Planning and costing agricultural adaptation to climate change in the pastoral livestock system of Tanzania

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Table of contents

Acronyms and abbreviations

ASDP	Agricultural Sector Development Programme
CMIP3	Coupled Model Intercomparison Project
FAOSTAT	The statistical database of the Food and Agriculture Organization of the United Nations
GCAP	Global Call to Action Against Poverty
GCM	Global climate model
GDP	Gross domestic product
GHG	Greenhouse gas
IIED	International Institute for Environment and Development, UK
MLFD	Ministry of Livestock and Fisheries Development
NAPA	*National Adaptation Programme of Action* (2007)
SEI	Stockholm Environment Institute
URT	United Republic of Tanzania

Executive summary

There is limited research on bottom-up adaptation economics in general – and climate change adaptation in animal agriculture in particular – to guide adaptation actions. This study therefore tries to address costing and planning of adaptation to climate change in animal agriculture in Tanzania. The study adopted a bottom-up costing of adaptation actions that were identified using a case study approach. A questionnaire interview involving a sample of pastoralists and agro-pastoralist was conducted to identify and quantify impacts due to climate change, and currently-used adaptation actions and costs, in some selected areas in Same, Chamwino and Mvomero districts. This was followed by key informants' interviews at district and national level to get insights on developmental and climate change policies and actions, and their costs.

A mini-workshop was later conducted to establish priority adaptation actions and their costs. The workshop involved local-, district- and national-level stakeholders. A country feedback workshop was then held to present initial findings and get additional inputs from experts and other stakeholders.

The case study findings showed that a changing climate has resulted in environmental shocks and extreme events such as drought, excessive rains, floods and high temperatures, which have an caused inadequate supply of water and pasture, increases in disease incidences, and death of animals. It is probable that in the future such events are likely to have even more serious repercussions and therefore there is a compelling need to plan mitigation measures.

Through this study, various adaptation actions envisioned to be capable of fostering resilience have been identified and categorised as addressing three levels: development deficit, climate variability, or climate change-related extremes and shocks. Current annual adaptation costs were estimated at 226.7 M US$ and up to 3,987.5 M US$ by 2030; some of these costs are already being incurred by farmers (such as those involving temporary and permanent migration). From this study, some policy-relevant recommendations have been formulated:

1. The need to establish an environmental section in the Ministry of Livestock and Fisheries Development (MLFD).

2. The necessity for increased investment systems and structures for animal agriculture.

3. The need for increased investment in research, extension and training.

4. The requirement for more bottom-up studies on the economics of climate change in agriculture to be undertaken in order to fill knowledge gaps, apply existing and emerging methods, and improve the estimates.

1. Introduction

1.1 The agricultural sector and its significance

The Tanzanian agriculture sector accounts for 27 per cent of GDP, 30 per cent of export earnings, and 65 per cent of raw material for domestic industries (URT 2006a). The sector is predominantly rainfed crop-based, and provides a livelihood to over 80 per cent of the population. Food crop agriculture accounts for about 65 per cent of agricultural GDP, with cash crops accounting for only about ten per cent; about a quarter of the remaining is accounted for by the livestock sub-sector (URT 2006a). Within food crops, maize is the most important (accounting for over 20 per cent of total agricultural GDP) followed by rice, beans, cassava, sorghum, and wheat (URT 2006a).

The development of the crop and livestock agricultural sub-sectors has been an important objective of the government. The focus has been on producing more food to enhance food security and alleviate poverty, with the ultimate goal of Tanzania becoming self-sufficient in basic food requirements. Agricultural GDP has grown at 3.3 per cent per year since 1985, the main food crops at 3.5 per cent and export crops at 5.4 per cent per year. Considering that the overall GDP growth target for halving abject poverty by 2010 was in the range of 6 - 7 per cent, this performance falls short of the needed growth (see: http://www.tanzania.go.tz/agriculture.html).

Livestock production provides about 25 per cent of the agricultural GDP (URT 2006a): about 40 per cent originates from beef production, 30 per cent from milk production, and another 30 per cent from poultry and small stock production. Njombe and Msanga (2010) summarise the performance of the livestock industry in Tanzania thus:

> 'Livestock commodity production figures indicate that annual meat production over a ten year period (1995 – 2005) increased from 244,000 tons to 378,500 tons (55 per cent increase), most of the meat having come from the traditional sector. However between 2005/06 and 2006/07 production of meat declined by 9.3 percent from 388,294 tonnes to 370,566 tons, due to outbreak of Rift Valley Fever. Milk production also increased from 555 million to 1.38 billion litres, between 1995 and 2005. Of this amount the traditional sector contributed about 70 percent. Between 2005/2006 and 2006/2007 there was only a modest increase in milk production from 1.41 billion litres to 1.42 billion litres, representing an increase of 0.7 percent. With regard to eggs, production increased from 380 million to 1.8 billion during 1995 - 2005 and further increased to 2.23 billion between 2005/2006 and 2006/2007 which is equivalent to 4 percent increase. Collection of hides and skins increased from about 1.3 million to 4.0 million pieces over the ten year period, out of which 86 percent were exported mostly in raw form.'

1.2 Climate trends and impacts on agriculture

The adverse impacts of climate change are already taking their toll on the livelihoods of Tanzanian people and in key sectors of the economy in the country. A detailed account of expected climate change trends and impacts on different sectors is presented in a 2007 National Adaptation Programme of Action (NAPA) project document. Predictions show that the mean daily temperature will rise by between 3^{o}C and 5^{o}C throughout the country and the mean annual temperature by between 2^{o}C and 4^{o}C by 2050. There will also be an increase in rainfall in some areas while other areas will experience decreased rainfall and seasonal shifts in precipitation.

Among the vulnerabilities due to climate change identified in the agricultural sector are: decreased production of different crops exacerbated by climatic variability and unpredictability of seasonality; erosion of the natural resource base; and environmental degradation. Average maize yield will decrease by 33 per cent countrywide with an increase in temperature and reduced rainfall, as well as a change in rainfall patterns (NAPA 2007). Climate change is also expected to further shrink the rangelands that are important for livestock-keeping communities in Tanzania.

Therefore there is a need for developing planning and investment to mitigate the effects of climate change in Tanzania. Key areas where good planning and targeted investments are required to invigorate the livestock sector challenged by the changing climate include, but are not limited to, land reforms and allocation of land to pastoralists, which can encourage them to practise controlled grazing.

Overall, climate change threatens progress on poverty reduction and the achievement of the Millennium Development Goals (MDGs). The impacts are likely to accentuate the existing shocks and stresses faced by many communities that rely heavily on climate-sensitive sectors such as agriculture.

1.3 Objectives of the study

The main objective of this study was to determine the cost and implementation plan for climate change adaptation in animal agriculture in Tanzania. Specific objectives were:

- To investigate climate and non-climate shocks facing animal agriculture and identify and document currently-used coping and adaptation strategies.
- To establish the most suitable adaptation measures and establish the roles of various stakeholders in implementing the strategies identified.
- To estimate adaptation costs of various strategies for now and to year 2030.
- To investigate the adequacy of the institutional set-up for implementation of climate change adaptation plans.

While the primary target of the main project is global policy, the Tanzanian country study has generated significant country and local-level messages.

2. Animal agriculture systems

2.1 Introduction: the significance of Tanzania's animal agriculture

Tanzania has a large head of ruminant livestock, estimated at 18.5 million heads of cattle, 13.1 million heads of goats, and 3.6 million heads of sheep (MLFD 2011). The trends in livestock populations and spatial distribution in Tanzania are shown in Figures 1 and 2, the latter of which shows that distribution is not uniform across the country. Large numbers of livestock are found in arid lands, semi-arid lands, and plateaux zones of the country, which are environmentally fragile (NAPA 2007). The animals are raised under different systems depending on location and purpose. The production systems that exist in the country are: pure pastoralist, agro-pastoralist, and commercial and smallholder dairy production systems.

Overstocking and overgrazing are very common, usually accompanied by the adverse effects of land degradation. Based on the livestock numbers, the population is 34, 43, and 5 times the recommended carrying capacity for Mwanza, Shinyanga and Dodoma regions respectively (NAPA 2007). Rising populations and the deterioration of land quality in the pastoralist and agro-pastoralist areas of northern and central Tanzania forced livestock farmers to migrate southward to the Iringa and Mbeya regions in search of water and pasture (Kangalawe and Liwenga 2005). The potential for expansion of the livestock industry into other regions is, however, constrained by the lack of clear land rights for livestock farmers nationally. Some districts and regions have imposed a ban on the entry of livestock from outside their administrative areas (Mashingo 2010). The argument is that land-use plans in the target areas are disrupted by the unplanned arrival of large numbers of livestock. In general, the future or sustainability of the free-ranging livestock-keeping system is uncertain as grazing land becomes scarce due to population pressure – both from livestock and humans – and the lack of demarcated land for livestock farmers nationally.

Livestock production is very important to the economy of Tanzania. Out of 4.9 million agricultural households, about 36 per cent keep livestock, 35 per cent are engaged in both crop and livestock agriculture, while one per cent is purely livestock keepers. Livestock accounted for 5.9 per cent to total GDP in 2006 and 4.7 per cent in 2010 (Mashingo 2010). The system also contributes to national food supply: most of the meat and 70 per cent of the milk consumed in Tanzania comes from the agro-pastoral and pastoral livestock production systems (Njombe and Msanga 2010). Cattle from these production systems contribute 53 per cent of total meat consumed in Tanzania, while sheep and goats contribute 22 per cent to the national meat supply.

Figure 1: Livestock trends based on 10-year running average for cattle, goats and sheep (Source: FAOSTAT 2011).

