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The impact of climate change and variability on agro-pastoralists' economy in Tanzania

Abstract

Tanzania has a total of 17.4 m cattle and 98% of this, is in the hands of pastoralists and agro-pastoralists involving about 2.2 m people. The ongoing climate change (CC) is likely to have affecting pastoralists more negatively because they are already living in marginal lands. Apart from this hypothetical thinking there has been inadequate empirical evidence to substantiate this. Also the impact of the adaptation and mitigation strategies undertaken by the pastoralists to address CC has not been analyzed critically.

The main objective of this study was to come up with an understanding of the impact of CC on pastoralists' economy in Tanzania. A total of 200 households were selected randomly from Ngorongoro District. There were also focus group and key informant discussions. The results from this study will inform policy makers, donors and the pastoralists.

The study revealed a high level of livestock death due to mainly drought. Moving to urban areas for livelihood alternatives has disrupted families and is preventing children from attending school because they are looking after the cattle. Moving livestock to other parts of the country has caused conflicts over resource use, especially with farmers, to the point of threatening peace in some places.

Keywords: climate change, pastoralists' economy, Tanzania.
JEL Classification: Q10, Q50, Q54.

Introduction

Tanzania has a total of 17.4 m cattle and 15.8 m shoats (FAO, 2005a). Ninety eight percent of the national herd, or approximately 16.7m cattle, are in the hands of pastoralists and agro-pastoralists. Out of this, about 80% of these animals are kept in the agro-pastoral system while 14% are in the pastoral system (URT, 2006). It is estimated that 3% of the 3.7 m households in Tanzania are pastoralists, and 7% are agro-pastoralists. This amounts to approximately 370,000 households, or 2.2 m people in total being either pastoralists or agro-pastoralists (Kipuri and Sørensen, 2008).

Although livestock contributes only 5.9% to the GDP, the sector plays a key role in national meat production and the pastoralists' economy and overall wellbeing. Most of Tanzania's meat and milk come from pastoralists and agro-pastoralists. Pastoralists are concentrated in the northern plains and in the central and some western parts of the country, where climatic and soil conditions do not favor crop production (FAO, 2005).

1. Theoretical background of the pastoralists' economy

Pastoralists use arid and semi-arid lands for grazing, farming and for making use of natural resources. This is an extensive production system based on the seasonal availability of forage and water, thus resulting in uncontrolled mobility (WISP, 2007).

Worldwide average surface temperatures has increased by an estimated 0.8ºC between 1900 and 2005 (Ehrhart and Twena, 2006). Water is the most limiting factor in relation to crop and livestock production in the arid and semi-arid lands of sub-Saharan Africa (Mwang'ombe et al., 2011). Climate disasters are heavily concentrated in poor countries especially in Sub-Saharan Africa. Some 262 million people were affected by climate disasters during the period of 2000 to 2004, over 98% of them in the developing world, compared with only one in 1,500 people in the developed countries (Boko et al., 2007). A large proportion of those suffering from hunger and malnutrition depend on agriculture and livestock production for their livelihoods, which makes them vulnerable to the impacts of climate change (Naess et al., 2010). The vulnerability of pastoralists to climate change comes both from being predominantly located in the tropics, and from various socio-economic, demographic and policy trends, limiting their capacity to adapt to change (Morton, 2007). The extent to which human systems will suffer economically from climate change depends on the adaptive capabilities within a region as well as across regions (Deke et al., 2011). Focusing on specific sectors, climate change will aggravate the water stress currently faced by some countries, while some countries that currently do not experience water stress will become at risk of water stress (Fields, 2005).

According to the United Nations' panel of climate experts, Africa is highly vulnerable to the impacts of climate change because of factors such as widespread poverty, recurrent droughts, inequitable land distribution, and overdependence on rain-fed agriculture (IPCC, 2001). Studies in the region show that temperatures rose by 0.7ºC during the 20th cen-

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tury, and changes in rainfall patterns saw reduced precipitation in the Sahel and a net increase across eastern-central regions (Ehrhart and Twena, 2006).

