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Tracking Effective Indigenous Adaptation Strategies on Impacts of Climate Variability on Food Security and Health of Subsistence Farmers in Tanzania

Riziki Silas Shemdoe

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Riziki Silas Shemdoe (Ph.D)
Institute of Human Settlements Studies, Ardhi University,
Dar es Salaam, Tanzania.

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Abstract

Both long and short term changes in climate disproportionately affect regions in both the semi-arid and arid parts of the globe and the more humid tropics. Within these areas, effects of climate change vary across regions, farming and food systems, households and individuals. As smallholder farmers have been staying in these areas and that the climate variability has been affecting them, farmers through experimentation over time, have developed different traditional technologies in order to cope with the climate change vulnerability. In the case study areas of Lushoto and Mpwapwa districts, little has been done in tracking indigenous adaptation strategies developed to address impacts of climate variability on food security and health of subsistence farmers. This paper therefore provides a highlight of the existing indigenous and other related technologies that farmers in the respective districts in Tanzania are employing to counteract to the impacts of climate change and climate variability. Data were collected through key informants interviews, focus group discussions and in-depth interviews using a structured questionnaire that was administered to 400 household heads in eight villages from two agro-ecological zones namely humid (Lushoto district) and semi-arid (Mpwapwa district) zones. In this paper, from community perspectives, indigenous and emerging technologies and innovations for climate change adaptation, ways communities behavior have changed towards climate change adaptation measures at individual and institutional levels; impacts of climate variability on food production and on health of farmers; both short and long term adaptation strategies developed by different rural communities are elucidated; policy recommendations for building climate change resilience at local and national levels in Tanzania are proposed. Based on the findings from this study a framework to support policy decisions in crop/livestock production and human health systems in Tanzania is recommended.

1. Introduction

Climate changes have a significant impact on livelihoods and living conditions of the poor in developing countries. Long-term changes in climate will disproportionately affect regions in both semi-arid and arid parts of the globe and the more humid tropics. Within these areas, the effects of climate change vary across regions, farming and food systems, households and individuals. Already there is some evidence that climate change has altered hydrological cycles and weather patterns, raised sea levels and increased the intensity and frequency of extreme weather conditions all of which have a significant impact on the livelihoods and living conditions of the poor in developing countries. Climate change and climate variability have been affecting smallholder farmers and livestock keepers in different ways. In the absence of effective adaptation, food insecurity and ill-health will deepen poverty and affect livelihoods, assets, infrastructure, environmental resources and economic growth thereby slowing poverty reduction and sustainable development strategies. As smallholder farmers are staying in these areas and that the climate variability has been affecting them, farmers through experimentation over time, have developed different traditional technologies in order to cope with the climate change vulnerability. These technologies need to be tracked, studied, documented, and harmonized with similar scientific-based knowledge.

1.1 Objectives

1.1.1 Main objective

The main objective of the present study was to track effective indigenous adaptation strategies developed to address impacts of climate variability on food security and health of subsistence farmers in Tanzania.

1.1.2 Specific objectives

- Identify and document effective indigenous and emerging technologies and innovations for climate change adaptation;
- Identify and document behavioral changes towards climate change adaptation measures at individual and institutional levels;
- Assess capacities building strategies to the farming communities in the study areas to adapt to climate change impacts;
- Assess the impacts of climate variability on food production and health of subsistence farmers
- Determine short and long term adaptation strategies developed by different rural communities;
- Make policy recommendations for building climate change resilience at the state and national levels in Tanzania.
- Develop robust framework to support policy decisions in crop/livestock production and human health systems in Tanzania.