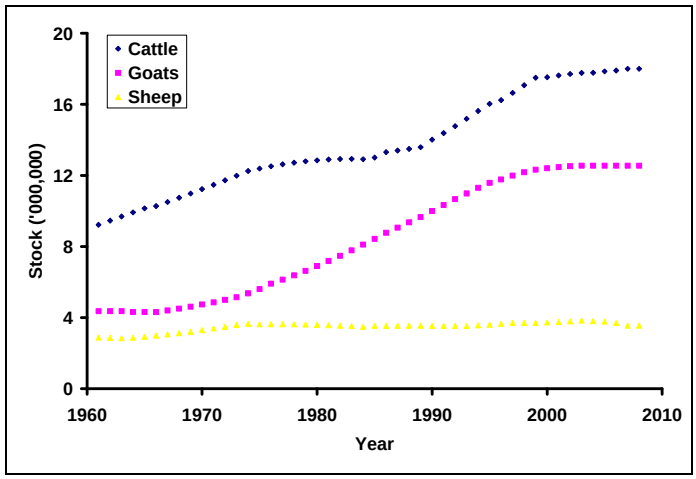
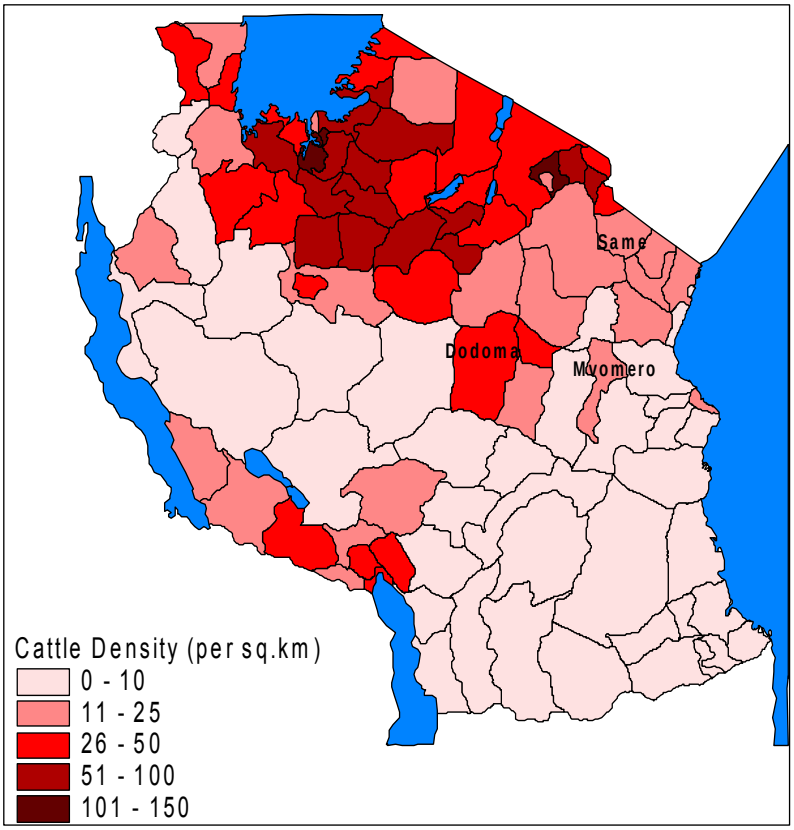


Figure 2: Spatial distribution of livestock in Tanzania (Source: FAOSTAT 2011).



About 80 per cent of the indigenous cattle in Tanzania are kept in the agro-pastoral system (URT 2006b). Owners practise temporary migration but often return to their fixed homesteads and cultivate crops to meet their food requirements and for market. Animals graze in the rangelands and also utilise the crop residues as part of their feed. The animals' feed can be supplemented with agro-processing by-products. Fourteen per cent of cattle in Tanzania – mainly local East African zebu – are reared in the pastoral system (URT 2006b). Cattle rely on extensive grazing in the unfenced rangelands.

About six per cent of the cattle in Tanzania are kept under commercial and smallholder dairy production systems (URT 2006b). Animals kept under these systems include those kept for beef by the National Ranching Company (NARCO) and other private companies, and those kept for dairy production by the Dairy Farming Company (DAFCO) and other government and privately-owned dairy farms (including smallholder dairy farming). Smallholder dairy farming is practised by peri-urban landless farmers and farmers with small land holdings in the high potential areas. They keep grade animals that have high potential for milk production and practise the 'cut and carry' feeding system whereby most of the grass fed to the animals is obtained from the rangelands. The animals' feed is supplemented with some sort of concentrate.

2.2 Impacts of climate change on the system

Prolonged drought has affected animals and pastoralists in the northern part of Tanzania. During prolonged drought, pastoral grazing land and water for livestock diminish. Distances to grazing and water sources increases with the magnitude of drought conditions. Roger (1999) reported an increase in distances in search of water sources from 2.1km pre-drought to 8.26km, and from 5.54km to 16.41km for grazing. Similarly, excessive rains that lead to floods also affect the animals in the rangelands. Animals may drown in the floods or suffer

from lack of feedstuff. Climate change may increase the survival and spread of livestock diseases to areas that were previously free of such diseases. Outbreaks of re-emerging livestock diseases are on the increase in Tanzania (Mdegela *et al.* 2011). The excessive rains that occurred in Tanzania in 2005/2006 led to the outbreak of Rift Valley Fever in Arusha, Manyara and Dodoma regions. Between January and May 2007, a total of 264 cases of Rift Valley Fever (RVF), including 109 deaths of humans, were reported in country. The disease was reported in ten out of the 21 regions of Tanzania (see: http://www.who.int/csr/don/2007_05_09/en/index.html).

Over the past four decades, the country has been hit by a string of severe droughts (Kandji *et al*. 2006). This has resulted into an increase in livestock mobility by pastoralists and agro-pastoralists in search of pastures and water, creating conflicts with crop farmers (Mashingo 2010). During drought periods the price of cattle may fall from US$130 to as low as US$13 and sometimes animals may die. For example, the drought in the northern part of Tanzania in 2009 caused the death of many cattle and other livestock. Statistics from five districts (Loliondo, Ngorongoro, Simanjiro, Kiteto and Mwanga) showed that a total of 143,787 animals died due to drought (Mashingo 2010).

Agro-pastoralists and pastoralists have different strategies to reduce their vulnerability and adapt to, or cope with, current climate variability. These strategies include temporary and permanent migration and keeping different types of livestock, cattle, goats and sheep (Obando *et al*. 2010). Goats and sheep are more adapted to drought than cattle: they can remain alive longer without water and they can browse on shrubs and trees. In the case of temporary migration, during drought periods livestock farmers disperse their herds to different locations depending on the availability of water and pasture. Unwritten arrangements that are always respected among pastoralists in different areas of the country allow them to settle temporarily in a new area in times of drought and return the favour when circumstances arise (Mashingo 2010). Other strategies help in adaptation to climate variability including partitioning of the herd into core and satellite herds and keeping them in different areas; maintenance of a female-dominated herd structure; restocking of the herds of destitute families from those of fellow pastoralists; and diversification beyond agriculture into activities such as mining (Haule 2009). Maintenance of a female-dominated herd structure is used as an adaptation strategy because it offsets long calving intervals and thus stabilises milk production (Coppock 1994).

Construction of charco dams and dams as water reservoirs is being practised in different parts of the pastoral areas.[1] About 800 charco dams and two reservoir dams were constructed by the Government of Tanzania between 2001 and 2006, although they have poor water retention capacity (Mashingo 2010).

[1] A charco dam comprises a pond dug in a flat, semi-arid area and designed to store surface runoff.

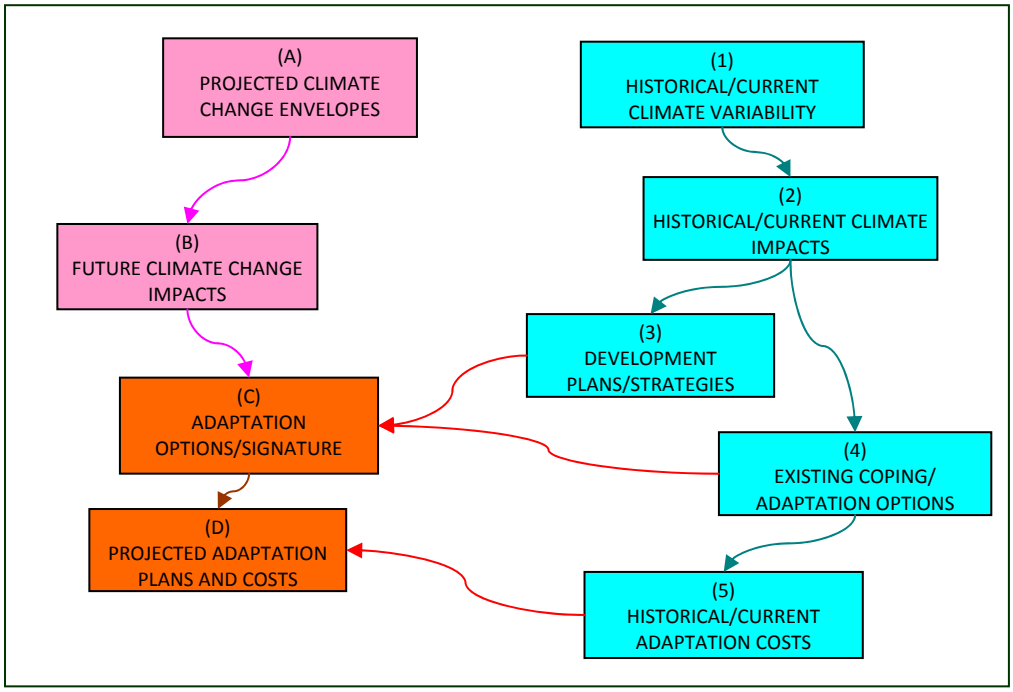
3. Methodology

3.1 Analytical framework of the study

In costing adaptation and understanding planning in animal agriculture, the study adopted a bottom-up design. The case study generated pertinent data and information. With this design at the heart of the methodology, data were collated from different sources. Such secondary sources include FAOSTAT, the National Bureau of Statistics (NBS), national production statistics from NBS, and relevant ministries.

The study was guided by the analytical framework shown in Figure 3. Boxes numbered 1 to 5 represent the current situation, while those designated A to D represent the future and adaptation costs to 2030. Future adaptation signatures (Box C) are determined by the projected climate change impacts (based in turn on the projected climate change envelopes) and the existing adaptation options (Box 4) and local- and national-level development plans and strategies (Box 3).

Figure 3: Analytical framework of the study.



3.2 Sites and the agricultural system

The study was conducted in three districts: Mvomero District (in the Morogoro Region), Same District (Kilimanjaro Region) and Chamwino District (Dodoma Region) as shown in Figure 2. Chamwino and the lowlands of Same District, where most of the livestock are kept, are much drier and vulnerable to drought than the other case study area of Mvomero District. The average precipitation figures during the main crop-growing season (March – April - May) for Morogoro and Same are 430mm and 251mm respectively. The crop-growing season for Dodoma is from December to April and the average seasonal precipitation is 300mm.

The Same District also has major climate/weather extreme events affecting different facets of animal agriculture. Mvomero District is relatively wet with vast sub-humid savannah plains that support both crop and animal agriculture. It also has perennial waters. This has been a major source of conflict between farmers and pastoralists.