In Tanzania climate change is expected to raise mean annual temperatures by 3-5ºC and average daily temperatures by 2-4ºC by 2075 (Tanzanian Initial National Communication, Vice-President's Office, 2003). A report by the OECD predicts an average annual increase of 2.2ºC in Tanzania by 2100 (Agrawala et al., 2003). Regarding rainfall, studies show that the timing of rains will become less predictable and their intensity more volatile (Agrawala et al., 2003). Seasonal variations will become accentuated, with a 6% decline in rainfall between June and August, traditionally the 'dry' season, and a 16.7% increase between December and February, the main rainy season (Agrawala et al., 2003). According to Sonica (2001), the effects of climate change on water resources will include a doubling of the amount of carbon dioxide, which will have an impact on how much water is absorbed by plants, and changes in seasonal precipitation, resulting in drought and flood hazards. In Tanzania, these extreme events are likely to take the form of drought, flooding, tropical storms and cyclones, which are expected to become more frequent, intense and unpredictable (IPCC (2003) as reported by Ehrhart and Twena (2006)).

2. Conceptual framework

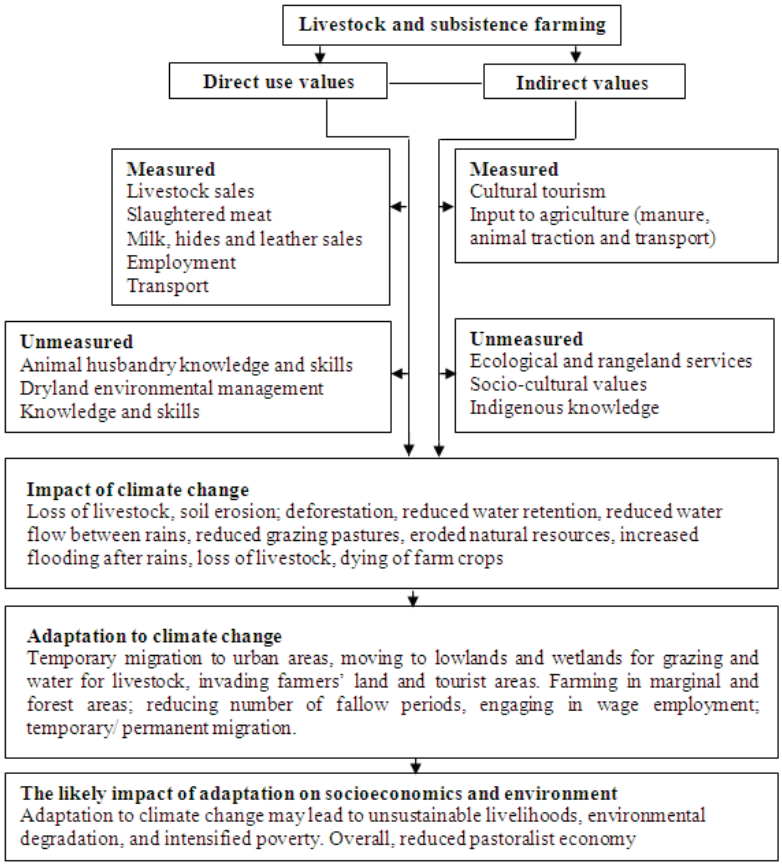
There are generally two types of economic value that relate to pastoralism (Figure 1). The first are direct values which include direct use and measurable products and outputs such as livestock sales, meat, milk and hides, as well as financial services (investment, insurance credit and risk management). The less easily measured values include employment, transport, knowledge and skills. The second are the indirect values of inputs into agriculture (manure, animal traction and transport) and complementary products such as honey, medicinal plants, wildlife and tourism (WISP, 2007).

As regards the environment, pastoralism plays a key role in protecting the ecosystem (such as biodiversity, nutrient cycling and energy flow) and a range of social and cultural values through properly managed rangelands (Hatfield and Davies, 2006). This study focuses on the direct and indirect values of the pastoralists' economy.

From this study it is believed that pastoralists depend on livestock for a number of uses, including the direct consumption of meat, milk and blood. Livestock also provides an income through selling and it creates employment for a large number of pastoralist communities. With the current changes in climate taking place, livestock productivity, survival and distribution will be affected through the reduced quantity and quality of rangeland and the prevalence of vector-born livestock diseases (IPCC, 2001). Climate change will lead to low productivity (draught power, milk and meat) due to the increased amount of carbon dioxide that reduces the amount of protein available from vegetation and the outbreak of new pests and diseases, for example ticks, snails and other pests. Studies show that milk and meat production will be reduced following the stress on grazing lands (IPCC, 2001). As regards agriculture projected reductions in yield in some countries could be as much as 50% by 2020, and crop net revenues could fall by as much as 90% by 2100, with small-scale farmers being the most affected (Boko et al., 2007).