2. Literature Review

2.1 Climate change in the Tanzanian Policies

Although the impact of climate change on social and economic sectors in Tanzania started to be felt as far back as in the early 1980s, the gravity of the impacts began to be recognized just over the recent years. Apparently this state of affairs is attributed to the fact that the country lacked scientific evidence that would be the justification for any concern and response to the impacts of climate change. In a recent study on mainstreaming climate change to policy and governance, (Shemdoe, 2010), it is reported that Tanzania has no stand alone policy for climate change, and indeed this is the same for many other developing countries; hence there is no legislation on climate change per se which may be used to guide implementation of the policy. The only existing document available on climate change is the National Adaptation Programme of Action (NAPA, 2009) which is designed to provide an opportunity to look at the country's climate change related vulnerabilities in various sectors that are important for the economy. As reported in Shemdoe (2010) there are however, several sectoral policies which touch on issues of climate change haphazardly. The policies that have showed a link with climate change issues in Tanzania include: National Environmental Policy, National Energy Policy of Tanzania, National Water Policy (NAWAPO), National Livestock Policy, National Forest Policy and National Wildlife Policy of Tanzania. In these policies, issues that are highlighted which have a direct link to climate variability and climate change include: land degradation; environmental pollution; as well as deforestation. Others include minimization of wood fuel consumption through the development of alternative energy sources and ensure efficient utilization of wood fuel; promotion of sustainable renewable energy resources; develop and utilize forest and agricultural residues for power and cooking energy production. On agricultural aspect, the policies highlights the impacts of agricultural practices have contribution on climate change through slash and burn practices; extension of cultivation to the sensitive and marginal lands such as wetlands hence contributing to climate change as more carbon dioxide is added to the atmosphere. Based on ecosystem goods and services, the policies have highlighted ecosystem stability through conservation of forest biodiversity, water catchments and soil fertility should be ensured; and encroachment, wildfires, illegal logging and poaching in the reserved forests to have contributed to the deterioration of wildlife population. Moreover, the policies have also highlighted water issues and specifically that water is a fundamental for various social – economic development activities hence the need to conserve water sources; and that there is a need for integrated water resource management (IWRM) to ensure that water does not become a constraint to national development.

2.2 Smallholder farmers' based indigenous technological adaptation strategies to the impacts of climate variability in different agro-ecological zones of Tanzania

Tanzania has about seven agro ecological zones whereby different crops under different farming systems are produced. In all these zones, climate variability and climate change can have impacts. The agro-ecological zones in Tanzania include: Coast, Arid lands, Semi-arid lands, Plateaus, Southern and Western Highlands, Northern highlands and alluvial plains. In this paper, the agro-ecological zones have been divided into two main categories; these are the highland agro-ecological zone, and the arid and semiarid zones. Smallholder farmers residing in these agro-ecological zones have developed a number of indigenous techniques and practices that are used by smallholder farmers in their farming systems. Some of the most frequently used technologies and their link to farming systems are described in the subsequent section.

2.3 Indigenous technologies in highland agro-ecological zone

Farmers in the Matengo areas in Ruvuma region apply Ntambo as one of the indigenous strategy in crop production. "Ntambo" as described in Matee, (2000) and Kato (2001) is a unit of land that is boarded by small (river) valleys and is normally located on mountain slopes. It is a suitable area that is used in raising crops during low rain seasons, thus community use these areas as a coping strategy to counteract drought as one of the impacts of climate variability in Tanzania. Another matengo indigenous farming system/technology is ingolu or ngolo. As described in Matee (2000) and Kato (2001) ingolu is characterized by a combination of anti-erosion and soil fertility maintenance techniques of pits and ridges on steep slopes. This technique evolved among the matengo over 100 years ago (Pike, 1938 in Matee 2000). This indigenous technique has been effective in controlling soil erosion, maintaining soil fertility and increasing crop yields produced in very steep slopes (Kato 2001).

In the Sukumaland, Shinyanga region, farmers are used to and exercise Ngitiri system. Ngitiri system refers to a system of 'bush fallow' management used by the Sukuma people. They are actually areas of grazing land, which have been 'closed' to livestock, by the village council, or a private landowner, and they are an example of an indigenous silvopastoral technology for land rehabilitation. Studies by Kamwenda (1999) indicate that the ngitiri has the potential of improving the ecology of the site where trees enrich the soil surface through decomposition and mineralization of their litters (i.e. leaves flowers, twigs and branches). The extensive ground cover of shrubs, grasses, herbs and forbs also help prevent soil erosion and facilitate water infiltration and percolation by reducing surface runoff and increasing soil water storage (Kamwenda, 1999). There is an increasing body of evidence that ngitiri is a widespread and very popular system in use since 1920's among the Wasukuma people of Shinyanga region, which comprises of six districts. The primary importance of the Ngitiri system is in fodder production, with some authorities estimating fodder production of up to 4 t DM/ha for the traditional Ngitiri and 8 t DM/ha for the improved systems (Kitalyi et al. 2004) in Jama and Zeila (2005). The interesting aspect about the Ngitiri system is that it is a farmer-led and farmer-managed initiative that has evolved after years of traditional grazing management.