3.3 Generation of climate envelopes

3.3.1 Downscaling

The method used to downscale climate forecasts is based on SOMD (Self Organising Map-based Downscaling), developed at the University of Cape Town. Details of the method can be found in the referenced paper (Hewitson and Crane 2006). The method recognizes that the regional response is both stochastic as well as a function of the large-scale synoptic. As such it generates a statistical distribution of observed responses to past large-scale observed synoptic states. These distributions are then sampled based on the global climate model- (GCM) generated synoptic in order to produce a time series of GCM downscaled daily values for the variable in question (typically temperature and rainfall).

3.3.2 Projections

The Coupled Model Intercomparison Project (CMIP3) archive GCMs were used in this study. The downscaling methodology requires daily archive fields which limited the number of suitable GCMs to a total of nine out of a possible 21. Each GCM has a number of simulations. The first is a simulation of the 20th century climate (1961-2000) forced by observed greenhouse gas (GHG) concentrations. This simulation is the GCMs' representation of the observed climate period. It is important to note that there is no correspondence between real years and the years of the 20th century simulations. This means that one can expect no likeness between a particular year in the 20th century simulation and that year in the observational record.

This was followed by a number of simulations of future periods and GHG concentration scenarios. For this study, the two future periods of 2046-2065 and 2081-2100 were selected, and the future development scenarios A2. The A2 scenarios are of a more divided world characterised by independently-operating and self-reliant nations and continuously increasing populations, regionally-oriented economic development, and slower and more fragmented technological changes and improvements to per capita income (www.wikipedia.org/SRES). A total of three GCM simulations, one 20th century period and two future periods, were therefore analysed for each particular GCM. Each GCM simulation was downscaled to the station location and various appropriate climatological summary statistics, such as number of days above 32^{o}C and monthly dry spell durations, were produced and presented in the form of climate projection envelopes (see Chapter 4 of this study). As mentioned above, projection envelopes capture the range of GCM responses to GHG forcing and represent the level of agreement or disagreement between the GCMs.

3.4 Primary data collection

3.4.1 Local level

At the local level, questionnaire surveys were administered to randomly-selected respondents. The aim was to obtain information on livestock dynamics, impacts of climate change on livestock, and adaptation strategies employed to cope with the changing climate.

The characteristics of the households interviewed are given in Tables 1 - 4, showing the type of respondents, education level of the household heads, their ethnicity, and household size. In Mvomero, 50 per cent of respondents were female compared with nine and 23 per cent in Dodoma and Same respectively. The level of education of household heads was almost the same across the three districts, with the majority having no education, or only primary education.

Table 1: Typology of respondents of the questionnaire survey.

District	Male	Female	Total
Mvomero	18	18	36
Same	31	3	34
Chamwino	27	8	35
Total	**76**	**29**	**105**

Table 2: Level of education of household heads (%).

Level of education	Mvomero	Same	Chamwino
None	30.6	50.0	40.0
Primary	69.4	41.2	57.1
Secondary+	0.0	8.8	2.9

In Mvomero and Same, it was mainly people from the Maasai and Pare ethnic groups who were interviewed, with Maasai accounting for about 56 per cent of respondents and Pare 44 per cent; whereas in Dodoma 91.4 per cent of those interviewed were from the Gogo ethnic group (Table 3). Given the fact that the locations were randomly selected, this is a reflection of the types of livestock keepers existing in the three districts. The average age of household heads was 50 years, with the maximum and minimum being 80 and 21 years respectively, with a standard deviation of 13.7 years. The majority (49.5 per cent) of households have fewer than ten members (Table 4), followed by those having between 10 and 20 members (37.1 per cent).

Table 3: Ethnicity of the household heads (%).

Ethnic group	Mvomero	Same	Chamwino
Chaga	0.0	0.0	2.9
Gogo	0.0	0.0	91.4
Maasai	55.6	55.9	0.0
Pare	44.4	44.1	0.0
Zigua	0.0	0.0	5.7

Table 4: Household sizes of the interviewed households in three districts.

Household size	Frequency	% Frequency
<10	52	49.5
10 - 20	39	37.1
20 - 30	7	6.7
30 - 40	5	4.8
>40	2	1.9
Total	105	100.0

3.4.2 District and national levels

Data and information were collected and collated at different scales. A desk study was carried out at different levels to review and synthesise existing information. At the higher level, key stakeholders were consulted through key informants' interviews. This included relevant district authorities, the Ministry of Environment, and the Ministry of Livestock and Fisheries Development. This was followed by a mini-workshop designed to establish various costs related to a selection of adaptation options identified during the questionnaire survey and key informants' interviews. Adaptation options were categorised into short-, medium-

and long-term. The mini-workshop was attended by four livestock farmers, three district-level livestock officers and one senior officer from the Ministry of Livestock and Fisheries Development; these participants estimated the costs of the selected adaptation options based on their experiences in undertaking similar measures.

3.4.3 Stakeholder workshop

A stakeholder workshop was held after the primary and secondary data synthesis. The workshop brought together livestock keepers from the study sites, livestock extension agents, and district-level livestock officers from the three districts. The workshop also brought together academics, researchers and policymakers at national level. The objectives of the workshop were to synthesise the draft report on costing and adaptation of the animal agriculture sector to climate change; provide additional input to the report; and discuss and agree on the institutional arrangement for implementation of the adaptation plans and actions.

Photograph 1: Enumerator training for the case study at a session held at Sokoine University of Agriculture (photo by S. Tumbo, February, 2011).

Photograph 2: Livestock farmers (2nd, 3rd and 5th from right), extension agent (1st from left) and case study researchers (1st and 4th from right) in the lowlands of Western Pare along the Pangani (Ruvu) River (photo by F. Rwehumbiza, October, 2010).

Photograph 3: Mini-workshop on costing in animal agriculture held at Sokoine University of Agriculture (photo by S. Tumbo, March, 2011).

Photograph 4: Participants listening to the presentation by one of the researchers in the stakeholder workshop in animal agriculture held at the Landmark Hotel in Dar es Salaam (photo by S. Tumbo. May, 2011).

3.5 Costing adaptation options

Costing was done in two broad investment areas for the development and adaptation of the animal agriculture sub-sector in a changing climate. These include structures and systems, and training and research across the sub-national and national scales.

The costs were discounted based on Stern's social interest rate (Stern 2006). Stern's discount rate is favoured over a commercial one (Dietz 2008), particularly in public investments with social utility – such as investing in adaptation (Stern's discount rate is an unusually low discount rate). This decision is based on the judgment that it would be unethical to assume that future generations' welfare should matter less in present-day decisions. Stern's discount rate is given by:

$$S = \rho + \mu g = 0.1 + (1*1.3) = 1.4\%$$

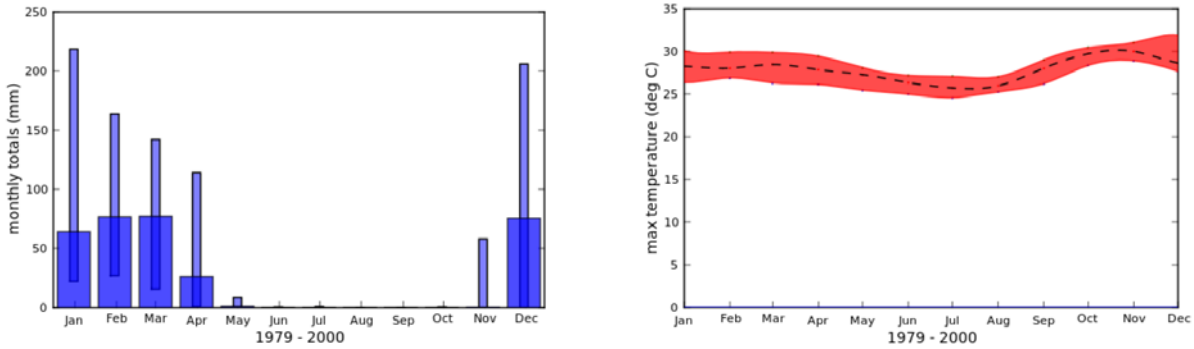
Where; 'S' is the social discount rate, 'ρ' is the rate of pure time preference, 'μ' is the elasticity of the marginal utility of consumption and 'g' is the rate of growth of per capita consumption. For more details on Stern's discount rate, including its critiques, see Stern (2006) and Dietz (2008).

4. Climate change impacts and adaptations

4.1 Observed climate trends, including local-level climate envelopes

Climate trends and envelopes were available for two stations only, Dodoma and Morogoro. Information on Kilimanjaro (Same) could not be obtained. The observed climate plots in Dodoma showed that rainy seasons started in December and ended around April, with February and March being the wettest months (Figure 4a). The seasonal cycle of temperature in Dodoma is fairly constant, as is typical in a tropical location (Figure 4b).

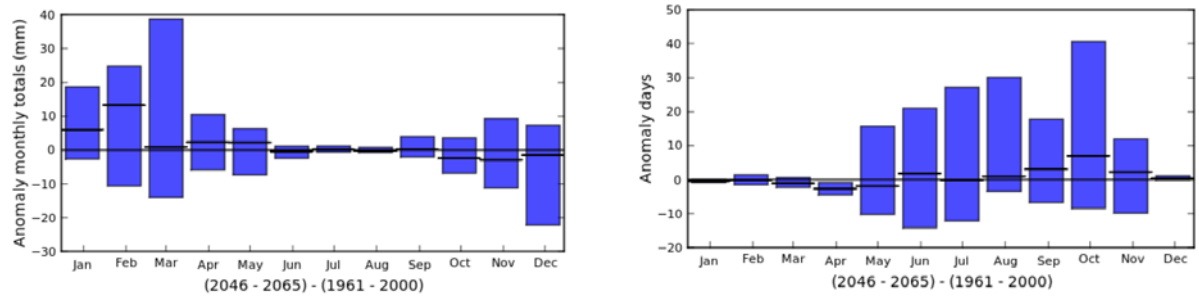
Figure 4: Dodoma current climate, (a) rainfall and (b) maximum temperature.



(a) **(b)**

Projected changes in monthly total precipitation show very little robust change (Figure 5). There is a possibility of wetter conditions during the middle of the rainy season, which would be in agreement with the general regional projections. Projected changes in temperature are consistent with those reported in the *National Adaptation Programme of Action* (2007) and show a general increase of around 2°C throughout the year (Figure 6). Associated changes in the number of days exceeding 32°C show significant changes from January - April and September - December.

Figure 5: Dodoma rainfall envelope anomalies in (a) totals and (b) days.



