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ORIGINAL ARTICLE

Climate change perception and adaptation of agro-pastoral communities in Kenya

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Abstract Data on agro-pastoralists' perceptions of climate change and adaptation options were collected from agro-pastoral communities in 7 rural districts of Kenya. Key adaptation strategies for livestock producers include mixing crop and livestock production, destocking, diversifying livestock feeds, changing animal breeds and moving animals to other sites. Desired adaptation options include introducing new breeds and increasing herd size. Additionally, the main barriers to adaptation identified include lack of credit or savings followed by lack of access to land and inputs. Farmers adaptation among livestock producers is also hindered by the absence of markets, particularly for the purchase of additional animal or new breeds or species.

Keywords Perception · Adaptation · Climate change · Livestock · Kenya

Introduction

Livestock systems play an important role in the livelihoods of many rural communities in Africa, more so in arid and semi-arid areas, where milk and meat are important dietary components due to lower availability of food from crops. In Kenya, livestock contributes to over 12% to GDP and 47% to agricultural GDP (Kabubo-Mariara 2009). Most livestock production takes place in the arid and semi-arid lands (ASALs), which are estimated to support about 25% of the human population and slightly over 50% of its livestock (Kabubo-Mariara 2009).

Livestock are particularly important for increasing the resilience of vulnerable, poor people, who are subject to climatic, market and disease shocks, through diversifying risk and increasing assets (Krisna et al. 2004; Freeman et al. 2008). There are many ways in which climate change may affect the livelihoods, food security, and health of vulnerable people through its effects on livestock and livestock systems, such as changes in water and feed availability, changes in biodiversity and animal health (Thornton et al. 2007, 2009; Luseno et al. 2003; McPeak 2006). Table 1 summarizes how livestock are affected from climate change directly and indirectly.

Adaptation is identified as one of the policy options to reduce the negative impact of climate change (Adger et al. 2003; Kurukulasuriya and Mendelsohn 2006). It refers to "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects" (IPCC 2007) and to "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2001).

Common adaptive responses to climate change for livestock involve technological (e.g. introduction of breeds), behavioural (e.g. reduced consumption), managerial (e.g. new approaches to farming) and policy aspects (e.g. new regulations).

Many local breeds are already adapted to harsh living conditions, but climate change projections suggest that

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Table 1 Climate changes impacts on livestock in the tropic areas

Direct impacts	
Quality and quantity of feeds	Increased temperatures can change herbal growth and increase lignifications of plant tissues, therefore reducing the digestibility and the rates of degradation of plant species. This leads to reduced nutrient availability and to a reduction in livestock production. Niches for different species may be altered, as the optimal growth ranges for different species. This may modify animal diets and compromise the ability of smallholders to manage feed deficits
Heat stress	Vulnerability to heat stress varies according to species, genetic potential, life stage and nutritional status. Livestock at lower latitudes are often well adapted to heat stress and drought with respect to the ones at higher latitudes. In general, hot and humid conditions may lead to behavioural and metabolic changes, including reduced feed intake and thus a decline in productivity. Increased drought frequencies to more than a drought every 5 years could cause significant, irreversible decreases in livestock numbers in arid and semi-arid areas (Bryan et al. 2011b)
Water	In response to increases in temperature, the demand of water for livestock will increase. It is uncertain how climate change will affect water resources in land-based livestock systems in developing countries, but increase demand and competition for water are likely going to happen
Livestock diseases and diseases vector	Mammalian cellular immunity can be suppressed following heightened exposure to ultraviolet B radiation. Climate change may bring to shift in diseases distribution and distribution of disease vectors. However, it is fair to say that climate change effects on livestock disease suffer intrinsic problems of predictability
Biodiversity	This is one of the most difficult impacts to assess. It refers to the erosion of genetic diversity, which is attributed to global livestock production practices and the increasing marginalization of traditional production systems and associated local breeds. Biodiversity loss has global health implications and many health risks driven by climate change will be attributable to a loss of genetic biodiversity
Systems and livelihoods	Climate change can modify the length of growing period and increase rainfall variability, leading to a shift from mixed crop-livestock systems to rangeland systems. The change in diet composition and the possible feed deficit in dry season can affect animal productivity. Increasing population and urbanization may lead to a contraction in cropping zones and to a decrease in livestock feed and cause dietary energy deficit
Indirect impacts	
It refers to the impact on livestock keepers, especially on their health through the impacts on food production and nutrition	

Adapted from: Thornton et al. (2009)

further selection of breeds with effective thermoregulatory control may be needed. Adaptation strategies may address not only the tolerance of livestock to heat but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases. Local genetics can be improved through cross-breeding with heat- and disease-tolerant breeds (Calvosa et al. 2009; Hoffmann 2008). However, there are multiple factors that can influence the adoption of new breeds by households and communities.