As adaptation strategies, pastoralists have been undertaking a number of activities, including extending the cultivation of land into marginal areas, engaging in wage employment and temporarily/ permanently migrating to urban areas. They have also been migrating to other areas, such as the lowlands and wetlands, to find pasture and water for their livestock. Pastoralists have also been invading farmlands and tourist areas, as well as selling weak cattle to avoid losses from death.

However, some of these adaptation strategies are likely to have serious adverse impacts. For example, these activities likely to lead to soil erosion, deforestation, reduced water retention, reduced water flow between rains and an eroded natural resource base, which may not be able to provide the same safety-net for livelihoods in the future. Quite often these adaptation strategies are unsustainable and ultimately are likely to negatively affect the pastoralists' economy and wellbeing (Figure 1).



Source: Modified from Hatfield and Davies (2006).

Fig. 1. Conceptual framework: the impact of climate change on pastoralists' economy

3. The study area

Ngorongoro District is one of the six districts of Arusha region in Northern Tanzania. The district headquarters is situated in Loliondo Wasso area, about 424 km from the regional headquarters in Arusha Town. The District has an area of 14,036 square kilometres, of which about 59% is under the Ngorongoro Conservation Area Authority (NCAA). The remaining land (41%) is under the Loliondo Game Controlled Area but is also utilized by the pastoralists as follows:

- Area under food crop production 441 sq. km – 3%.
- Area for livestock keeping 3638 sq. km – 26%.
- Area covered by natural forests 863 sq. km – 6%.
- Area planted with trees 799 sq. km – 6%.

The District is characterized by a tropical climate, whereby some areas are hot and dry while other areas receive as much as 1000 mm of rain annually. Other areas like the Loliondo division are dry and cold almost throughout the year. Average annual rainfall in Loliondo varies between 400 mm and 600 mm. The southern part is the famous Ngorongoro Conservation Areas under the control of NCAA.

According to the population census of 2002, the district has a total of 129,362 people, of whom 62,689 are males and 66,673 are females. Using the annual growth rate of 4.5% the current population is estimated to be 154,208.

The community's accessibility to social services is below the national average (URT, 2009). According to the National Census of 2002, the literacy rate of the district's population was significantly lower (27%) than the national average of 71% and health indicators are bad and probably worse than the national average (URT, 2009). The water supply sources in the district include natural rivers, dams, springs, bore holes, shallow wells, and gravity schemes in a few areas.

The main economic activities performed by the communities in the districts are livestock keeping, agriculture and tourism. Food crops grown include maize, sorghum and beans. Most of the farmers use hand hoes for farming and only an insignificant number uses inputs and practice irrigation. The district has approximately 380,000 cattle. There are also 300,000 and 250,000 goats and sheep, respectively. Most of the rivers in the district are seasonal, making fishing activities negligible.

Ngorongoro district is endowed with a spectacular natural environment with attractive scenery. The district has an abundance of wildlife, making almost

the whole of the district a conservation and game-controlled area. However, out of the three divisions, only Ngorongoro has a well developed tourist industry with much to attract tourists, especially the famous Ngorongoro crater.

4. Methodology

Both primary and secondary data were collected. The study started with an extensive review of literature in the study area, which helped to familiarize her with the sector and to establish a gap for field data collection. The field data collection tools were prepared concurrently with the literature review. The tools developed were a household structured questionnaire, semi-structured interviews and a checklist for focus group discussion and key informant interviews, respectively.

Two villages were selected randomly from Loliondo Division. The sampling frame was based on the village household roster. The total number of households (n) to be surveyed was determined using the following formula:

$$n = \frac{N}{1 + Ne^2},$$

where: n is the sample size between 5 and 10%; N is the total number of households in the area; and e is the desired margin of error.

Some 200 households were selected for interview from a total of 840 households in the study villages. The respondents were basically heads of households and where the head of the household was unavailable, a spouse, child or a member of the family who was knowledgeable responded on behalf of the household.

