.3	6.3			
Transportation	2.9	0.1	6.7		0.1	0.1	48.4				
Eggs for food						4.8					
Honey for sale										33.3	
Biogas		0.1									
Total	100	100	100	100	100	100	100	100	100	100	100

1.4 Livestock management dynamics

In general the households manage all the animal they own, a small part of them, 2 percent, may delegate to herdsmen the management of part of the herd for security purposes and lack of land for grazing. In few cases the households can manage animals they do not own primarily because in this way they can benefit from the products.

2. Feeding management practices

Tables from 5 to 11 illustrate the different type of feed provided to cattle, oxen, other cattle, sheep, goat, poultry and pigs in each district during the 1rst dry season, which covers the months from January to February, during the 1rst rain season, which goes from March to May, and during the 2nd rain season starting on October and ending on December.

These tables show that all the households have a homogeneous feeding management for the different categories of animals. Short distance rangelands remain the primary source of feed during dry and wet

seasons, maize stover, roadside weeds and cut and carry fodders represent the other sources of feed for the herd.

Table 5. Types of feed provided to cattle, oxen, other cattle, sheep, goat, poultry and pig (number of respondent on 134 interviewed people on Garissa district).

	Other cattle			Sheep			Goat		
	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season
Rangeland(short distance)	6	14	10	2	1		17	19	15
Rangelands(long distance)	13	6	3	1	1	1	13	5	2
Crop lands(specify which crop)	2								
Forest areas	4	6	1	1	1	1	6	12	7
Maize stover							1		1
Legume stover							2		
Sorghum stover									
Millet stover									
Cowpea stover									
Salt									
Crop by products (brans,cakes)	1						1		
Roadside weeds			1			1		2	
Cut and carry fodders								1	2
Hays							1		
Dairy meal									
Maize grains									
Sorghum and millet grains									
Kienyeji mash							17	19	15

Table 6. Types of feed provided to cattle, oxen, other cattle, sheep, goat, poultry and pig (number of respondent on 96 interviewed people on Gem district).

	Cattle			Oxen			Other cattle			Sheep			Goat			Poultry		
	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season
Rangeland(short distance)	2	6	5	2	5	4	16	48	46	3	8	5	6	27	26	19	23	21
Rangelands(long distance)	3	2	2	4	3	2	38	12	12	4	2	3	20	2	3	4		1
Crop lands(specify which crop)	2		1	2		1	10		2			1	1		1	7	7	7
Forest areas	1	1	1	1	2	2	3	3	3				2		1			
Maize stover	5	2	2	4	3	3	33	22	25	2	3	2	3	2	3		1	1
Legume stover	1			1			1	4	1	1	1	1	2	2	2		1	1
Sorghum stover					1	1		1	1		1	1	1	1	1			
Millet stover	1			1			1	1		1								
Cowpea stover																		
Salt		1					2											
Crop by products (brans,cakes)		3					1									2		1
Roadside weeds	1				1	1	3	12	10	1	1		2	2				
Cut and carry fodders	3		2	2	1	1	7	2	2	2	1	1	2	1	1			
Hays	1			2			2			2			2					
Dairy meal																		
Maize grains																38	35	34
Sorghum and millet grains																8	8	7
Kienyeji mash																1	2	2

Table 7. Types of feed provided to cattle, oxen, other cattle, sheep, goat, poultry and pig (number of respondent on 98 interviewed people on Mbeere South district).

	Cattle			Oxen			Other cattle			Sheep			Goat			Poultry		
	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season
Rangeland(short distance)	6	7	5	5	9	8	15	18	16	6	2	4	16	16	13			
Rangelands(long distance)	1	1	1	5	5	5	5	3	4				3	2	2			
Crop lands(specify which crop)													2		1	2	2	2
Forest areas							1	1	1	4			3	3	1			
Maize stover	6		1	12	3	1	29	4	3		2		12	1	1			
Legume stover	1			1			8	1	1				2	2	1	1		
Sorghum stover			1	1			5									2	2	
Millet stover				1			3		1							1	1	
Cowpea stover	1		1	2			5		1					1	1	2	2	1
Salt				1		1	3	1	2									
Crop by products (brans,cakes)							2		2									
Roadside weeds	1	1	1	1	4	4	6	15	12	2	3	2	10	15	13		1	1
Cut and carry fodders	1	1		1	1	2	8	6	5				2	4	4			
Hays	1						1						1	1	2			
Dairy meal							7	5	4				2	1				
Maize grains							1							1		14	13	12
Sorghun and millet grains																3	1	1