Institutional and policy changes can enhance adaptation by removing or introducing subsides and insurance systems, by promoting income diversification practices and establishing livestock early warning systems and other forecasting and crisis-preparedness systems. It is important to analyse how effective are these measures in facilitating adaptation.

Adjustments in production practices may also facilitate adaptation through diversification, intensification of crop and livestock production, changes in land use and irrigation, modifying stock routes and distances, integrating mixed livestock farming systems.

Changes in livestock management can also reduce vulnerability to climate change by providing shade and water to reduce heat stress, reducing livestock number and changing livestock/herd composition (Calvosa et al. 2009; Thornton et al. 2009).

Countries in Sub-Saharan Africa are particularly vulnerable to climate change impacts, because their widespread poverty limits adaptive capacity. For example, lack of information, lack of money, shortage of labour, shortage of land and poor potential for irrigation were identified by Deressa et al. (2008) as key components of adaptive capacity that are lacking in Ethiopia. Knowledge of the adaptation methods and factors affecting the perceptions of climate change enhance policy towards tackling the challenges that climate change is imposing on Kenyan households. Identifying potential adaptation measures to cope with adverse impacts of climate change on livestock production can support the identification of the factors which influence the choice of adaptation strategies.

Adaptation to climate change requires that farmers first notice that the climate has altered. Farmers then need to identify potentially useful adaptations and implement them. We investigated pastoralists' perceptions of climate change, how they have adapted to perceived climate change, and the barriers to adaptation.

Analytical methods

Identification of the determinants of adaptive capacity

Farmers' decisions to adjust their farming practices are influenced by a number of factors in addition to the climate stimulus. This study uses econometric methods to assess the influence of various factors influencing farmers' decisions to adapt.

Data were collected through a survey of households from 13 divisions within 7 different districts of Kenya spanning the arid, semi-arid, temperate and humid agro-ecological zones (AEZ). 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. Control sites were selected with comparable biophysical and socio-economic characteristics for each of the program district/divisions.

Study sites were drawn from the following districts: Garissa, Gem, Mbeere South, Mukurweini, Njoro, Othaya and Siaya. Such districts have been aggregated according with the agroecological zone they belong to: Garissa has been classified as arid, Mbeere South and Njoro are semi-arid, Mukurweini and Othaya are temperate, and Gem and Siaya are humid.

The study sites were selected to represent the various agroecological zones that will be affected by climate change in Kenya and where people are most vulnerable to such impacts, with the exception of the coastal zones (Herrero et al. 2010). The sites cover various production systems as well as a range of policy and institutional environments.

The total number of households interviewed was seven hundred and ten. 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 difficulty in locating pastoralist households for interview. The results presented in this study are only for the 640 households, out of the total of 710, which reported owning some livestock.

Variables referring to farm structure, farmer characteristics, productive orientation and technical support were considered. These are the most commonly cited household characteristics that can summarize the diversity of farming situations and can also drive the perception of climate change and the consequent adaptation processes (Maddison 2007; Nhemachena and Hassan 2007; Deressa et al. 2008).

Open-ended questions were used to ask farmers whether they had noticed changes in temperature and precipitation, and about the adaptations they had made as a response to whatever changes they had noticed. For those farmers who felt they had experienced climate change, there were further questions about the nature of any barriers which prevented them from fully adapting to climate change.

A logistic regression was used to analyse the factors influencing farmers' perceptions of climate change and adaptation decisions. The results of the logistic regressions show the expected change in the probability that farmers perceive climate change or will choose a particular adaptation measure with respect to a one unit change in an independent variable, holding all the other factors constant. The dependent variables are dummy variables equal to 1 if the farmer reported noticing a long-term change in temperature, rainfall or rainfall variability, and equal to 0 otherwise. Similar to the analysis of perceptions, the dependent variables for "adaptation" are dummy variables equal to 1 if the farmers changed their farming practice in response to perceived climate change and 0 otherwise.

The main adaptation choices (the dependent variables) were the following: destocking, change in livestock feeds, change in breed and moving animals to a different site. Similar adaptation measures were grouped together to simplify the dependent variables into the main options employed by farmers (as change on feed and diversification of feed).

The preferred method to analyse farmers' decisions to adopt particular adaptation strategies would be a multinomial logit (MNL) model, which estimates the effect of a set of explanatory variables on a dependent variable involving multiple choices with unordered response categories. However, most households reported adopting several adaptation options simultaneously, and the number of response categories would be too great to perform a MNL. We, therefore, opt to analyse each adaptation strategy separately using a binary response model.