This study was conducted between the 2nd and 30th September 2010. It involved intensive consultations with focus groups and key informants, such as district and village government authorities, extension workers, traders and Masai elders. The data were collected using structured questionnaires, semi-structured interviews and checklists.

The type of data collected concerned demographic patterns, land ownership, number of livestock, experience of climate change and its impacts on agriculture and livestock, livelihood adaptation strategies to cope with climate change and their implications for livelihoods, the environment and sustainability.

The data were analyzed using the Statistical Package for Social Sciences and livelihoods model. The results are presented in tables, graphs and figures.

5. Results and discussion

The majority of the respondents in both villages were Masai, 90.5% in Ololosokwan and 96.2% in Soitsambu. Other ethnic groups comprised 9.5% and 3.8% of those in Ololosokwan and Soitsambu, respectively, and 95.2% and 92.3% were male in Ololosokwan and Soitsambu, respectively. Only a few in both villages were cohabiting, divorced or widowed. Family size was 5.1 in Ololosokwan compared with 4.6 in Soitsambu.

5.1. Education level of the respondents. The education level of most of the respondents (57.2%) in both villages was low, below standard seven, and about 21.5% had not received any formal education. Only 33% of the respondents had completed standard seven and 9% had completed form four. Less than 1% had received an education beyond form four. The low level of education suggests that most pastoralists have few livelihood options, as they cannot find decent employment because of their low level of education. A high proportion of the respondents are aged 20-50 (82.5%), those aged over 50 comprised 12.5% and those under 18 comprised 5%.

5.2. Socio-economic activities. The main economic activities were livestock keeping (78.9%) and agriculture (17.5%). Other minor economic activities included running a petty business (6.3%) and being a civil servant (1.9%). Surprisingly, no respondent mentioned tourism as one of the economic activities despite the fact that they are surrounded by a large number of wildlife, tourist hotels and campsites (Table 1). These findings also suggest that the pastoralists' economy is gradually switching to expanding agriculture. One of the reasons for this change could be related to the limited land for cattle grazing and mobility. Also the high death rate of livestock due to drought has contributed to the changing of livelihood sources.

Table 1. Economic activities (%)

Activity	Ololosokwan n = 100	Soitsambu n = 100	Total N = 200
Livestock	80	77	78.5
Farming	15	20	17.5
Petty trading	5	2	3.5
Civil servant	0	1	0.5

From these findings it is clear that a considerable number of pastoralists are settling down and agriculture is becoming an important economic activity. While starting farming could probably enhance the pastoralists' livelihoods, it could also mean more pressure on natural resources in terms of clearing the bush for agriculture. It may also lead to conflicts between other land users such as investors and hunting operators in the area (Campbell et al., 2000).

5.3. Assets ownership. Owning assets is important for both the security of livelihoods and social capital. Wealthy people are more respected in society

than the poor, and they can also use their wealth/ assets to buy food or obtain credit. An analysis of the factors affecting the decision to adapt to perceived climate change reveals that farmers are more likely to adapt if they had access to credit and land (Bryan et al., 2009).

Livestock is the pastoralists' main asset and depend more on availability of land for grazing and agriculture. Findings from this study show that pastoralists have a very limited amount of land and therefore their livelihoods are threatened. On average, each household owns about 4 acres of land. However, most of the respondents had a large number of cattle, about 48 and 35 in Ololosokwan and Soitsambu, respectively (Table 2). The findings also reveal a high level of standard deviation, suggesting that the ownership of livestock varied widely among the pastoralists. While some respondents had no livestock others had up to 140 and 200 cattle in Ololosokwan and Soitsambu, respectively (Table 2). They had also a large number of goats and sheep.

Table 2. Asset ownership

	Ololosokwan *n* = 100	Soitsambu *n* = 100	Total *N* = 200
Land	4.0 (3.0)	4.1 (3.7)	4.1 (3.4)
Cattle (herds)	59.1 (48.3)	34.6 (33.9)	46.5 (41.5)
Range	0-140	0-200	0-200
Goats (herds)	64.1 (61.1)	73.4 (58.1)	66.9 (60.3)
Sheep (flocks)	20.5 (49.9)	120.9 (67.6)	85.4 (44.1)
Motorcycles	5	0	2.5
Generators	1	0	0.5

Note: Figure in brackets indicates standard deviation.