(a) **(b)**

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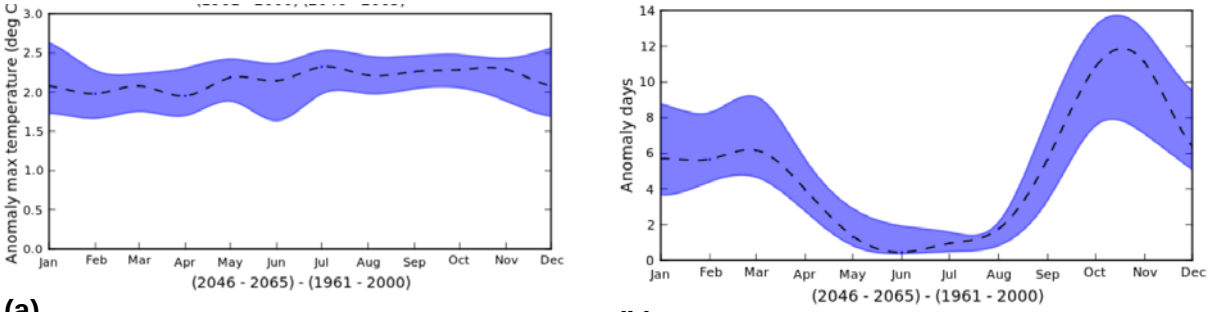
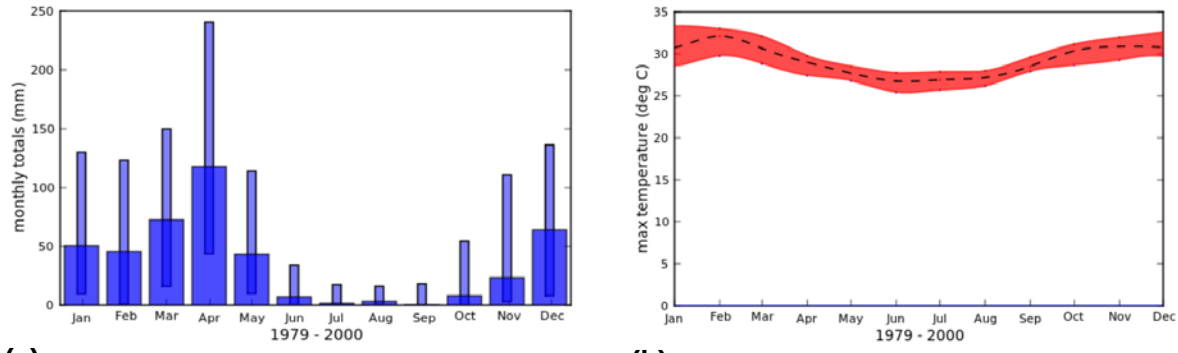
Figure 6: Dodoma temperature envelope anomalies (a) temperature and (b) days.



(a) **(b)**

The observed climate plots for Morogoro show that the rainfall season starts in November, drops off in February, starts to increase again in March and ends in May (Figure 7a). The dry season extends from June through to October. Temperature seasonality shows a small seasonal variation, though the number of days exceeding 32°C is significantly higher during the hottest months of November through to March (Figure 7b).

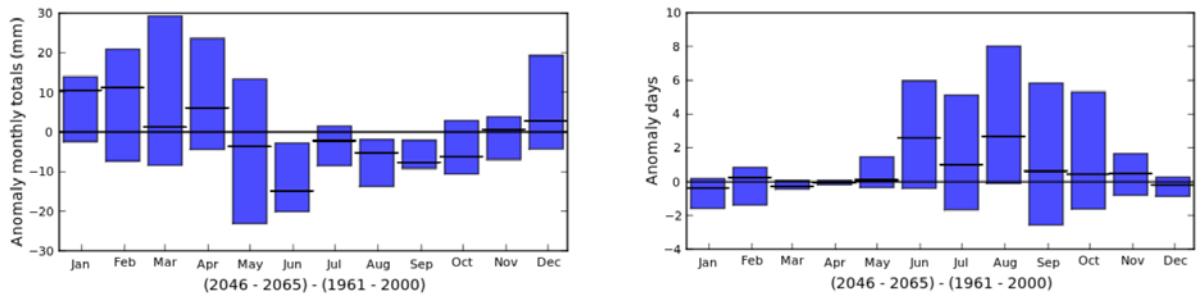
Figure 7: Morogoro current climate (a) rainfall and (b) maximum temperature.



(a) **(b)**

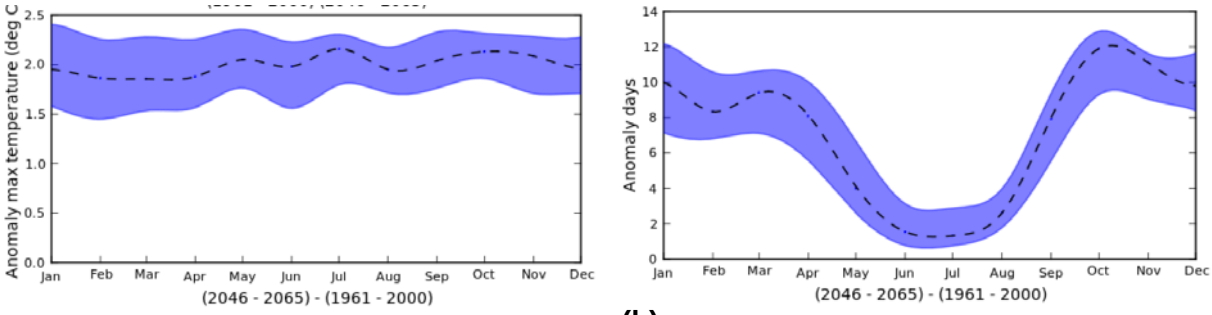
The projected changes in precipitation for Morogoro show a possible increase in mid-season rainfall with a corresponding possible decrease in the late-season rainfall (Figure 8). Projected temperature changes are fairly consistent and robust – around 2°C throughout the year (Figure 9).

Figure 8: Morogoro rainfall envelope anomalies (a) totals and (b) days.



(a) **(b)**

Figure 9: Morogoro temperature envelope anomalies (a) temperature and (b) days.



(a) **(b)**

The projected increases in the mean temperature due to climate change in both Dodoma and Morogoro imply increases in evaporation and demand for water for livestock. The possible increase in the length of the dry season implies the need for large water reservoirs to ensure a sufficient supply of water for livestock.

4.2 Vulnerability to climate variability and change

The extent to which animal agriculture is negatively affected by the changing climate or climate shocks and extremes is the measure of the vulnerability of the livestock production system. The main shocks identified from this study are moisture extremes – namely drought and floods. The study does not cover other areas that might be impacted by climate change such as diseases and vector dynamics, and animal physiology. These normally manifest as externalities of droughts and floods.

The vulnerabilities experienced in livestock production systems are mainly due to the combined effect of droughts of different magnitudes. Droughts alone account for 72 to 84 per cent of the climate shocks (Table 5), as perceived by the pastoralists. Too much rain, accompanied by floods, is the second most important cause of vulnerability. The shocks identified from this study affect animal agriculture and pastoralists in several ways as is shown in Table 6. Loss of animals, famine, and lack of pasture are the most important effects due to droughts and excessive rains.

Table 5: Climate shocks and their importance (%) as perceived by pastoralists in Same, Mvomero and Chamwino districts in Tanzania.

Shocks	Mvomero	Same	Chamwino
Severe drought	50.0	66.3	67.3
Moderate drought	34.2	17.5	5.8
Excessive rains	10.5	0.0	15.4
Floods	0.0	13.8	9.6
Excessive temperature	5.3	2.5	1.9

Loss of cattle due to climate shocks is common in all three case study districts, with (respectively) 38 per cent, 60 per cent and 73 per cent of the respondents in Same, Chamwino and Mvomero districts who have lost any cattle reporting the loss of ten or fewer cattle due to climate shocks (Table 7). Loss of large numbers of animals is common in Same District, where 20 per cent of pastoralists lost more than 50 animals (compared to only six per cent and three per cent in Chamwino and Mvomero respectively). Same is a very dry district with very unreliable and unpredictable rains; most respondents in Mvomero District are migrants from Same District.

Table 6: Effects of climate shocks and their importance (%) as perceived by pastoralists in Same, Mvomero and Chamwino districts in Tanzania.

Effects	Mvomero	Same	Chamwino
	n=51	*n=98*	*n=47*
Loss of animals	47.1	26.5	38.3
Hunger/famine	13.7	36.7	34.0
Lack of pasture	13.7	18.4	2.1
Loss of house	0.0	7.1	21.3
Crop failure	13.7	10.2	2.1
Lack of water	11.8	1.0	2.1

n = total number of responses based on the number of events they encountered in the past.

Table 7: Extent of loss of cattle due to climate shocks and % of respondents who have lost cattle in Same, Mvomero and Chamwino districts in Tanzania.

No. of cattle lost	Mvomero	Same	Chamwino
	n=33	*n=60*	*n=48*
0 - 10	72.7	38.3	60.4
11 - 20	18.2	21.7	18.8
21 - 50	6.1	20.0	14.6
51 - 100	3.0	13.3	2.1
> 100	0.0	6.7	4.2

n = total number of responses based on the number of events they encountered in the past.

The changes in the number of average and median herd sizes were used to understand the vulnerability of the livestock system to climate variability and change (Table 8). The number of cattle in Same District has either remained constant or declined, as is evidenced by the mean and median values. This information is also supported by the migration of livestock keepers from Same to areas such as Mvomero, and the herd splitting practice (as will be shown later). The mean and median herd size is stable in Chamwino. The reasons behind changes in livestock numbers over time in the three districts include: drought, diseases, sale of animals, changing climate conditions, and other less significant reasons such as sudden death and theft.

Photograph 5: Cattle suffering through lack of pasture due to the 2009 drought in Longido District, Arusha Region (photo by V. C. Mwita, MLFD, Tanzania, August, 2009).

Photograph 6: Livestock farmers, livestock extension staff and policymakers from the Ministry of Livestock and Fisheries Development looking at the remains of cattle that died due to the 2009 drought in Longido District, Arusha Region. (photo by V. C. Mwita, MLFD, Tanzania, August 2009).

Table 8: Change in the herd size in the last three decades in Mvomero, Same and Chamwino districts.

District	Statistics	1980s	1990s	2000s
Mvomero	Mean	56.0	72.9	86.6
	Median	8.0	31.5	24.5
Same	Mean	115.5	94.4	63.2
	Median	40.0	70.0	45.0
Chamwino	Mean	51.1	48.5	42.0
	Median	20.0	40.0	30.0
Overall	Mean	92.0	77.6	64.7
	Median	30.0	50.0	35.0

The price of livestock during climatically good years and bad years is also a good indicator of a vulnerable system. The price of cattle in Same District tends to fall drastically, with the mean price during bad years falling by 76 per cent compared to about 50 per cent in Mvomero and Chamwino (Table 9). The low prices are caused by loss in weight of the animals as drought escalates. Good and bad years are differentiated by the amount of rainfall received and the subsequent availability of food, pasture and water.