These models can be derived from an underlying latent variable model. The household i decides to choose a certain adaptation measure if the derived benefits B_i are higher than a certain threshold T (Kabubo-Mariara 2008; Staal et al. 2002):

$$Y_i = 1 \text{ if } B_i > \text{AM} \rightarrow X_i\beta + \alpha_i > \text{AM farmer i decides to adopt}$$

$$Y_i = 0 \text{ if } B_i < \text{AM} \rightarrow X_i\beta + \alpha_i < \text{AM farmer i decides not to adopt}$$

where X_i is a vector of explanatory variables, β is a vector of coefficients to be estimated and α_i is an independent, farm specific, *ex ante* stock. The model has the form:

$$Y_i = x_i\beta + \alpha_i,$$

where x_i is a vector of explanatory variables derived from the survey, β are the corresponding regression coefficients and α_i are the intercept parameters.

Explanatory variables

The explanatory variables were selected on the basis of previous studies on factors influencing adaptation and development pathways (Pender 2004; Baltenweck et al. 2003; Staal et al. 2002). These variables included:

Gender of the head of the household

Depending on the context, studies differ on whether male- or female-headed households are more likely to adopt new technologies. Male-headed households are often considered to be more likely to get information about new technologies and take business risks than female-headed households (Asfaw and Admassie 2004). Other studies have shown that female-households are more likely to take up climate change adaptation since they are responsible for much of the agricultural work in the region and have better experience and access to information on various management and farming practices (Nhemachena and Hassan 2007).

Education and years of experience of the head of the household

Evidence from various sources indicates that there is a positive relationship between education level of the household head and years of farming experience and access to information on improved technologies and the adoption of improved technologies (Igoden et al. 1990; Lin 1991). Therefore, farmers with higher levels of education or those with longer farming experience are more likely to take measures to adapt to climate change.

Household size

On the one hand, large households may be forced to divert part of the labour force to off-farm activities in an attempt to earn income in order to ease the consumption pressure imposed by large family size (Yirga 2007). On the other hand, larger households are normally associated with a higher labour endowment, which would enable the household to accomplish various agricultural tasks (Croppenstedt et al. 2003; Nhemachena and Hassan 2007).

Farm and non-farm income and livestock ownership

These are indicators of wealth. It is regularly hypothesized that the adoption of agricultural technologies requires sufficient financial well-being (Knowler and Bradshaw 2007; Solano et al. 2000). Furthermore, higher income farmers may be less risk averse, have more access to information, have a lower discount rate and have a longer-term planning horizon. Farm income is in this study is defined by the profit from milk sales, while non-farm income includes earnings from or access to off-farm jobs declared by the respondents (business/trader, officer worker, artisan, mechanic, factory).

Extension and training on livestock production and access to climate information such as weather forecasts and early warning

Access to extension services and information facilitates decision making with regard to adaptation to climate change (Bryan et al. 2009; Deressa et al. 2009; Gbetibouo 2009; Maddison 2007; Nhemachena and Hassan 2007; Kebede et al. 1990). Access to extension services and information is captured by a dummy variable for whether the household receives extension services, weather forecasts, early warnings and information on livestock production. Extension services in this study include farm visits, farmer research groups, farmer field schools, farmer-to-farmer exchange visits and common interest groups.

Access to formal and informal credit

The availability of credit eases cash constraints and allows households to purchase inputs. Research on the adaptation indicates that there is a positive relationship between the level of adoption of adaptation strategies and the availability of credit (Bryan et al. 2009; Deressa et al. 2009; Gbetibouo 2009; Yirga 2007). Access to credit is captured by a dummy variable for whether the household has borrowed from formal or informal sources over the previous year.

Distance to the closest commercial centre

This is an indicator of location and access to markets. Some studies have showed that proximity to markets increases the likelihood of adaptation (Maddison 2007; Solano et al 2000). On the contrary, others have found that the likelihood of adaptation increases with distance to output markets, suggesting that there is less of an opportunity cost for households in remote areas to adopt adaptation practices that may be labour intensive (i.e. where fewer income earning opportunities are available) (Bryan et al. 2009).

Food or other aid received

Food or other aid represents the extent to which there is a social safety net in place to support adaptation. That is, households may be more willing to take on the risk involved in adopting new agricultural technologies or practices if there is a social safety net in place that assures that basic needs will be met in the event of a shock.

Descriptive results on domestic herd size and composition

The categories of livestock owned by farmers in the study areas are sheep, goats, oxen, cattle, other cattle (such as breeding bulls), rabbits, pig, poultry and donkeys. Cattle mainly contribute to the value of the average domestic herd in the study sites, followed by sheep and goats (see Fig. 1). Owning livestock makes households more resilient to climate shocks (Bryan et al. 2011a, b). 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).