Most of the respondents had traditional houses built with poles and mud and thatched with grasses. This a proportion of 76% and 65% in Ololosokwan and Soitsambu, respectively. For semi-permanent houses it was 24% and 35% in the two villages, respectively (Table 3). These are houses made with either bricks but thatched with grasses or mud and poles but roofed with iron sheets. No respondent had a permanent house, i.e. one with brick walls and roofed with iron sheets and a cement/tiled floor (Table 3). Such types of houses especially the traditional ones can easily be demolished when there is flood or wind due climate change.

Table 3. Housing quality (%)

	Ololosokwan *n* = 100	Soitsambu *n* = 100	Total *N* = 200
Traditional	76.0	65.0	71.5
Semi-permanent	24.0	35.0	28.5
Permanent	0	0	0

5.4. Level of dependence on natural resources. As anticipated, the study revealed a high level of dependence on natural recourses (Table 4). All respondents reported that they depended on fuelwood for cooking, and over 90% of respondents depend on traditional medicine and raw materials for building. Natural resources also play a key role in providing food, water and animal traction. Surprisingly, a considerable number of respondents reported that they also consumed game meat in both the study villages. By tradition, the Masai community does not consume game meat and these results may mean they are gradually changing their culture in adapting to climate change. Alternatively, those who reported consuming game meat could have come from the minority of respondents from other ethnic groups including the Sonjo. Nevertheless, such adaptation could have negative impacts on conservation.

Table 4. Level of dependence on natural resources (%)

	Ololosokwan *n* = 100	Soitsambu *n* = 100	Total *N* = 100
Firewood	100.0	100.0	100.0
Medicine	95.0	96.0	95.5
Raw materials	100.0	85.0	92.5
Food	43.0	50.0	46.5
Beekeeping	52.0	46.0	49.0
Game meat	14.0	19.0	16.5
Pasture	100.0	100	100.0
Tourist attraction	38.0	46	42.0

5.5. Impact of climate change. The respondents were asked to rank the major impacts of climate change on their economy and their responses are summarized in Table 5. Over 90% of the respondents reported that drought was the major constraint on the productivity of their livestock and agriculture. It was reported that over 48% of the livestock have died due to drought over the past 10 years (Table 5). Further, it was reported that due to climate change there has been an increase in the prevalence of pests and diseases, implying increased expenditure on drugs to treat livestock and on preventive measures. The sale of weak animals as a strategy to avoid complete loss from death has resulted in very poor earnings due to low selling prices. About 23.5% of the respondents in the two villages reported a decline in household incomes by about 50% over the past 5 years (Table 5).

Likewise climate change has affected agriculture, particularly food production. As many as 97% of the respondents had lost at least 50% of their farm crop harvest due to drought and 44.5% had lost them due to pests and diseases.

The pastoralists are also suffering from attacks by wildlife. A considerable number of respondents

(30%) reported having lost about 5% of their livestock due to such attacks and 56% of the respondents had lost about 30% of their crops due to attacks by wildlife, suggesting that pastoralist communities living next to conservation areas have not only been affected by climate change but are also facing serious losses of agricultural crops and livestock due to attacks by wildlife.

There was no significant difference between the losses encountered by the two villages. They had an almost equal number of losses because they have similar agro-ecological characteristics and are similarly impacted by climate change. Climate change has also seriously affected the availability of grazing pasture, as most of it has dried up or is infested with weeds, which is an indication of overgrazing. Many water sources are drying up, especially during the dry season. Currently, pastoralists move long distances to obtain for water for their livestock and for domestic use. It was reported that women spend 3-4 hours fetching water. These findings are consistent with those reported by Shemsanga et al. (2010) that the death of large numbers of livestock due to lack of water and pasture has been a repeated occurrence.