Table 9: Livestock price (Tsh) dynamics between climatically good and bad years, based on the recent experiences of pastoralists.

Statistics	Mvomero		Same		Chamwino	
	Good year	*Bad year*	*Good year*	*Bad year*	*Good year*	*Bad year*
Average	325,000	160,294	428,529	98,970	395,142	174,371
Median	300,000	135,000	400,000	100,000	400,000	150,000
Standard dev.	126,281	83,683	163,190	74,200	128,872	102,701
Maximum	600,000	400,000	800,000	300,000	700,000	400,000

1 x USD = 1,500 TShs.

4.3 Existing coping strategies

Coping strategies that livestock farmers have utilised when they experience climate shocks (such as drought, floods, too much rain, and high temperatures) are presented in Table 10. Such strategies include: migration, sale of animals, food relief from government/NGOs, remittances from relatives, community help and other strategies (which included building stable houses to withstand floods, selling of labour, and selling of durables and assets). Disposal of personal assets is a last resort and is therefore an indication of desperation. Sale of animals and migration are the main coping strategies.

Table 10: Coping strategies for livestock farmers when they experience climate shocks.

Coping strategies	Mvomero	Same	Chamwino
	n=44	*n=72*	*n=61*
Migration/relocation	54.5	26.4	8.2
Sale of animals	38.6	51.4	44.3
Relief food from government/NGOs	4.5	12.5	19.7
Remittance	2.3	1.4	11.5
Community help	0.0	5.6	1.6
Others	0.0	2.8	14.8

n = total number of responses based on the number of shocks they encountered in the past.

Temporary migration to areas where water and pasture are abundant is practised by a majority of respondents (Table 11). The extent to which this is practised among pastoralists is 97 per cent for Mvomero and Same, while for Chamwino it is 67 per cent. In principle, pastoralists are practising transhumance, i.e., a seasonal movement of herds between fixed points to exploit the seasonality differential of pastures and water resources. A permanent homestead and base is maintained where the older members of the community remain throughout the year.

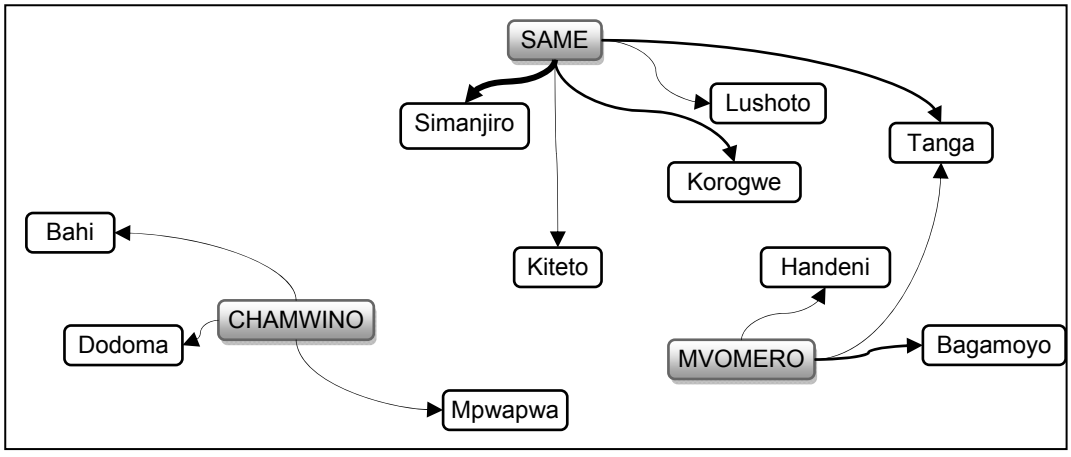
Table 11: Extent of temporary migration and herd splitting.

Action	Mvomero		Same		Chamwino	
	n	%	*n*	%	*n*	%
Temporary migration	*34*	97.1	*29*	96.6	*21*	66.7
Herd splitting	*34*	5.9	*32*	56.3	*24*	8.3

n = number of responses.

Herd splitting on the other hand is semi-permanent to permanent in nature. Pastoralists practise herd splitting – where men take away the majority of the animals in search of distant grazing lands and water, leaving some family members behind with a few lactating cows. Figure 10 shows the livestock farmers' temporary migration networks. It should be noted that the pastoralists return to their homesteads in Same, Chamwino and Mvomero each year.

Figure 10: **Livestock farmers' temporary migration networks.**



4.4 Long-term adaptation strategies

Table 12 shows some of the long-term adaptation strategies that respondents felt they could implement. Generally, destocking or animal harvesting seems to be more favoured by the livestock farmers, followed by migration and diversification. Animal harvesting is a practice whereby animals are sold on a regular basis to avoid overstocking. In Chamwino it is mainly regular animal harvesting that is practised whereas in Same, sale of animals (or destocking) is mainly caused by drought. Migration is very popular in Mvomero. In this area, most of the livestock keepers are immigrants (as described earlier) hence migration comprises their foremost option. Other adaptation actions include: purchase of pasture land, conservation and storage of forage, consulting veterinarians, building community dips, and keeping more animals of resilient species.

Table 12: Long-term adaptation strategies.

Adaptation strategies	Mvomero	Same	Chamwino	Total
	n=43	*n=35*	*n=35*	*n=113*
Destocking/harvesting	9.3	20.0	60.0	28.3
Migration	34.9	2.8	2.9	15.1
Diversification beyond pastoral enterprises	9.3	20.0	17.0	15.0
Restocking/keeping more animals	14.0	17.2	5.7	12.4
Collective actions on pasture and water	7.0	22.8	2.9	10.6
Investing in own water points	18.6	2.8	2.9	8.9
Other adaptation actions	6.9	14.4	8.6	9.7

n = number of responses based on different types of shocks.

Photograph 7: Charco dam for water for livestock in Mvomero District – a means to adapt to a changing climate (photo by F. Rwehumbiza, December, 2003).

Photograph 8: A water tank and water trough for livestock built adjacent to a charco dam in Kwesasu village in the lowlands of the western Pare Mountains (photo by F. Rwehumbiza, June, 2004).

Diversification is another adaptation strategy listed in the adaptation signature. Table 13 shows the kinds of diversification that respondents mentioned. Diversification options for Mvomero and Chamwino districts are mainly restricted to commercial buildings and crop production, as compared to Same District with more diversification options. Commercial buildings provide livestock farmers with additional income through businesses such as guesthouses, shops and hotels (or just by renting them out). The greater number of options that are available in Same District is possibly due to the good road infrastructure linking it to the business cities of Dar es Salaam, Moshi, Arusha and Nairobi.

Table 13: Diversification beyond pastoral system.

Enterprises	Mvomero	Same	Chamwino	Total
	n=26	*n=53*	*n=37*	*n=116*
Commercial buildings	34.6	24.5	48.6	34.5
Small business	19.2	32.1	5.4	20.7
Artisan	7.7	22.6	0.0	12.1
Crop production	38.5	20.8	45.9	32.8

n = number of responses (multiple response question).

External safety nets during crises are often expected to be provided by the government but interviews with respondents showed that most livestock farmers are not anticipating safety nets from the government (Table 14). Some respondents in Chamwino (42.8 per cent) and Same (24.1 per cent) expected some form of government support; these areas have been recipients of relief food due to severe droughts. Also, respondents in Mvomero expected some support with regard to water points (25.0 per cent), indicating that the district was a beneficiary of some government support of charco dams.

Table 14: Expectations from external safety nets.

Expectations	Mvomero	Same	Chamwino
	n=36	*n=29*	*n=35*
No expectations	66.7	58.6	51.4
Government support	5.6	24.1	42.8
Support for water points	25.0	10.3	0.0
Others*	2.8	6.8	5.8

**Others: relocation to good pasture; compensation for lost animals; shelter provision; improve the infrastructure; education on how to manage impacts.*

n = number of responses.

Production of crops is another strategy to adapt to changing climate and livelihoods. During the mini-workshop it was found that Maasai in Mvomero had started to grow crops in the last two to three decades after Pare agro-pastoralists migrated into the area. The respondents keep livestock and grow crops so as to meet their food requirements. The main cereal crops are maize, rice and sorghum. Maize is the most important crop in Same and Mvomero while sorghum is the main crop in Chamwino. The ability to meet household food needs is significantly limited (Table 15). With respect to maize, only few households are able to meet their annual requirements: 17 per cent of the households in Mvomero, eight per cent in Same were maize self-sufficient and none at all were in Chamwino. Generally, most households were able to meet only between 25 per cent and 50 per cent of their food needs with respect to the main cereal crops.

Table 15: Level (%) of meeting household food demand from crops grown.

Food sufficiency level	Mvomero		Same	Chamwino	
	Maize	Rice	Maize	Sorghum	Maize
	n=23	*n=19*	*n=26*	*n=37*	*n=25*
<25%	30.4	42.1	53.8	21.6	28.0
50%	43.5	52.6	34.6	48.6	56.0
75%	8.7	0.0	3.8	8.1	16.0
100%	17.4	5.3	7.7	21.6	0.0

n = number of responses (multiple response question).

5. Planning and costing adaptation actions

5.1 Adaptation actions

The most helpful adaptation options for the majority of respondents in the three districts were identified as: purchase of pasture land, which guarantees pastoralists access to pasture; herd splitting; forage conservation; collective investment in pasture; private water points; communal dips; and communal water points (Table 16). These adaptation options must be enhanced by the government through policies and public investments. Some local government and national government priority actions and plans for adaptation from now up to 2020 include: taking a census of animals in order to have a proper record for land-use planning; and having proper land-use plans where there is demarcation of land for livestock, crop production and other uses.

Table 16: Respondents' perception on the helpfulness of different adaptation actions (% yes).

No.	Adaptation option	Mvomero		Same		Chamwino		All	
		n	%	n	%	n	%	n	%
1	Quit pastoralism	3	9	15	44	9	47	27	41
2	Destocking	7	21	15	45	24	83	46	61
3	Go semi-intensive	10	30	28	82	10	56	48	66
4	Acquire well-adapted species	19	58	20	59	16	84	55	66
5	Increasing stock	18	59	27	82	13	54	58	69
6	Buy pasture land	28	78	26	76	19	68	73	75
7	Herd splitting	20	61	27	93	14	74	61	78
8	Conserve forage	31	89	26	81	17	81	74	84
9	Collective investment in pasture	33	94	29	88	13	62	75	86
10	Water point (private)	32	100	30	83	15	83	77	90
11	Community dips	34	100	31	91	25	78	90	91
12	Water point (communal)	36	100	31	91	27	84	94	92

n = number of responses, % = percent responses with 'yes'.