Table 8. Types of feed provided to cattle, oxen, other cattle, sheep, goat, poultry and pig (number of respondent on 134 interviewed people on Njoro district)

	Cattle			Other cattle			Sheep			Goat			Poultry		
	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season
Rangeland(short distance)	2		2	6	7	5	16	6	9	3			10	5	6
Rangelands(long distance)				5	3		7	2	3	2			1	1	2
Crop lands(specify which crop)					4	2		2	1				1	2	
Forest areas				1	1		1	1		1					
Maize stover	5	1	2	40	4	16	31	4	13	5			2	2	1
Legume stover				1	11	10	1	7	4		1				
Sorghum stover				1											
Millet stover		2													
Cowpea stover		2													
Salt	2	1	2	7	13	13	4	6		1		1			
Crop by products (brans,cakes)		4		6	3	2	7	3		1			13	7	7
Roadside weeds			1	5	16	14	7	25	17	1	3	3	11	10	3
Cut and carry fodders			3	11	35	30	12	25	23		4	3		2	
Hays	1			15	3	5	7	1	1	2	1				
Dairy meal	1			4	8	8	2	2	2			1		9	9
Maize grains		1			2		1	2					10	7	11
Sorghun and millet grains													1	5	3

Table 9. Types of feed provided to cattle, oxen, other cattle, sheep, goat, poultry and pig (number of respondent on 95 interviewed people on Mukurwe-ini district).

	Cattle			Oxen			Other cattle			Sheep			Goat			Poultry		
	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season
Rangeland(short distance)																		
Rangelands(long distance)																		
Crop lands(specify which crop)		1					1	7	5				1			1	1	1
Forest areas										1							1	
Maize stover	3	4	4	1	2	2	21	20	25		2	1	11	10	6	1		1
Legume stover								5	3				1					
Sorghum stover		1	1					1										
Millet stover																		
Cowpea stover								1										
Salt	1						14	18	22				6	2	4			
Crop by products (brans,cakes)							5	5	5				1	1	1	2	2	2
Roadside weeds	1	1	1				2	4	4				19	6	2			
Cut and carry fodders	2	1	1	1	1	2	14	31	26				11	8	11			
Hays	1	1	2	1			6	4	3				1					
Dairy meal							30	28	24				4					
Maize grains	1			1			14	15	14				9	3	3	11	9	9
Sorghun and millet grains		1					3	4	2				2	3	4	3	5	3

Table 10. Types of feed provided to cattle, oxen, other cattle, sheep, goat, poultry and pig (number of respondent on 88 interviewed people on Othaya district).

	Cattle			Other cattle			Sheep			Goat			Poultry		
	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season
Rangeland(short distance)		1		5	6	4				1	2	1			
Rangelands(long distance)															
Crop lands(specify which crop)				2	2	2			1	1	1	1	1	2	2
Forest areas		1			1	2	2			1					
Maize stover	1			13	19	19		4	3	4	5	7			
Legume stover		1	1	6	9	8			1	1	4	4			
Sorghum stover															
Millet stover				1											
Cowpea stover															
Salt				20	17	12	4	4	3	3	5	5			
Crop by products (brans,cakes)				8	7	6				3	2	2	3	3	2
Roadside weeds				2	3	2	1	1		2	3	1	10		
Cut and carry fodders	2	1	1	20	28	25	3	3	3	7	8	8	3		
Hays				7						2					
Dairy meal				25	19	19				4	3	3		10	10
Maize grains				4	4	4	1							2	3
Sorghun and millet grains													1	1	1

Table 11. Types of feed provided to cattle, oxen, other cattle, sheep, goat, poultry and pig (number of respondent on 96 interviewed people on Siaya district).