Farmers in the northern Tanzania have also developed their indigenous intensive crop management systems that they refer to as iraqw system by the Iraqw tribe (Shetto, 1998). The iraqw systems are prepared in the hilly areas, where the crop residues in the field and manure from stall fed cattle is incorporated into cultivated ridges. Terraces are made to control soil erosion, and fodder is cropped on the edges of the terraces for the cattle, being supplemented by grass from fallow fields. Trash lines and cut off drains are also used to slow down surface runoff and to increase infiltration (Shetto, 1998).

In the Usambara Mountains as reported in Sokoni and Shechambo (2005), smallholder farmers have been using Ndiwa which is an indigenous traditional irrigation system that has been in operation in Usambara Mountains for several decades since 1940s. Sokoni and Shechambo (2005), describe Ndiwa as an overnight reservoir or farm pond. Ndiwa is often dug on mountain slopes and is fed by springs. Spring channels are dammed; the water is allowed to accumulate for 12 to 24 hours and then released for irrigation. Sometimes a dam is constructed beside a spring or a stream channel. Ndiwa has been useful in crop production in the mountainous areas during dry seasons and are one of the suitable indigenous technologies that can be used as an adaptation strategy to the impact of climate variability.

2.4 Indigenous technologies in arid and semi arid agro-ecology

For years now farmers in semi arid central Tanzania have been applying different soil and water conservation methods in order to improve crop production. Hatibu and Mahoo, (1999) mention pitting, as a traditional system of sowing to have been used by farmers to collect runoff during the early growing stages of the crops in the area. Hillside sheet and runoff utilization which exploits valley bottoms and plains where runoff collects, have been widely used by farmers for growing high water demand crops such as maize in the area (Hatibu and Mahoo, 1999). Shemdoe et al (2008; 2009b) report some farmers in semiarid central Tanzania to have used traditional terraces (matuta) and mulching from the crop residues left from the preceding season to conserve soil moisture and to increase soil water availability to plants hence improve crop production.

In most of the Tanzanian arid and semi-arid areas, other local-based coping strategies with droughts have included remittances from migrant household members, collecting wild fruits, switching to non-farm activities or, in extreme cases, selling assets. Eriksen et al. (2005) give an example of farmers in Same District, one of the semiarid districts in Tanzania to have resorted to casual labor, brick making, handicraft, collecting honey and charcoal burning during droughts, allowing household to make money to purchase food and to obtain other necessities.

3. Methodology

3.1 Study area

This study was carried out in two different districts with two different distinctive characteristics. These districts are Mpwapwa district in Dodoma Region Tanzania which is semi-arid and Lushoto found in Tanga region with humid environment.

Mpwapwa District is characterized by a semi-arid ecological zone, with un-imodal rainfall, which is unreliable, and varies between 350 to 800 mm per year, concentrated between December and April. The main economic activities for the majority of people in the district are crop production and livestock keeping (URT, 2001). The main food crop in the case study villages is sorghum *(Sorghum bicolour)*, though a few farmers plant maize *(Zea mays)* intercropped with groundnuts *(Arachis hypogaea)* in some fields. On the other hand, *Arachis hypogaea* is the main cash crop of the area; other cash crops include vegetables such as onions *(Allium cepa)*, tomatoes *(Solanum lycopersicum)*, cabbage *(Brassica oleracea)*, and *Amaranthus tricolor* which are grown in the valleys (Shemdoe and Mwanyoka, 2006).

Lushoto district, West Usambara, northeastern Tanzania lies between 38° 10' and 38° 36' E and 4° 24' and 5° 00' S with altitudes ranging from 800 to 2300 m a.s.l. The population density ranges from 68 to 400 persons per square km. The area falls under rainforest vegetation type and soils are generally latosols. Rainfall is in bimodal pattern; short rains from October to December and long rains from March to June. The rainfall ranges from 600 to more than 1200mm. The existing land use pattern is divided into four categories, namely; dry land farming contributing to 58%, tree crops and irrigated area (11%), forest reserve (16%) and grazing area (15%).

3.2 Data collection method

Data collection included key informants interviews and focus group discussions during the pilot study, literature reviews and detailed surveys that involved the use of in-depth interviews using a structured questionnaire whereby a total of 400 heads of households, 200 from each district were interviewed.