Based on the questionnaire analysis, which ranked the adaptation actions based on willingness to invest, and through the responses of farmers at the mini-workshop, six adaptation actions that farmers are willing to invest in were identified. These were:

1. Communal water points
2. Community dips
3. Private water points
4. Stock increase
5. Herd splitting
6. Collective investment in pasture

Actions that were perceived as low priority included: conserving forage, buying pasture land, going semi-intensive, destocking, acquiring well-adapted species, and quitting pastoralism.

There is a clear discrepancy between the actions pastoralists consider the most helpful and those they are willing to invest in, which can be explained by a number of factors. Conservation of forage is not likely to be popular in terms of investment because livestock farmers maintain large herds. Reluctance to go semi-intensive is related to the low adaptative capacity of improved breeds. Destocking and quitting pastoralism is not an option because of a lack of alternative investment options and also due to cultural values. Farmers are also uncertain regarding land ownership; this may be related to previous negative experiences – especially if their traditional lands have later been converted to other uses by local and central governments. Furthermore, ranches previously owned by the government, which most livestock farmers expected would be given to them, were sold to investors from other regions or countries. Identifying these barriers to adopting the most helpful adaptation measures is crucial to determining how to address them.

During the stakeholder workshop it was noted that it is possible for farmers to have positive attitudes towards these actions nevertheless. What is needed is education, supply of information, and actions by local and central government that address their needs so as to reduce uncertainties. Education can be provided through various means, including use of influential people such as religious and political leaders. Also, for livestock farmers to take radical decisions such as quitting pastoralism, option portfolios which are safe and have high yields should be present and accessible to them.

5.2 An adaptation pathway in animal agriculture

The adaptation options highlighted in the questionnaires, the mini-workshop, government policies, and in interviews with livestock farmers and stakeholders at district and national levels were used to develop an adaptation pathway, which was later adjusted during the stakeholder workshop. Figure 11 and Table 17 show the adaptation pathway, indicating adaptation options at three levels: development deficit, climate variability, and climate change. The development deficit box demonstrates that the magnitudes of the effects in the livestock sector are also caused by the development deficit typical of less-developed countries. Figure 11 and Table 17 imply that in order to reduce the vulnerability in animal agriculture, significant investment and actions are required to address this development deficit.

Figure 11: The adaptation pathway in animal agriculture.

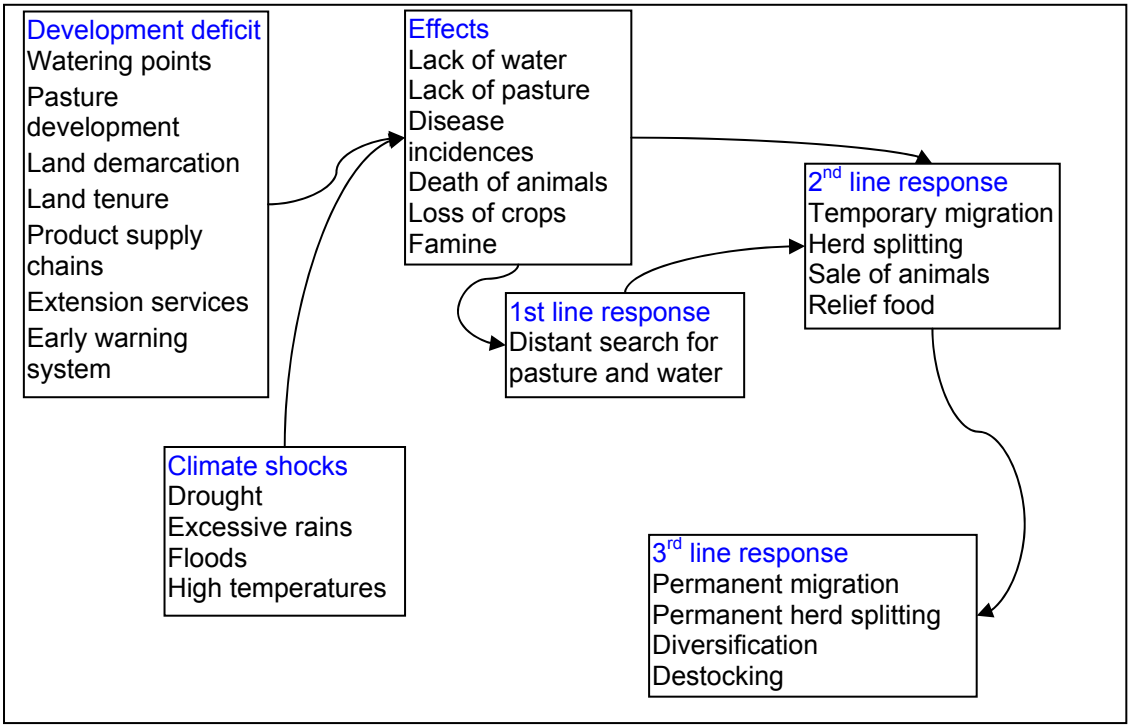


Table 17: Development deficit, coping and adaptation actions.

Development deficit	Climate variability	Climate change
Water and dip systems	Distant search for pasture and water	Permanent migration
Pasture development	Unscheduled sale of animals	Permanent herd splitting
Land-use plans	Temporary migration	Diversification
Animal harvesting	Temporary herd splitting	Destocking
Product supply chains	Relief food	Agro-forestry (crop-livestock-tree)
Extension services	Temporary employment	
Research and training		Changing livestock grazing systems
Early warning system		

5.3 Cost estimation and scaling-up

The costs of different adaptation pathways were derived in an integrated bottom-up approach. The approach involved a range of key stakeholders at different development and adaptation planning scales – local, sub-national and national. A systematic blend of practical experiences from these stakeholders and policy actions established a credible basis for scaling-up of cost estimates at a national scale. While some of the adaptation pathways relied solely on local experiences for costing, some relied on inputs from higher planning scales, or a mixture across scales. Furthermore, the three communities and their climate settings seem to represent a typical Tanzanian agro-pastoral ecosystem striving in a changing climate. Across the country, human population has doubled in the past twenty-five years from 20 million in the late eighties to 40 million in 2011. Scarcity of grazing land and water is becoming critical as production of food takes more of these resources. Temporary and permanent migration is an option that is employed in other parts of the country. The Sukuma and Nyamwezi livestock keepers have, for example, moved from Mwanza, Shinyanga and Tabora to Iringa and Mbeya regions in southern Tanzania in search of water and pasture. The central government has facilitated the transfer of livestock keepers from Usangu Plains (Iringa and Mbeya) to the coastal region of Lindi. This is evidence of the feasibility of the 'migration' option in other parts of the country for the time being. Therefore, the adaptation actions proposed are applicable to other communities in Tanzania outside the case study area.

5.4 Systems and structures

Table 18 provides a summary of the actions and actors and what could be done now and in the future for systems and structures.

- A 'system' is defined here as set of methods, procedures, and routines established to solve a problem (an early warning system, and temporary and permanent migration are considered as systems).

- 'Structures' refers to physical objects such as watering points and dips.

Therefore systems and structures earmarked for adaptation actions include an early warning system, temporary and permanent migration, building watering points and dips, and development of land-use plans and management plans.

5.4.1 Early warning system

The Government of Tanzania, through the Ministry of Livestock and Fisheries Development, is planning to develop an early warning system on the predicted status of pasture and water for livestock based on seasonal rainfall forecasts, and to inform livestock farmers so that they can take appropriate coping actions. Through consultation with ministry officials, the initial cost of setting up the system was estimated at US$180,000, with management of the system estimated at around 30 per cent of the investment per annum. In the stakeholder workshop it was observed that the amount is too small to establish such system at a national scale and the research team has therefore estimated that it will be necessary to quadruple the amount originally suggested.

Table 18: Adaptation actions in the area of systems and structures.

Actions	Actor	Now	Later
Early warning system	National	Develop early warning system	Maintain early warning system
Temporary migration	Local/district	Re-establish livestock routes and facilities and create new ones	Maintain livestock routes and facilities
Permanent migration	Local/district	Identify and equip potential areas for migration	Maintain and promote migration of livestock farmers to established sites
Building watering points	Local/district	Build more watering points	Continue building watering points; undertake rehabilitation every five years
Building dips to control diseases	District	Build more dips	Continue building dips; undertake rehabilitation every five years
Developing land-use plans	National/district	Capacity building and implementation of land-use plans	Implementation of land-use plans
Developing land management plans	District	Start land management plans	Continue with land management plans

5.4.2 Temporary migration of livestock farmers

Temporary migration of livestock is very common among livestock keepers (as was proven in the case study). This study managed to establish the costs involved in temporary migration of livestock through a workshop that involved key informants – livestock farmers from Mvomero District. The costs involved are based on a typical case involving moving livestock from Mvomero District to Bagamoyo District (about 150km), a regular destination for temporary migration of 300 cattle (Table 19). This seems to be an average distance for a temporary migration practice in a typical Tanzanian agro-pastoral setting.

Scaling-up of temporary migration costs involved a number of empirical assumptions. It was assumed that 72 per cent of the cattle would be relocated temporarily countrywide. This figure was computed by multiplying the percentage of farmers who migrate temporarily (Table 11) and the proportion of cattle they normally relocate with (80 per cent), which was the figure given by livestock farmers during the mini-workshop. About 20 per cent of cattle are left behind for various reasons, including milk production. The growth of the cattle population was projected using the annual average growth rate (5.6 per cent) from the 1990s over the costing time horizons of 2020 and 2030. In establishing the temporally migration episodes across time, a recurrence period of two in every five years was assumed. This reflects a general trend of severe droughts warranting temporary migration, particularly in the semi-arid drylands. During the mini-workshop, the average cost of moving one head of cattle temporarily was estimated to be around US$16.

Table 19: Various costs pastoralists incur during temporary migration of 300 cattle from Mvomero to Bagamoyo.

Cost items	Amount (US$)
Trekking – return journey	1,000
Drugs	133
Permit	600
Death	1,667
Settlement	240
Opportunity cost	1,200

5.4.3 Permanent migration

The cost for permanent migration includes the costs listed for temporary migration (Table 19, but re-calculated for a one-way journey) and additional costs listed in Table 20, which include those involved in processing school migration documents for children and the settlement fee.