	Cattle			Oxen			Other cattle			Sheep			Goat			Poultry		
	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season	1rst Dry season	1rst rainy season	2nd rainy season
Rangeland(short distance)	16	16	11	7	8	4	36	45	34	14	18	14	16	16	10	7	7	8
Rangelands(long distance)	7	6	3	4	4	1	19	16	9	8	7	5	7	7	4	2	2	2
Crop lands(specify which crop)	1			1			5	1	2						1			
Forest areas	2	1		1	2		4	4		2	1		13	12	10			
Maize stover	12	1	7	4	2	5	39	10	21	1	1	6	4	2	7	3	3	3
Legume stover		2			1		1	7	2		5			3				
Sorghum stover			1			1	2		4			2			1			
Millet stover			1			1	1					1			2			
Cowpea stover											1						2	2
Salt							2	3	3									
Crop by products (brans,cakes)	1						2	2	2	1						8	5	19
Roadside weeds	9	10	11	4	3	2	24	25	18	15	12	13	23	20	20			4
Cut and carry fodders Hays	4	4	2				7	7	9			2	1		1			
Dairy meal		1					1	2	2				1	1	1			19
Maize grains							3						16	16	10	17	14	79
Sorghun and millet grains				7	8	4	1	1	1				7	7	4	6	7	21

3. Herd dynamics and changes

Most of the smallholders said that have seen significant changes in their livestock herd during the last 10 years. The major cause of change has been attributed to the death of the animals, caused in general by drought or lack of grazing; diseases have also been recognized as one of the causes involved on the reduction of the livestock herd. Other cause that has determined a decrease in number of livestock has been the sale of animals forced primarily by the conditions mentioned before. Few smallholders think they will increase the number of livestock in their herds due to prices and lack of stock.

Systems are also intensifying and becoming more market orientated. The profile of livestock herder is also expected to change in terms of breed choices and others. Some of the changes seen are: upgraded breeds, use of crossbreds, shift from local to graded breed (from indigenous to exogenous), improvement of health practices, better treatment and feeding.

Livestock offtake is defined as the percentage of the year's herd that is removed through sales, death, gifts, home-slaughter or theft. In general pastoralists are reluctant to sell stock since they have to maintain a certain level of stock for substance purposes. Households declared they may increase the removal of live animals or their products mainly to outside destinations in case the herd size is increased enough to allow sale of more animals and when the market will become favorable and the animals could be sold to higher prices.

3.1 Planned future changes

A pastoralist's decision rule to sell an animal or keep it for sale in the future depends on what is the implicit value of animal products consumed by the pastoral family, liquidity, security, prestige, power and aesthetic pleasure (Nyariki, 2004).

The size of the herd may be changed it in the future by increasing the number of cattle and poultry in order to ensure food for home consumption and more manure, they declared they may consider to increase the number of goats to have more milk for sale, while the breeding could allow to have more bulls. The factors that may support the enlargement of the herd are linked to market reasons, in particular to higher prices and the possibility to easily sell the animals in the market. On the contrary the reduction of the herd can be caused by the fact that there are not enough food and water available or for financial reasons, since the animals may be sold to finance school fees, food and other needs.

3.2 Future investments to increase animal productivity

Different measures have been identified according to the different type of animal take into consideration. For cattle, sheep, camels and poultry the availability of more feeds represents the major issue to allow to increase the productivity, while for oxen, donkey and rabbits it is the health of the animals that has to maintained in better conditions. There is a widespread perception that genetic improvements are needed to increase the productivity of cattle and goat, even though evidence suggests that lack of feed is the main constraint to increased productivity.

Table 12. Products from livestock (average and standard error)