Table 5. Climate change and related impacts on pastoralists (%)

Shock item	Ololosokwan	Soitsambu	Total
Livestock loss due to drought (at least 50%)	94	86	90.0
Livestock loss due to crop pests and diseases (at least 50%)	46	50.0	48
Crop loss due to drought (at least 50%)	74	66	70
Crop loss due to crop pests and diseases (at least 50%)	41	48	44.5
Complete or near complete livestock loss due to wildlife attacks (at least 50% loss of herd)	23	19	21
Major cut in household income due to falling prices for livestock	25	22	23.5
Complete or near complete crop loss due to floods or more than normal heavy rains (at least 50%)	10.0	16.0	13.0

The hypothesis that there has been no reduction in the number of livestock and cross-bred cattle and in maize yield due to climate change was rejected. Instead, an alternative hypothesis was accepted that there had been a significant decline in the number of cattle and cross-bred cows and in maize yield ($P < 0.01$). However, the findings show no significant difference in the decline in the number of goats, sheep and chickens between the two periods but the second column shows a declining trend (Table 6). This suggests that goats, sheep and chickens are relatively more resistant/and or adaptable to climate change than large grazers, such as cattle and cross-breeds. The pastoralists should be advised to keep more small ruminants (i.e. goats and sheep) and chickens, as they appear to be more adaptable to climate change than cattle. Also maize production in such marginal lands is not suitable and therefore pastoralists should be advised to grow early maturing and drought-resistant crops like sorghum and cassava.

Table 6. Trend of livestock ownership over the past 20 years

Shock item	10 years back	Now	Level of significance
Sample size	100	100	
Number of cattle owned (herds)	129 (44.3)	57.1 (41.4)	***
Cross-bred cattle	6.6 (0.7)	4.0 (0.4)	***
Number of goats owned (herds)	283.3 (123.8)	259.4 (96.5)	NS
Number of sheep owned (flocks)	80.0 (48.0)	70.5 (42.0)	NS
Number of chickens owned (flocks)	8.0 (5.2)	7.0 (5.7)	NS
Maize yield per acre (bags)	3.0 (1.5)	0.7 (0.4)	***

Notes: *** Significant at $P < 0.01$. NS = Not significant.

6. Adaptation strategies to deal with effects of climate change

It is normal practice to combine adaptation strategies to combat the effects of climate change. According to Laukkonen et al. (2009), it is not enough to concentrate on either mitigation or adaptation, but a combination of these results in the most sustainable outcome. However, the authors caution that the two strategies do not always complement each other, but can be counter-productive if care is not taken.

6.1. Adaptation to climate change. Effective adaptation depends on the capacity to respond to and manage climatic variability, including extreme events (Fankhauser et al., 1999). In this study one of the adaptation measures by the pastoralists has been to buy more cattle whenever they get the money. The pastoralists have a slogan that says "cattle will die during bad weather but will recover during good weather". The government, in collaboration with the donor community, also seems to agree with this slogan as sometimes

they have supported the pastoralists by distributing cattle to them to compensate for their losses due to climate change with the intention of sustaining their livelihoods. These findings contrast those of Morton and Barton (2002), who reported that pastoralists were destocking their livestock as a strategy in times of drought. This study found that, although cattle were sold, it was only when they were very weak and approaching death. It was a choice between getting something or losing everything!

Rural-urban migration (especially by young males) was found to be another mitigating measure taken in response to the effects of climate change. Young pastoralists migrate temporarily or permanently to urban areas, where they act as night watchmen and plait women's hair during the day. However, such adaptation measures have had adverse impacts on the pastoralists' community. When they move to urban areas their wives and children remain behind to look after the cattle. This prevents children from going to school, thereby worsening poverty levels. This also increases the number of livestock that is concentrated in the hands of absentee herd owners.

There is also a concern that moving into urban areas is putting the pastoralist community at a risk of contracting and/or spreading diseases such as HIV/AIDS and other sexually transmitted diseases. Many of the youth who migrate to urban areas are married and when they move there they may establish temporary or even permanent relationships. When there are no women who need their hair plaited during the day, the pastoralists tend to sleep under the shade of trees as they never rent rooms/houses. These trees where the pastoralists sleep quite often there are no toilets and/or washroom facilities, which could also lead to the spread of diseases such as diarrhoea and typhoid.

Another measure taken by pastoralists to mitigate the effects of climate change has been to run a petty business, which has also increased their dependence on the market. Through these petty businesses cattle are sold to buyers from other areas, particularly from Kenya. However, because the cattle are seriously weak, they are sold at a giveaway price and so income from this business is very low. During the time of this study, it was found that cattle sold for Tshs 30000 (USD 20) while goats/sheep sold for Tshs 80000 (USD 54). Switching to the consumption of cereals and other foodstuff acquired from the market has also been a challenge (as such transactions need cash) and due to poor infrastructure, such as roads and telecommunications, marketing has not been running smoothly. Pastoralists live on periphery of the country, with poor roads, water services and telecommunications. As a result, market imperfections are common in such an environment, which increase marketing and transaction costs (Mwakaje, 1999).