The first assumption was that on a weighted average, 27 per cent of agro-pastoral households practise permanent migration (Table 10). It was also assumed that a typical agro-pastoralist with a median-sized herd of cattle might practise permanent migration. Results in Table 8 indicate that the most recent overall median-size herd was 35 heads of cattle. To obtain the number of households with median-sized herds of cattle countrywide, the projected cattle population was divided by the median number of cattle owned by a typical livestock farmer, i.e., 35. Those with migration habits were obtained by multiplying the proportion of those who practised migration in the study communities (27 per cent) with households with median of 35 heads of cattle. A per animal cost of practising permanent migration was estimated to be about US$11.

Table 20: Various costs pastoralists incur (with 300 cattle and four wives) during permanent migration from Mvomero to Bagamoyo.

Cost items	Amount (US$)
Housing for four wives	853
Processing children's school documents	128
Hiring trucks for calves	267
Buildings for calves	33
Settlement cost/fee	367

5.4.4 Watering points and dips

The costing for watering points and dips was computed based on 5,000 livestock in total in three villages with one dam, three charco dams and three boreholes (one for each village). One dip was considered necessary alongside the dam for the control of tick-borne diseases. The entire system for the three villages, comprising these components, would cost around US$260,000 for initial investment costs. The cost for each water reservoir/source and one dip are given in Table 21. The final figure used in the projection was adjusted by a factor of 1.2 to take into account watering troughs and pumps for lifting water from boreholes into troughs.

In scaling-up at country scale, the projected numbers of the various animal species, based on past annual growth rates (from 1999), were converted into an equivalent number of cattle. The standard tropical animal equivalents (tropical livestock units – TLU) were used in the conversion process.[2] Watering points are required in most regions where livestock are kept in large numbers, e.g., Mwanza, Shinyanga, Tabora, Singida and Arusha. Inadequate watering points are the source of most conflicts between livestock keepers and crop growers in most parts of the country, as both converge on the same water sources.

Table 21: Estimated costs for building various types of reservoirs or water sources.

Water source	Unit cost (US$)
Dam	133,300
Charco dam	46,700
Borehole	53,300
Dip	23,300

5.4.5 Land-use planning and management

Land-use planning for each village to demarcate land for various uses (including for livestock) is in the plans of the government. Creating a village land-use plan is estimated at costing US$6,700; the estimated number of villages is 11,000. The village land-use plan creation rate must be at least 515 per annum so as to complete the task by 2030. This exercise will address issues of priority to farmers (see Table 16) related to the options of increasing stock, going semi-intensive, and destocking because farmers will have knowledge on the available land for livestock. For example, the decision to increase stock or to destock will be decided by the available land for grazing allocated to individual or a group of livestock farmers. This also addresses the issue of buying pasture land. At the moment, livestock farmers are not in a position to own pasture land because of lack of a land-use plans in most of the rural areas.

The basic assumptions are that all villages countrywide require land-use plans that will enable allocation of land resources to different sectors, including livestock farming; and that the integration of crop and livestock (i.e., agro-pastoral) farming is a practice suitable in all villages in the country. The latter assumption appears to hold true since recently there has been government-facilitated movement of pastoralists and their animals to the southern regions of Lindi and Mtwara that have never served as pastoral destinations in the past. However, attribution of the entire costs of land-use planning and management to livestock farming alone gives a higher cost figure compared to a cost figure that would combine crop and livestock farming. Additionally, allocation of land to pastoralists will pave the way for improvement of rangelands by individuals through seeding the land with nutrient-rich pastures and fodder plants. Currently, investing in the improvement of rangelands by individuals is not feasible because most grazing land belongs to the central government and therefore anyone can use it at any time.

5.4.6 Research and training

Research and training components of adaptation actions focus on building knowledge on climate change and adaptation actions for livestock farmers, extension agents, researchers and policymakers (Table 22). The focus of actions is in training livestock farmers on crop agriculture, diversification beyond agriculture, semi-intensive livestock keeping, forage conservation, pasture development, and climate change issues. (All stakeholders, however, need to be trained on climate change issues.) Several livestock and rangelands research areas have been proposed.

[2] TLU = Tropical Livestock Unit, a weighted standardisation of different types of livestock. One TLU is equal to 250 kg. A cow = 0.90 TLU; an oxen = 1.5 TLU; a sheep or goat = 0.20 (Defoer, *et al*. 2000).

Table 22: Adaptation actions in the area of training and research.

Action	Actor	Now	Later
Training pastoralists who are practising agriculture	District	Train pastoralists on agronomic management aspects	Train pastoralists on agronomic management aspects
Training pastoralists on semi-intensive livestock agriculture	District	Train pastoralists on semi-intensive livestock agriculture	Train pastoralists on semi-intensive livestock agriculture
Training livestock farmers on diversification beyond agriculture	National/ district	Train livestock farmers on alternative enterprises	Train livestock farmers on alternative enterprises
Training of farmers on climate change issues	District	Train farmers on climate change	Train farmers on new emerging issues
Basic training for extension workers	National	Include climate change aspects in the syllabus and increase annual output	Maintain annual output of extension professionals
Re-training extension workers	National	Current extension workers	New emerging issues on climate change
Re-training policymakers	National	Current policymakers	New emerging issues on climate change
Research on water-efficient breeds	Research institutions	Start research on water-efficient breeds	Continue research on water-efficient breeds
Research on water for rangelands	Research institutions	Start research on water for rangelands	Continue research on water for rangelands
Research on re-seeding of the rangelands	Research institutions	Continue with research on re-seeding of the rangelands	Continue with research on re-seeding of the rangelands
Research on rangelands, water and livestock	Central government	Improve policies on rangelands, water and livestock	Improve policies on rangelands, water and livestock

During a mini-workshop on costing, the participants estimated the cost of training one farmer at around US$100 per annum. This includes training and follow-up trips after training. It was noted that the number of livestock extension staff is still low. According to the Minister of Livestock and Fisheries Development's budget speech in 2008, the number of livestock extension staff required was 16,050. The cost for training one extension staff member in the public agricultural and livestock colleges for at least two years at certificate level is around US$1,000. Re-training of extension staff and policymakers on climate change-related issues was also mentioned as a priority area. The cost was estimated at around US$1,070 each, which will include a daily subsistence allowance, teaching materials and the time of resource persons. The estimates are based on ministerial medium-term expenditure frameworks (MTEFs) that are the basis for budgeting.

The research cost for adaptation in animal agriculture is based on the amount computed for agricultural research (Tumbo *et al*. 2010). The research cost is estimated at 30 per cent of agricultural research into adaptation needs, based on the livestock sector's contribution to the agricultural GDP (30 per cent).

5.5 Cost for various adaptation actions to 2030

Local practical experiences and historical investment projects, at micro-level and sub-national scales, were the basis of cost aggregation at national scale. The national data and plans complemented such local estimates. The future value of the current investment costs were obtained through discounting, using Stern's social rate of interest (as explained earlier).

Re-training of policymakers and installation of an early warning system are the least costly adaptation actions. For now (and in the future), training pastoralists in how to venture into crop agriculture and other income-generating enterprise activities seems to be the most expensive adaptation option. The two factors that seem to have contributed to the higher costs of training pastoralists include the increasing number of pastoralists to be trained over the coming years and the expense of trainings – particularly on entrepreneurship – that fall outside mainstream extension activities. Other adaptation options that need huge budgets to implement include migration for pastures; provision of water for animals; and livestock research. Some of the adaptation actions that are likely to bring greatest benefits include the creation of land-use plans and implementation of the early warning system. Land-use plans will establish carrying capacity and therefore strategies to develop and maintain rangelands. The early warning system will provide information to stakeholders so that they can take appropriate actions before shocks arrive. Other adaptation actions which are currently very effective, such as temporary and permanent migration, are already being practised by livestock farmers themselves.

In order to implement a range of key adaptation options in animal agriculture, Tanzania needs about US$226 million per annum, US$2,200 million by 2020 and about US$4,000 million by 2030. The annual development deficit and adaptation costs in animal agriculture are estimated at US$87.7 million and US$139.0 million. The combined annual costs for both development and adaptation for livestock farmers, district, and national levels are estimated at about US$36.9 million, US$169.2 million and US$3.0 million, respectively.

Table 23: Development deficit and adaptation costs for now, 2020 and 2030 in million US$.

Planning scale	Actions	Sub-actions	Time scales	Now	y2020	y2030
National	Early warning system	Early warning system	Short term	0.4	3.2	4.8
	Extension training	EW - basic training	Medium term	1.2	11.1	20.8
District	Watering points	Watering points - investment	Medium term	60.7	563.1	1,053.1
		Watering points - R & M	Long term	12.1	112,6	210.6
	Dips	Dip system - investment	Medium term	5.1	46.9	87.8
		Dip system - R & M	Long term	1.4	12.9	24.1
	Land-use plans	Village land-use plans	Short term	3.4	31.8	59.5
		Village land management plans	Medium term	3.4	31.8	59.5
Livestock farmers	Migration	Temporary migration	Short term	84.4	793.2	1,504.5
		Permanent migration	Long term	9.1	84.1	157.2
District	Training	Training: crop agriculture[+]	Medium term	51.9	487.9	925.3
		Training: diversification	Long term	31.2	292.7	555.2
National	Training	Training: EW - climate change	Short term	1.3	11.9	22.2
		Training: policymakers - climate change	Short term	0.1	0.6	1.1
	Research	Livestock research	Long term	17.6	181.2	311.6
			Total	**283.3**	**2,670.4**	**4,997.3**

[+]*crop agriculture, semi-intensification.*

EW[=] Extension workers.

R & M = repair and maintenance.

6. Institutional arrangements and funding for implementing adaptation

6.1 Current institutional set-up

6.1.1 Ministry responsible for animal agriculture

Efficient implementation of adaptation in the pastoral system requires a robust institutional set-up. Functional linkages and hierarchies need to be well coordinated to guide adaptation actions across line sector ministries. Governance of livestock and crop sectors has experienced repeated restructuring in the past three decades. The two sectors used to be under one ministry but are now under two different ministries: the Ministry of Agriculture, Food Security and Cooperatives, and the Ministry of Livestock and Fisheries Development (MLFD), which deals with the livestock sector at national scale including policy, planning, research and training. The decentralisation policy has also brought into play the Ministry of Local Government, which is responsible for extension activities in both crop and animal agriculture. This has further complicated the coordination of actions in the two sectors. Agro-pastoralists, who comprise the majority of farmers in the country, operate their farms as one entity.