For local communities in semi-arid areas, livestock are the main source of wealth, and income is derived from the sale of livestock and its products. Farmers consider milk production for feeding the family, cash income and the production of manure to fertilize the soil as the most important reasons for keeping cattle. Cattle are also kept for the provision of draft power to cultivate the land and to finance future expected expenditures such as the purchase of food and the payment of school fees and medical expenses. Traction and manure are both valuable and saleable products especially in agro-pastoral areas.

Climate change perception

The literature on adaptation makes it clear that perceptions of climate change are a necessary prerequisite for adaptation (Roncoli et al. 2002; Hansen et al. 2004; Vogel and O'Brien 2006; Thomas et al. 2007).

In the survey, households were asked about their perceptions of climate change with respect to change in temperature, change in average rainfall and change in rainfall variability. Variability pertains to both the temporal and the spatial distribution of rainfall. In particular, rainfall at the beginning of the rainy season is essential for agricultural production as it represents a critical moment for farmers to plant annual crops. "Seasonality change" had been identified by farmers as a frequent delay in the onset and a premature end of the rainy season (Roncoli et al. 2010).

The literature suggests that farmers are more likely to perceive climate change when they have more farming experience (Maddison 2007). We therefore classify the perceptions of climate change according to the heads of the households' years of farming experience. In Table 2, we group the responses of famers into 3 categories: those that have less than 15 years, those that have between 16 and 22 years and those with 23 or more years of experience.

The table shows that a larger percentage of more experienced farmers perceives changes in rainfall associated with climate change. That is, a larger percentage of those with over 23 years of farming experience reported noticing a long-term decrease in the average amount of rainfall and long-term changes rainfall variability.

However, Table 2 does not indicate whether the differences between the views of experienced and less inexperienced farmers are statistically significant. Nor does it indicate whether the results are sensitive to other factors, such as differences in farmer's education, presence of non-farm income. However, the logit regression results do indicate that experienced farmers are significantly more likely to perceive changes in climate; the coefficient on years of farming experience is positively signed and statistically significant at the 5% level (see Table 3). Other significant factors influencing farmers' perceptions of climate change are information on livestock production (such as destocking, new breeds, indigenous breeds, livestock-crop integration, livestock diseases) and food aid.

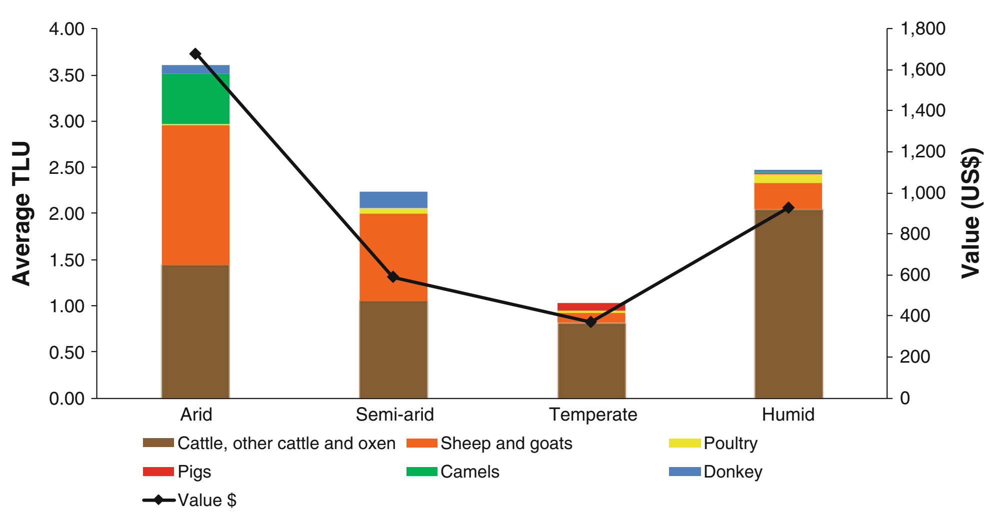

Fig. 1 Variation in size and value of household domestic herds per agroecological zones

Table 2 Perception of climate change by farmer experience (number and percentage of respondents)

	Years of experience					
	1–15		16–22		23+	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Change in temperature (total number of respondent 633)						
Increased temperature	162	92	143	96	293	95
Decreased temperature	3	2	1	1	9	3
No change in temperature	2	1	0	0	3	1
Don't know	10	6	5	3	2	1
	177		149		307	
Change in average rainfall (total number of respondent 630)						
Increased average rainfall	11	6	12	8	12	4
Decreased average rainfall	146	83	129	87	290	95
No change in average rainfall	9	5	4	3	3	1
Don't know	9	5	4	3	1	0
	175		149		306	
Change in rainfall variability (total number of respondent 631)						
Changes in rainfall variability	153	87	132	89	297	97
No changes in rainfall variability	9	5	4	3	6	2
Don't know	14	8	13	9	3	1
	176		149		306	