Herd migration has been another means of mitigating the effects of climate change, leading to the utilization of scarce range resources. Pastoralists move temporarily to other places, preferably in the wetlands, thereby degrading further the environment. Worse still, moving to other regions or wetlands to look for pasture and water has created ethnic conflicts, especially between pastoralists and farmers, to the point of killings happening in some areas (e.g., Kilosa, Mbarali, Rufiji and Kilombero). Such moves have also been a major source of environmental degradation (Mwakaje, 2009). Moving with cattle from one place to another also affects children's education as they have to move with their parents.

The Government is encouraging livestock keepers to identify indigenous cattle species, which have proved to be adaptable to climate change, so that they can be multiplied at the local research center (personal communication with the Director of Livestock Production 2010, Ministry of Livestock Development and Fisheries).

Pastoralists have also been enhancing cultural tourism as an alternative livelihood activity, which includes the Masai festival and cultural bomas. At Olosokwan village, communities are also involved in the tourist business, like providing tainted camp facilities for tourists. In addition, the village was earning from land concession fees by tourism investors, which has helped it to earn over USD 100000 per annum.

Another adaptation strategy has been the establishment of permanent settlements and becoming agro-pastoralists. However, with the scarcity of land in the study area and the existence of a large number of investors in the tourism sector, the starting and/or extending of agro-pastoralism has intensified conflicts with them.

A particular adaptation measure that some pastoralists have taken has been to promote their interests through forming social networks and trade groups to enhance their businesses and increase their capital, although only a few pastoralists are involved, most those who has a relatively good level of education. They bought cattle at very low prices from their fellow pastoralists, attempted to fatten them and then sold them to Kenyans. This was a kind of network between the Kenyans and those pastoralists in the study area. On some occasions they obtained loans from Kenyans to buy the cattle and later on they sold them back to them.

Conclusion and recommendations

This study investigated the impact of climate change on pastoralists' economy, focusing on Loliondo area.

It also analyzed the implications of the pastoralists' mitigation and adaptation strategies. The findings reveal that climate change has had a significant impact on pastoralists' economy. Pastoralists have lost a large number of cattle and agricultural productivity has declined.

There have been attempts to adapt to the effects of climate change. These include migrating to urban areas to become night watchmen and to plait women's hair. Whenever they get extra money they tend to buy cattle to replace the ones they lost, a strategy which seems to be supported by the government and donor community, with the intention of sustaining pastoralists' livelihoods. However, the migration to urban areas has had an adverse impact on their children, who, instead of attending school, are forced to remain at home to take care of the cattle. Attempts to diversify livelihoods by establishing permanent settlements and engaging in farming as well as moving cows to other regions in search of water and grazing pastures have led to conflicts over resource use to the point of fights taking place between farmers and pastoralists, sometimes resulting in killings.

Pastoralists have also been diversifying their livelihoods through engaging in petty trade, mainly the selling of cattle, in order to buy necessities like cereals. However, the cattle that are weak due to climate change have been fetching very low prices, and so this has not been a help in mitigating the impact of climate change. Also poor marketing infrastructure has affected marketing transactions due to the high cost of doing business.

Policy recommendation

It is recommended that there should be a multiplication of indigenous cattle that have proved to be adaptable to climate change, i.e. survival of the fittest principle should be adopted. Farmers' capacity should be built to identify and keep records.

The keeping of goats and sheep, including dairy goats, should be promoted as they are more adaptable to the effects of climate change than cattle.

Rainwater harvesting should be promoted among the pastoralist community and the country at large.

The government should improve the infrastructure to facilitate market interactions.

Promote alternative livelihoods through socio-cultural tourism and ecotourism among the pastoralist communities, especially in places bordering the Ngorongoro crater and Serengeti national park.

Early warning information on climate change should be provided using different strategies so that the information is effectively communicated to pastoralists and all Tanzanians.

The education of pastoralists' children should be enhanced through the provision of boarding schools at all levels. This would be a significant strategy to prevent pastoralists from being too dependent on cattle and the associated risks.

Formal/customary land tenure should be provided for pastoralists' communal resources to protect them from other land users, including the investors.

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