Given the inseparability of the sectors at the grassroots level, the multiplicity of adaptation stakeholders, and the complexities around climate change adaptation, the efficacy of the current institutional set-up remains contentious. Uncoordinated and parallel efforts may be of little help to the agro-pastoral communities.

6.1.2 Ministry responsible for the environment

The Ministry of Environment has a full minister but is under the office of the Vice President. At the moment, climate change issues are handled by the Assistant Director of Environment. This section negotiates climate change funds for the country, and in some cases coordinates funds for climate change activities.

The institutional set-up at national level with regard to environment and climate change is in place but not yet fully implemented. Each district is supposed to have an environmental committee and officer, and every ministry is supposed to have an environmental section. Most of the districts have not yet employed environmental officers or established environmental committees. Some of the districts have assigned task to individuals or sections with inadequate training and knowledge on environmental matters. Also, the MLFD is yet to establish an environmental section. Participants at the stakeholder workshop who represented the ministry indicated that they are likely going to start the process of forming an environmental section. Furthermore, participants at the stakeholder workshop were informed by the Assistant Director of Environment that several countries – such as Nigeria, Kenya, South Africa and Uganda – have already established units or secretariats on climate change. The Ministry of Environment in Tanzania recognizes the change that has already taken place in other countries, including those surrounding Tanzania, and the need to restructure itself so as to have a proper climate change section.

6.2 Budgetary allocation for livestock development

The information in Table 24 shows the proportion of the MLFD budget that was allocated to the pastoral system from 2007/2008 to 2009/10. The actual amount allocated to the pastoral system has increased significantly over the past few years, however the proportion of the budget allocated to pastoralism remains at about 1 - 2 per cent of the total livestock budget. Since the pastoral system accounts for about 14 per cent of the cattle in Tanzania, the amount of money allocated to the system was 13 per cent, 10 per cent and 10 per cent of its ‘expected’ allocation for 2007/08, 2008/09 and 2009/10 respectively. This indicates that only small proportion of the budget is allocated to the pastoral system.

Table 24: Budget allocation for livestock and pastoral system development (2010 US$) (Source of data: ministerial budgets).

Budget items	2007/08	2008/09	2009/10
Overall livestock budget	18,266,247	38,744,665	48,287,962
Pastoral system budget	343,258	557,123	724,941
Share of pastoral system budget (%)	2	1	2
Expected pastoral budget (14% of livestock budget)	2,557,275	5,424,253	6,760,315
Pastoral system financing gap	(2,214,017)	(4,867,130)	(6,035,374)

6.3 Current flows of funding for climate change adaptation

Central government has been allocating funds that (directly or indirectly) are addressing climate change related actions. Land-use planning activities have been budgeted TShs150 million (US$100,000) for 2011 (for development of land-use and management plans).

Similarly, the development of the early warning system has been allocated TShs116,000,000 (US$77,300); construction of dams and small dams for individual farmers was allocated TShs191,000,000 (US$127,300). These sums have been allocated to the Ministry of Livestock and Fisheries Development budget. Although these three actions only make up a small proportion the total livestock budget of US$48m for 2009/10, their combined costs are equal to almost half the current pastoral budget of US$725,000.

There are three types of external funding for climate change mitigation and adaptation activities. The first falls under the climate change agreement of the Kyoto Protocol. Bilateral agreements are the second source of funding and the third is institutions that can provide funds either as loans or grants – such as Pilot Project on Climate Resilience (PPCR) funds from the World Bank. It is worth noting, however, that so far these funds have not targeted climate change adaptation and mitigation in animal agriculture.

7. Conclusions and recommendations

The changing climate has resulted in environmental shocks such as drought, excessive rains, floods and high temperatures – causing an inadequate supply of water and pasture, an increase in disease incidences, death of animals, and other effects. Through this study, various adaptation actions have been identified and categorised as operating at three levels: development deficit, climate variability, and climate change. Some of these actions include: the establishment of an early warning system, investments in systems that will improve pasture and water, and training and research. Costing of the adaptation actions was done up to 2030.

In general, current climate change actions are not properly coordinated at local, district and national scales, even though there is an institutional set-up at national level. Investments to address the shocks in animal agriculture are uncoordinated and inadequate. Structures, trained staff and existing institutional arrangements are inadequate to meet the challenge. Extension personnel with expertise in climate change adaptation have to be trained and deployed in rural areas.

This study on the economics of climate change in Tanzanian animal agriculture is possibly the first, and it was undertaken for a very short period (four months). There are several gaps that need to be addressed and some estimates need to be improved. For example, the study has not addressed issues related to extreme temperatures and floods. These areas need basic research to establish the likely impacts and their costs for adaptation. Research has been recommended based on suggestions put forward by participants during the stakeholder workshop. In this study, most of the costs considered are those arising from drought, which is currently the main climate change shock. Therefore, based on the findings of this study the following are the policy recommendations:

1. **Establish an environmental section in the Ministry of Livestock and Fisheries Development**: currently this ministry does not have this section and therefore it is left out in most of the climate change activities organised in the country. The Ministry of Agriculture and Food Security already has such a section and is coordinating activities related to environment and climate change in its various sections and departments.

2. **Increase investment in systems and infrastructure in animal agriculture to increase resilience to climate change shocks:** the study found that systems and infrastructure for livestock are lacking or inadequate, and that current investments are inadequate. Therefore there is an urgent need to increase investment in this area by taking advantage of the various sources of funding, through climate change and bilateral agreements.

3. **Increase investment in research, extension and training (including introduction of special courses in climate change mitigation and adaptation).** The sector's contribution to Tanzania's national economy is not generally well acknowledged; however one pastoralist asked during the stakeholder workshop if anybody present passed a day without consuming meat or another livestock product. This study recommends: an increased investment in adaptation research in animal agriculture; short-term training of livestock farmers on climate change and on various diversification options; training and deployment of more livestock extension staff; and short-term re-training of existing extension staff, policymakers and policy implementers in climate change adaptation in animal agriculture.

References

Coppock, D.L. (ed.) 1994. *The Borana plateau of southern Ethiopia: Synthesis of pastoral research, development and change, 1980–91*. ILCA Systems Study 5. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Defoer, T., Budelman, A. and Carter, S. 2000. Building common knowledge: participatory learning and action research. In: Defoer, T. and Budelman, A. (eds) *Managing soil fertility in the tropics. A resource guide for participatory learning and action research.* Royal Tropical Institute (KIT), Amsterdam, the Netherlands: 39-46.

Dietz, S. 2008. *A long-run target for climate policy: the Stern Review and its critics.* Supporting research for the UK Committee on Climate Change's inaugural report *Building a Low-Carbon Economy – the UK's Contribution to Tackling Climate Change.* See: http://www.theccc.org.uk/reports/adaptation/1st-progress-report-2010

Food and Agricultural Organization of the United Nations (FAOSTAT). 2011. See: http://faostat.fao.org,

Haule, M.E. 2009. Assessment of attitude towards selling livestock among the pastoralists in Ngorongoro District of Tanzania. MSc. dissertation, Sokoine University of Agriculture, Tanzania.

Hewitson, B.C. and Crane, R.G. 2006. Consensus between GCM climate change projections with empirical downscaling: precipitation downscaling over South Africa. *International Journal of Climatology* 26: 1315-1337.

Kandji, S.T., Verchot, L. and. Mackensen, J. 2006. *Climate Change Climate and Variability in Southern Africa: Impacts and Adaptation in the Agricultural Sector*. UNEP and ICRAF (Nairobi).

Kangalawe, R.Y.M and Liwenga, E.T. 2005. Livelihoods in the Wetlands of Kilombero Valley. in Tanzania: Opportunities and challenges to integrated water resource management. *Physics and Chemistry of the Earth* 30: 968-975.

Mashingo, Maria S.H. 2010. Vulnerability assessment on pastoral livestock and pasture development to the extreme climatic events in Tanzania. Paper presented under the study on Economics of Climate Change in Tanzania Phase 3 at the stakeholder inception round table meeting held at the Peacock Hotel, Dar Es Salaam, Tanzania, 26 March, 2010.

Mdegela, R.H., Mathew, C., Omari, A.N., Ngoi, J. and Joseph, S. 2011. Health and disease challenges in fisheries and aquaculture in Tanzania. Paper presented at the 3rd TSAP/TVA Joint Scientific Conference, Olasiti Lodge and Garden Park, Arusha, Tanzania, 18th -20th January 2011.

Ministry of Livestock and Fisheries Development (MLFD) 2011. Livestock investment opportunities. See: http://www.mifugo.go.tz/livestock_resources/index.php

National Adaptation Programme of Action (NAPA) project. 2007. *National Adaptation Programme of Action.* Division of Environment, Vice President's Office, Tanzania.

Njombe, A.P. and Msanga, Y.N. 2010. *Livestock and dairy industry development in Tanzania.* Department of Livestock Production and Marketing Infrastructure Development, Ministry of Livestock and Fisheries Development. See: http://www.mifugo.go.tz/documents_storage/LIVESTOCK%20INDUSTRY%20DAIRY%20DEVELOPMENT%20IN%20TANZANIA%20-%20LATEST3.pdf

Obando, J., Ogindo, H., Otieno, W., Macharia, A., Ensor, J., Tumuising, E., Kisianganii, E., Muchiri, L. and Amollo, N. 2010. Reducing vulnerability of pastoralists communities to climate change and variability in Northern Kenya. A paper presented at the International Conference: Climate, Sustainability and Development in Semi-arid Regions (ICID), Fortaleza-ceara, Brazil, 16-20 August 2010.

Roger, P.J. 1999. *Pastoral resource management institutions in Northern Tanzania*. Paper prepared for the Conference of the International Association for the Study of Common Property, Washington, D.C., USA, 17-20 September, 1992.

Stern, N. 2006. *The Economics of Climate Change: The Stern Review.* Cambridge University Press, Cambridge, UK.

Tumbo, S.D., Mbilinyi, B.P., Rwehumbiza, F.B. and Mutabazi, K.D. 2010. *Economics of climate change for agriculture sector in Tanzania: Adaptation options and their costs*. SWMRG, SUA, Morogoro, Tanzania. See: http://economics-of-cc-in-tanzania.org/reportsandpublications.html.

United Republic of Tanzania (URT). 2006a. *Agricultural Sector Development Programme – Government Document.* See: http://www.fao.org/righttofood/inaction/countrylist/Tanzania/Tanzania_ASDP_GovernmentProgramnmeDocument.pdf

United Republic of Tanzania (URT). 2006b. *National Livestock Policy*. Ministry of Livestock Development (MLD). See: http://www.tzonline.org/policies.asp.