Table 3 Determinants of farmers' perceptions of climate change (corresponding regression coefficients)

	Perceive change in climate	
Gender of the household head	−1.315	
Education of the household head	0.126	
Years involved in farming	**0.099****	$p = 0.021$
Household size	0.032	
Farm income (milk sales)	0.000	
Non-farm income	1.040	
Livestock ownership (TLU)	0.013	
Food or other aid received	**2.241*****	$p = 0.001$
Distance from the centre	−0.026	
Livestock extension field visits	**−3.150*****	$p = 0.002$
Training	0.087	
Information on livestock production	**0.919****	$p = 0.029$
Weather forecast	1.137	
Seasonal forecast/early warning	0.461	
Formal credit	0.613	
Informal credit	0.246	

* $p < .1$; ** $p < .05$; *** $p < .01$

Extension advice is a factor that is believed to create awareness to climate change. Farmers with access to extension services are likely to perceive changes in the climate because extension services provide information about climate and weather (Maddison 2007; Gbetibouo 2009; Trærup and Mertz 2011). The negative effect of extension advice on perception may be due to the limited number of visits received and to the difficulty in delivering information in a context of uncertainty (Crane et al. 2011; Roncoli et al. 2010).

Perceived impact of climate change on livestock production

Households reported on the impact of climate change with regard to the availability of feed sources for livestock, which is a key observable variable. The farmers themselves were asked to use a ranking system to weight the level of severity. Figure 2 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, goat).

In general, feed availability is not constant during the whole year, and moderate deficits are affecting all the species considered, in particular during the long dry season and between August and October.

The major production constraints for the global area of study are shown in Fig. 3, although some of them are connected. Figure 4 shows production constraints by district. According to 36% of the households, the feed resources appeared and disappeared because of drought and in a broader sense as a consequence of environmental changes and climate change impacts, although these two

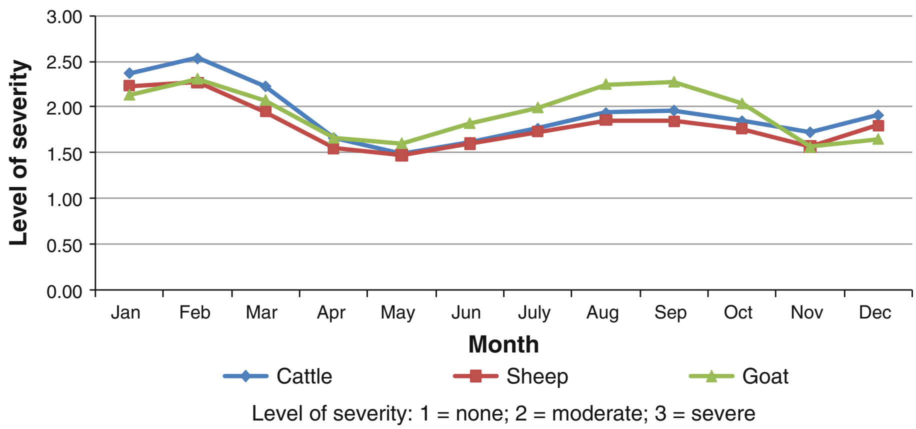

Fig. 2 Level of severity of shortage of feed during 1 year of period for cattle, sheep and goat