3.2.1 Key Informant and Focus Group Discussions

For the pilot study (PS), Lushoto District was selected and key informants interviews and focus group discussions were carried out. During this phase, a visit to the district was scheduled and meetings with the District Executive Director (DED), District Agricultural and Livestock Officer (DALDO) and the District Soil and Water Conservation Officer were held. After the meetings with the district officials, a visit to the villages was

done and interviews with the village officials (Village chairpersons and Village Executive Officers) as key informants were carried out. The key informants schedule was used to capture key informants' insights on the objectives. Focus group discussions with village representatives was arranged and carried out. These meetings were carried out where by village representatives were invited. The pretesting of the questionnaire was not deeply carried out due to shortage of time but adequate information to improve the questionnaire was collected in this general focus group discussion meeting which was subsequently followed by a general session to discuss the questionnaire and the issues therein.

3.2.2 Literature surveys

Literature survey included review of effective indigenous technological adaptation strategies employed by farmers in different agro-ecological zones in Tanzania. In the review we started by highlighting historical trends of climate change issues as highlighted in different Tanzanian policies, through a review of different policies that have addressed climate change issues whether directly and /or indirect. This helped to show how the implementation of the policies could take into consideration smallholder farmers' technologies and indigenous adaptation to climate change impacts in different areas in the country.

3.2.3 Questionnaire survey

In each of the two districts where the study was carried out, four villages were selected whereby a total of fifty respondents were interviewed using the questionnaire in each village. In-depth interviews with heads of households using a structured questionnaire with both open- and close-ended questions were conducted in July and August 2010. In the two districts a total of 400 heads of households were interviewed. Issues that were included in the questionnaire include climate change and copping strategies by communities in the case study areas, copping strategies to the impacts of climate variability, behavioral changes towards climate change adaptation measures at individual and institutional levels in the study area, and behavioral changes towards climate change adaptation strategies instituted by the local government to the communities' district level. Others include communities' preferences on the local government strategies towards influencing communities to adapt to climate change, capacity building to the communities on climate change issues and information, effects of climate change on food security, effects of climate change on human health and livestock, and measures taken to reduce the impacts of human diseases linked to climate change. The information was useful in developing a framework to support policy decisions in crop/livestock production and human health systems in Tanzania.

Most of the qualitative data collected were analyzed using content analysis (Mayring 2000). Descriptive statistics were also used in analyzing quantitative information collected during in-depth interviews from the structured questionnaire.

4. Findings

This chapter contains findings from the field research on tracking effective indigenous adaptation strategies on impacts of climate variability on food security and health of subsistence farmers in Tanzania. The study was carried out in two case study agro-ecological zones i.e. semi- arid and humid zones. The chapter aims at providing answers to the questions derived from the key specific objectives. The questions/issues that are addressed in this chapter are as follows:

- Characteristics of the communities in the case study areas
- The effective indigenous and emerging technologies and innovations for climate change adaptation in the study area;
- Behavioral changes towards climate change adaptation measures at individual and institutional levels in the study area;
- Impacts of climate variability on food production;
- Impact of climate variability on health of farmers and food security;
- Adaptation strategies developed by different rural communities.

4.1 Respondents' Characteristics

Characteristics of the respondents involved in the study from the two different agro-ecosystems were determined. This was done purposely to determine capacity of communities with different characteristics in order to understand the climate variability and its associated impacts to their production systems and their livelihoods at large. The characteristics of the respondents included age, sex and education. Others included originality in the area of residence as well as occupations.

4.2 Age, sex and education levels of the respondents

Respondents interviewed in this study were from 18 to above 60 years old. Respondents were grouped into three different age categories notably between 18-35, 36-60 years and those above 60 years. In the two agro-ecosystems, there was a slight difference in numbers of respondents interviewed in those age groups. Mpwapwa district had a large number of respondents within the 18-35 years age category compared to Lushoto district. Whereas Mpwapwa district has a good number of respondents in a productive age that can invest their labour power in different economic activities, Lushoto district has a large number of respondents aged above 60 years which indicate high dependency ratio (Fig.1).