		Cattle		Goats		Sheep		Camels	*Slaughtering (meat)*	*Other products*
		Fresh milk (litres)	**Meat (kg)**	**Fresh milk (litres)**	**Meat (kg)**	**Meat (kg)**	**Wool (kg)**	**Fresh milk (litres)**	**Chicken (kg)**	**Eggs (kg)**
Garissa	Amount per one animal	275.6 ± 48.6	10 ± 0	106.8 ± 19.5	8 ± 0	8 ± 0		659.4 ± 260.1		113.3 ± 52.1
	Average per household	720.6 ± 172.6		583.7 ±189.5	24.0 ±16.0	40 ± 0		1585.6 ± 540.2		280.0 ±166.5
Gem	Amount per one animal	548.6 ± 115.3		77.4 ± 6.7					1.5 ± 0.2	41.6 ± 13.1
	Average per household	954.6 ± 217.7		506.9 ± 96.3					3.3 ± 0.9	127.4 ± 41.9
Mbeere South	Amount per one animal	860.0 ± 149.6		165.1 ± 38.7	15 ± 0				4.8 ± 1.9	74.9 ± 29.9
	Average per household	1167.4 ± 207.2		381.6 ± 101.4	15 ± 0				9.8 ± 4.9	275.4 ±109.1
Mukurwe-ini	Amount per one animal	2089.5 ± 231.9		146.7 ± 27.8						233.7 ± 87.7
	Average per household	3023.0 ± 442.5		171.7± 37.8						1233.1 ± 567.1
Njoro	Amount per one animal	1256.8 ± 168.8	150 ± 0	147.3 ± 45.9	8.7 ± 4.1	33.4 ± 10.1	3.2 ± 2.7		4.9 ± 1.2	108.6 ± 20.9
	Average per household	1764.3 ± 247.9		331.6 ± 120.1	18.7 ± 13.4	47.0 ± 11.1			19.7 ± 8.2	555.6 ± 111.5
Othaya	Amount per one animal	2035.1 ± 148.4		522.9 ± 185.0	62.3 ± 43.7				6.6 ± 1.2	330.4 ± 58.5
	Average per household	2682.6 ± 335.7		592.9 ± 190.4	181.3 ±134.4				28.7 ± 7.7	1457.1 ± 281.5
Siaya	Amount per one animal	706.4 ± 97.3	58.0 ± 23.1	200.0 ± 80.0					2.0 ± 0.4	45.7 ± 4.2
	Average per household	1205.8 ± 244.5	70.0 ± 20.5	200.0 ± 80.0					8.0 ± 5.5	166.6 ± 19.8
Total	Amount per one animal	1151.7 ± 66.5	64.3 ± 22.5	134.4 ± 16.6	27.2 ± 15.4	32.2 ± 9.7			4.0 ± 0.6	100.5 ± 11.7
	Average per household	1686.9 ± 117.8	72.9 ± 20.9	486.6 ± 71.3	737 ± 47.5	46.7 ± 10.6			14.7 ± 3.7	440.3 ± 57.4

4 Products from livestock

Table 5 illustrates the products from livestock. Virtually all households received an income from livestock (i.e. live animal sales, milk sales and sale of other livestock products such as skins, hides and manure). Table 5 confirms that in many agro-pastoral systems, the sale or barter of milk (and milk products) is as important as its use for home consumption. Opportunities for milk sales for cattle are related to neighbors, middlemen/trader and market, while milk from camels and goats are primarily sold on the market or consumed by the family.

5 Costs associated with livestock

Table 13 illustrates the cost of management, feed and other general costs associated with livestock. With respect to the allocation of livestock management activities, the Figure 1 shows for cattle, goats and sheep which are the activities that the owner does and which ones (s)he delegates to hired labor. Most of the activities are performed by the owner which delegates to professional support the veterinary treatment as tick removal, tsetse fly protection and supply of medicine.

Table 13. Average costs associated with livestock (average and standard error in US$ per year).

Livestock	Management (care) costs							Other costs				
	Watering	Feeding	Herding	Veterinary treatment,[a]	Housing	Grazing	Breeding	Buildings	Electricity	Tools	Machinery	Veterinary
Cattle	258.3 ± 49.3	301.7 ± 57.4	317.1 ± 85.0	76.8 ± 19.9	276.0 ± 76.0	377.0 ± 125.9	136.3 ± 50.0	90.7 ± 23.8	41.2 ± 28.5	13.5 ± 3.2	41.1 ± 16.2	19.8 ± 3.9
Goats	370.3 ± 99.9	357.4 ± 116.3	396.6 ± 113.7	216.4 ± 74.9	392.5 ± 124.0	613.3 ± 231.7	614.2 ± 285.8	91.3 ± 46.5		19.2 ± 9.8		16.9 ± 3.6
Oxen												18.3 ± 19.9
Sheep	356.9 ± 192.8	389.5 ± 208.2	421.0 ± 227.5	94.9 ± 56.0	274.1 ± 157.6	367.1 ± 210.9	359.4 ± 235.1	81.7 ± 58.6		12.8 ± 5.7		27.8 ± 3.8
Pigs								19.3 ± 5.3		20.1 ± 6.7		11.0 ± 12.5
Poultry	113.3 ± 32.5	128.2 ± 31.2		356.9 ± 192.8				24.4 ± 3.9	137.4 ± 130.7	18.2 ± 12.7		67.0 ± 3.5

[a] tick removal, tsetse fly protection, medicine

Figure 1. Allocation of livestock management activities.