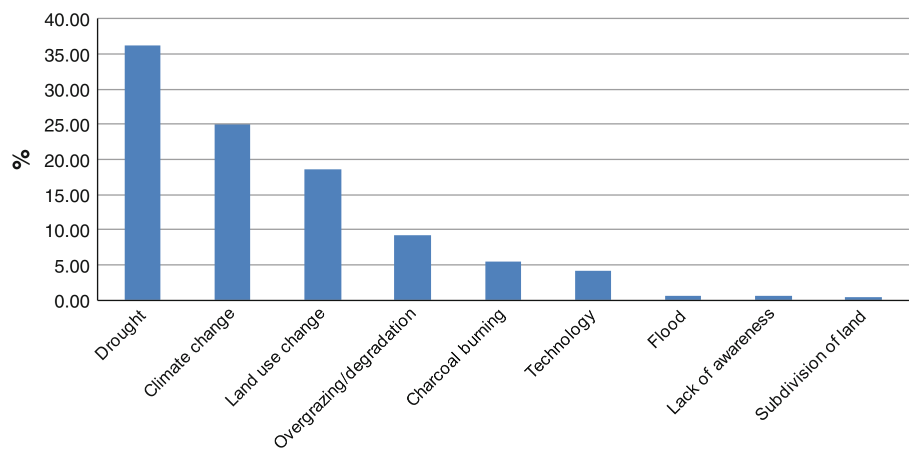

Fig. 3 Reasons that have caused the feed resources to appear and disappear

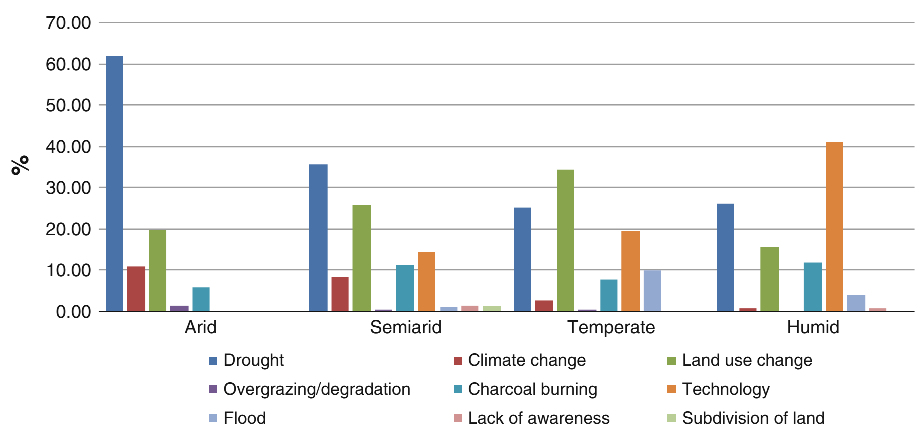

Fig. 4 Reasons that have caused the feed resources to appear and disappear per agroecological zones

are difficult to separate. The change in land use has been identified by almost 18% of households as one of the main reasons for change in feed availability, but mostly in districts where the possibility of multiple land use forms is available (i.e. Othaya).

When considering the causes of shortages of feed (Fig. 4), we can see that the perceptions of causes differ by agroecological zones. The impact of technology seems to be quite high in the humid zones and flood is thought to reduce the availability of feed resources in particular in the temperate zone. Drought is identified as the main reason for feed shortages in the arid and semi-arid zones and as one of the major drivers of feed availability in temperate and humid zones. These reasons reflect the agricultural potential of different agroecological zones.

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

Climate change impacts are also identified as the major cause of the reduction in herd size during the last 10 years, and drought and lack of grazing are thought to be the main reasons for the reduction, by causing the death of animals.

Coping strategies to climate shocks

Because climate change may change the frequency of extreme events such as drought and flood, the survey sought information on the types of climate shocks households experienced over the last 5 years and the types of coping strategies employed by households in response to these climate shocks. The main reported climate shocks were the following : drought (84.9%) and erratic rainfall (9.7%). Flooding was mentioned by only 1% of interviewed farmers. This surprising result indicates that households may actually perceive flood as a less important climate shock than drought. The main reported results of the climate shocks were reduced crop yield, food shortage, food insecurity, death of livestock and food price increases.

Table 4 illustrates the main coping responses to climate shocks by agroecological zone. Given that the main result of the climate shocks was a decline in crop yield, the main coping responses involved the purchase of additional food, reducing consumption or consuming different food. However, selling livestock was also important strategy for households coping with climate shocks, particularly in the semi-arid and temperate study sites. The results also show that livestock sales following a climate shock also support the purchase of food to make up for crop losses −17% of those household that purchased food also reported selling livestock. Additional coping strategies employed by the households that purchased food include borrowing from relatives (8%), seeking off-farm employment (4%), receiving food aid (3%) and selling asset (2%).

Other studies also demonstrate that selling livestock is an important coping strategy in response to climate shocks (Deressa et al. 2009; Cross et al. 2006).

Surprisingly, a large percentage of households reported that they did nothing in response to climate shocks. Among households that reported doing nothing, 50% are located in the arid areas where many pastoral households are located. The low probability of adaptation in these areas may be partly due to the fact that they have already adjusted to more difficult production conditions—including irrigated crop production (for those households engaged in crop production) and/or drought-tolerant crop varieties and livestock breeds- and have limited additional options at their disposal. In addition, lack of information, technology or credit also limits households' ability to cope with climate shocks in this area. It is also well documented that many pastoralists are reluctant to sell livestock during periods of drought, preferring to take the risk that many will survive (Homewood et al. 2009).