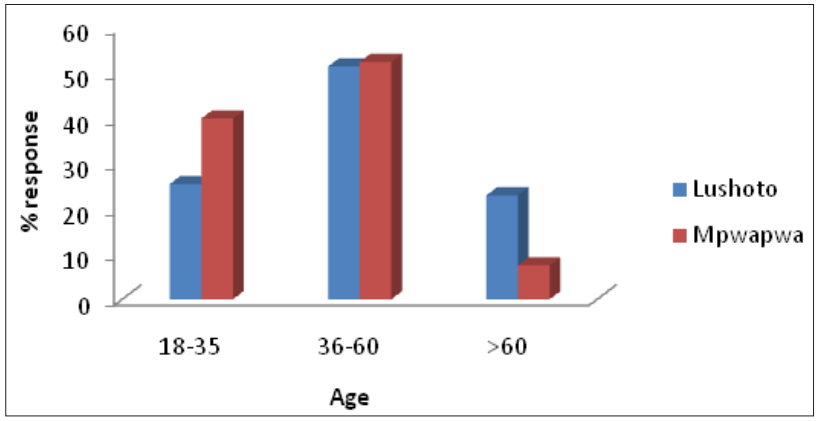

Figure 1: Age of respondents in the two case study areas

With regards to the sex of the respondents, in the two agro-ecosystems, majority of respondents were male (Fig. 2). In this study, female representatives were 26.5% in highland ago-ecosystem (The Lushoto district) and 35% in the semi-arid agro-ecosystem (The Mpwapwa district). The trend is normal for male dominated systems where males tend to be the ones with a mandate to stand and speak for their household issues than females. Nevertheless, the interviewed female representatives have given their understanding on the issues of climate variability and how it affects them and the way it contributes to changes in gender roles and goals in the respective societies in the two agro-ecological zones.

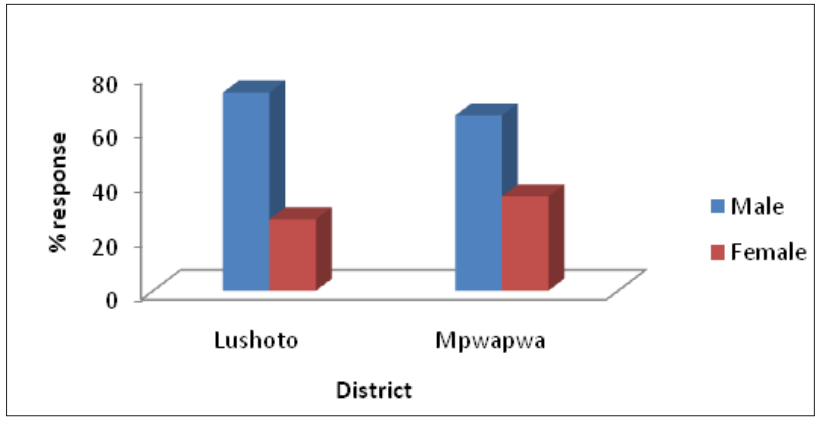

Figure 2: Sex of respondents

The majority of respondents in the two different agro-ecological zones studied have some formal education. About 85% of the interviewed respondents in Lushoto and 83% in Mpwapwa district have acquired primary education with the majority having one to seven years of primary school education. Just 6.5% in Lushoto and 2.5% in Mpwapwa have acquired secondary education (Fig.3). This observation is supported by Jörgensen (2002) mentioning land-using persons in tropical and sub-tropical regions to have a limited education and in this case the primary education for Lushoto and Mpwapwa districts. Low level of education in the respective areas is also reported in Shemdoe et al, 2009a; and Ngware et al 2006).

Undoubtedly, low levels of education in these areas make people depend much on the subsistence agriculture and livestock keeping which are the sectors highly impacted by climate variability and climate change and as a result communities in these areas are compelled to have their own coping strategies which are being tracked in this study.