Table 4 Coping strategies by agroecological zone (percentage of respondents)

Coping strategies	Arid	Semi-arid	Temperate	Humid
Did nothing	89.4	27.6	16.5	11.5
Sold livestock	1.6	31.5	24.5	7.7
Sold assets	0.0	6.6	1.4	0.5
Borrowed from friends or relatives	0.0	2.8	5.0	6.6
Borrowed from the bank	0.0	0.0	5.8	0.5
Received food aid	0.8	5.0	3.6	2.2
Sough off-farm employment	0.8	5.0	4.3	4.4
Bought food	0.0	47.5	49.6	70.9
Ate less	4.1	8.8	7.9	28.6
Ate different foods	0.0	3.9	6.5	19.2

Climate change adaptation

Changes in livestock ownership and the way in which livestock are managed are essential for adapting to long-term changes in climate (Deressa et al. 2008). Table 5 illustrates the adaptation measures that farmers adopt in response to perceived climate change. The type of adaptation measures implemented is strongly related with the agroecological zones the farmers belong to. As with coping

Table 5 Adaptation strategies per agroecological zones (number of farmers)

Adaptation strategies	Arid	Semi-arid	Temperate	Humid
Mix crop and livestock production	0	9	9	5
Destocking	1	22	17	3
Diversify/changes/supplement livestock feeds	5	7	24	10
Change animal breeds	0	8	1	1
Move animals to another site	14	1	0	0
Total	20	47	51	19

strategies, the range of adaptation measures applied in the arid site was extremely limited and the rate of adaptation very low. In arid areas, the number of farmers that declared they did nothing in response to climate shocks 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. Among households that did adapt, the main adaptations strategies included: moving animals to a different site (with a permanent migration of the entire herd or part (herd split)), diversifying/changing, or/supplementing livestock feed.

Other adaptation practices include changing animal breeds, destocking (mainly in the semi-arid and temperate zones) and mixing crop and livestock production (see Table 5).

Many households also reported adaptation strategies they would like to implement but are unable to because of a number of constraints. The main desired adaptations included irrigation, agroforestry and changing crop types; however, several households also expressed interest in changing animal breeds and increasing the size of the herd.

The reported constraints to changing animal breeds include lack of money (55%), lack of credit (12%), lack of access to land (7%), lack of market access (8%) and input (5%). While the reported constraints to increase the size of the herd are lack of money (32%) credit (36%) inputs (11%) and water (11%).

Determinants of adaptation

The results, shown in Table 6, indicated that most of the explanatory variables described above affected the probability of adaptation, except the gender of the household head, years of farming experience, household size and access to formal and informal sources of credit. Variables that influenced adaptation to climate change included: education of the head of the household, farm and non-farm income, food and other aid received, distance from the market centre, livestock extension field visits, training on livestock production and access to climate information, such as weather and seasonal forecasts and early warnings.

The level of education (measured in years) significantly increases the likelihood that farmers decrease the number of livestock and change animal consumption.

In terms of the influence of socio-economic factors, the results suggest that wealthier households are more likely to

Table 6 Determinants of adaptation (corresponding regression coefficients)

	Adaptation		Destocking		Change feeds		Change breed		Move animals	
Gender of the household head	0.032		−0.663		−0.641				−1.486	
Education of the household head	**0.095*****	$p = 0.001$	**0.244****	$p = 0.025$	−0.065		0.068		−0.273	
Years involved in farming	0.013		0.025		0.012		−0.029		−0.121	
Household size	−0.006		−0.114		0.052		−0.067		−0.380	
Farm income (milk sales)	**0.000***	$p = 0.084$	0.000		−0.001		0.000		0.000	
Non-farm income	−0.148		**−1.806****	$p = 0.043$	**2.706****	$p = 0.020$	−0.420		**2.116***	$p = 0.091$
Livestock ownership (TLU)	−0.008		−0.371		−0.558		**0.174****	$p = 0.004$	0.127	
Food or other aid received	−0.344		**2.025****	$p = 0.020$	−0.840		1.067		1.133	
Distance from the centre	−0.041		**−0.697****	$p = 0.048$	**−0.532****	$p = 0.040$	0.103		0.107	
Livestock extension field visits	**−0.690****	$p = 0.053$	−1.452		−0.091		**2.029***	$p = 0.074$		
Training	**0.320***	$p = 0.084$	0.097		**1.010*****	$p = 0.003$	0.172			
Information on livestock production	0.221		−0.098		−0.668		−0.135		−0.347	
Weather forecast	**0.562****	$p = 0.042$	1.790		−0.569		−1.153		**3.699*****	$p = 0.014$
Seasonal forecast/ early warning	−0.041		**1.746*****	$p = 0.019$	−0.509		−1.004			
Formal credit	0.179		0.524		−0.406		0.532			
Informal credit	0.629		−0.591		1.010		0.044			

* $p < .1$; ** $p < .05$; *** $p < .01$

adapt to climate change. Farm income has a positive and significant impact on the likelihood that farmers adapt. In addition to agricultural income, non-farm income also significantly and positively increases the likelihood that farmers decide to move animals and change feeds and significantly and negatively decrease the probability of destocking. These results are coherent with the fact that having an extra farm income allows households to keep animals during drought and other adverse climate conditions rather than sell them to purchase inputs and food. Financially well-being also allows household to change or supplement livestock and to move animals to an alternative site to reduce the risk of animal loss during climate shocks. The availability of food or other aid is also an important determinant of destocking. Given the challenges facing households that are forced to rely on food aid, these households may be limited in the types of foods they are able to consume and many may need to sell animals in order to finance consumption.

Greater distance to the markets where outputs are sold diminishes the probability of destocking and changing feeds. Isolation increases the vulnerability of pastoralists (van Lier 2000; Grahn 2008). They have poor roads, few health services and limited access to markets for inputs and to sell their goods. These households therefore have less ability to purchase alternative feeds or feed supplements and to sell livestock or livestock products. These households also have less access to information due to limited opportunities for exchange with other farmers (for example, about other types of feed available).

While extension advice about livestock production received during field visits appears to discourage adaptation generally, it increases the likelihood that households change livestock breeds. Training on livestock production was shown to help farmers switch to alternative feed sources.

The negative effect of extension advice on adaptation generally may be due to the limited number of visits that households received or because information about climate change and the appropriate adaptation response is not being delivered by extension agents. Only about 20% of households had field extension visits and for about 66% of those that received visits, the frequency of the visits was limited to 3 or fewer visits per year. Adaptation involves making decisions under a great deal of uncertainty. Even with the best information from meteorological data, climate forecasts or local observations, households are still faced with a considerable degree of uncertainty (Crane et al. 2011; Roncoli et al. 2010). This complicates the delivery of extension messages. A study on the adaptation of public agricultural extension services to climate change shows that extension services may be less effective in the context of the uncertainty due to climate variability, since it renders the timing and content of extension advise more difficult (Crane et al. 2011).

Despite the limitations of climate information, providing weather and seasonal forecasts and early warnings does promote household adaptation to climate change. When farmers are aware of possible change in weather conditions, they are more likely to respond by moving animals to a different site and reducing the size of their herd.

Among pastoralists, mobility has long been a key to survival, as communities followed their herds in search of greener pastures.

Conclusions

The study shows that most households perceive long-term climate change and there remain considerable challenges to adaptation.

In addition, households continue to rely on traditional coping and adaptation strategies to deal with climate variability, although these may become less effective under future climate changes. Many of the coping responses to climate-related shocks, such as drought and erratic rain, are decisions that households are typically reluctant to make, such as selling livestock. Projected future climate variations may push farmers beyond the bounds of what they have been exposed to and had to cope with in the past. Current practices, processes, systems and infrastructure that are more or less adapted to the present climate may easily become inappropriate as the climate changes and more fundamental adjustments will be needed.

For example, many households reported wanting to increase the size of their herd in order to better adapt to climate change. However, this may not be an appropriate response to future climate change and may increase the vulnerability of these households to climate shocks—if not for example coupled with the adoption of well-adapted and productive species or livelihood diversification activities.

Livestock have been and are an essential resource for coping with climate shocks and adaptation is needed to ensure that livestock keepers maintain their livelihood under future climate change. More support has to be provided to households to enable them to change their livestock management practices in a way that increases their resilience to future climate change and variability. Particularly in areas, such as the arid lands, where households seem to be more vulnerable to climate change and climate shocks given limited options for coping and adaptation.

Some adaptation is already taking place as some livestock keepers have chosen to mix crop and livestock production to spread risk, to reduce the size of the herd while improving the quality of the animals and their ability to withstand shocks, to diversify or supplement livestock feeds or to select breeds that are more resistant to new climate conditions. However, more could be done to increase the rate of adaptation and to support decision making under a considerable amount of uncertainty.

While investments in and dissemination of new technologies, such as drought-tolerant breeds, are essential, supporting investments are also needed to encourage adaptation among livestock keepers. Such measures include expanding access to extension and credit services, training of extension agents to support adaptation and investments in infrastructure to improve market access. Livestock keepers also need education and training to facilitate livelihood diversification both within and outside of agriculture.

Learning about the most appropriate agricultural and production techniques can facilitate adaptation at the household level. When certain agricultural practices are outside the range of experience of the livestock keepers, adoption of these practices is difficult. Even if it is farming experience that determines whether or not farmers perceive climate change, it is education, extension advise and access to climate information that largely determines whether or not they adapt.

It is important to review the messages being delivered by extension agents as well as the delivery approach. In some cases, field visits may be important—in particular for encouraging adoption of new breeds—while in other cases livestock producers need a greater degree of training, including in new livestock feeds and supplements.

Extension agents also need to be trained to deliver climate information and to help households make decisions despite uncertainty.

Climate variability is a problem that affects farmers concretely and it is one that they must deal with. The uncertainty created by climate variability is already a key problem for extension services, since it renders the timing and content of their advice more difficult. Extension approaches that foster learning processes (Gabathuler et al. 2009) will become even more important, since climate change impacts are highly contextual and require a profound understanding of patterns of variations and trends and uncertainties involved.

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