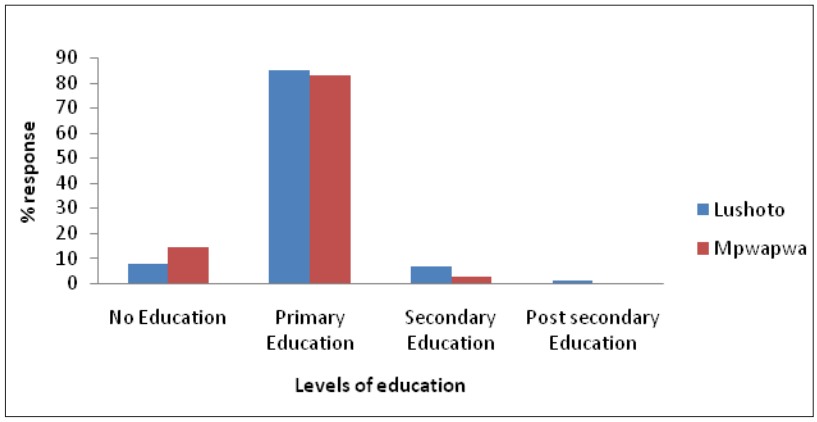

Figure 3: Respondents levels of education

4.3 Respondents original place of birth and occupations

Residence status of the respondent's interviewed in the area was also assessed. This was deemed important in determining communities coping strategies to the impact of climate change and climate variability in the respective areas. It was observed that most of the respondents in Lushoto district were born within the villages; only 4% migrated into the area. This is contrary to the respondents in Mpwapwa district where about 16% of the respondents migrated into the area (Fig 4). This attests that the migration of people in arid and semi-arid areas is high probably due to the high negative impacts of climate variability and climate change in this agro-ecological zone. Of the 16% who migrated from other areas in Mpwapwa district, 12% were from within the district but moved from one village to the other, 2% out of the district and 2% out of the region. The reasons for migrating from one village to another to search areas for cultivation due to changes in rainfall and poor quality of soils in the places they were residing.

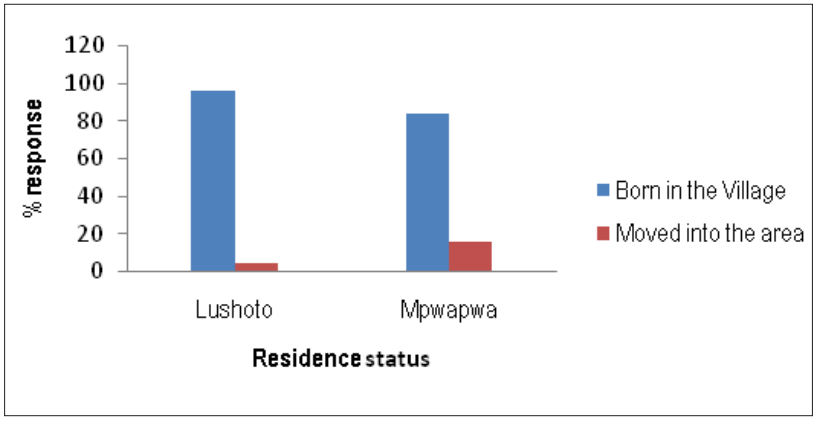

Figure 4: Respondents areas of origin

Respondents' occupation status for the two districts does not differ much. The study observed that, most of the respondents in the case study areas practice both subsistence farming and traditional livestock keeping which is dominated by free range systems as listed in figure 5. Of the 200 respondents in each district, 60% in Lushoto and 66% in Mpwapwa district practice both subsistence farming and livestock keeping while those who practices subsistence farming only are 34% for Lushoto and 27.5% for Mpwapwa district (Fig 5). This information implies that, livelihoods of most of the people in these two districts depend much on subsistence farming and livestock keeping which are currently reported by the interviewed representatives to have been affected significantly by the unpredictable amount of and rainfall patterns in the respective areas. Other studies such as Shemdoe et al, (2009) and Ngware et al,(2006) confirms subsistence farming and livestock keeping to be highly affected by rainfall patterns and amount within these two agro-ecological zones.

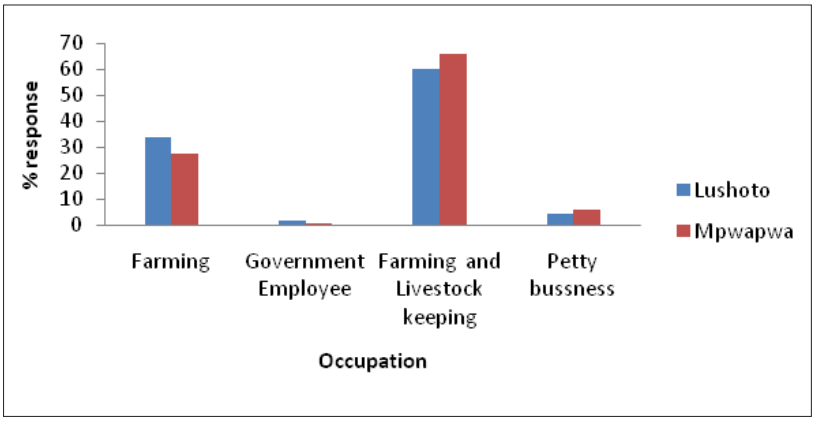

Figure 5: Respondents occupation

4.4 Climate change and copping strategies by communities in the case study areas

In the case study areas, existence of unpredictable rainfall pattern and amount as well as prolonged droughts has been referred to as the main indication of climate change. All of the 400 (100%) respondents involved in this study in Lushoto and Mpwapwa districts, confirmed climate change to be a reality in their areas. Several indicators of climate change in the two agro-ecological zones reported by the communities include prolonged drought, unpredictable rainfall, pattern of rainfall, food shortage, poor pasture regeneration, and human and animal emerging diseases. Drought was the frequently mentioned indicator for climate change in both districts. Of the 200 respondents in each district, 46% in Lushoto and 44% in Mpwapwa mentioned drought as the main indicator which contributes to food shortages and reduced pastures (Fig.6) in the respective areas.

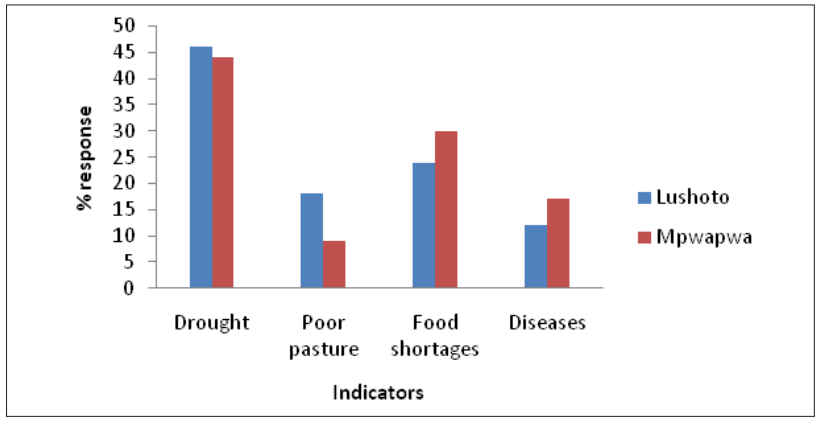

Figure 6: Indicators of existence of climate variability and climate change reported by communities in the case study areas

4.4.1 Copping strategies to the impacts of climate variability in the case study areas

In these areas, as a way to counteract the impact of climate variability and climate change, local communities have developed a range of strategies. Such measures include traditional terracing (matuta), destocking, tree planting, traditional food preservation methods, drilling traditional wells, construction of locally based water reservoirs (Nkunisa), mixed cropping and crop diversification. Tree planting was found to be more practiced in both case study areas. Of the 200 respondents interviewed in each district, 46% and 39% of respondents in Lushoto and Mpwapwa district respectively, indicated tree planting as an adaptation strategy to the impact of climate variability as well as to climate change. Another locally based technology that is used by local communities in both agro-ecological zones is traditional terracing (Matuta) that was reported by 40% of the respondents in Mpwapwa and 18% of respondents in Lushoto district. This practice increases soil water holding capacity when applied in the field as reported in Shemdoe at el (2009b).

Respondents in Lushoto district practice drilling traditional wells and traditional water reservoirs (Nkunisa) and practicing mixed cropping as adaptation measures to climate change. These techniques are not practiced in Mpwapwa most likely due to the fact that the area is drier and there is no spring water which could be used as a source of water for traditional irrigation. In Mpwapwa the traditional technology that farmers apply most is the traditional food preservation method which is practiced by the majority of the respondents in Mpwapwa district than in Lushoto district (Tab. 1).

Table 1: Copping strategies to the impacts of climate variability

Adaptation Measures	Lushoto		Mpwapwa	
	Frequency	% response	Frequency	% response
Traditional terracing (Matuta)	36	18	80	40
Destocking	16	8	25	13
Tree planting	91	46	78	39
Traditional food storage methods (vihenge)	2	1	17	8
Drilling traditional water wells and construction of traditional water reservoirs (Nkunisa)	37	18	0	0
Crop diversification	13	7	0	0
Family planning	5	2	0	0
Total	**200**	**100**	**200**	**100**

Adaptation measures to the effects of climate change and variability in the study areas are found to be feasible solutions. The majority, (90.5% and 98%) of the respondents in Lushoto and Mpwapwa district respectively (Fig 7) commended some of the indicated adaptation measures to be feasible in overcoming the effects of climate change and variability as they have helped them to survive over the years.

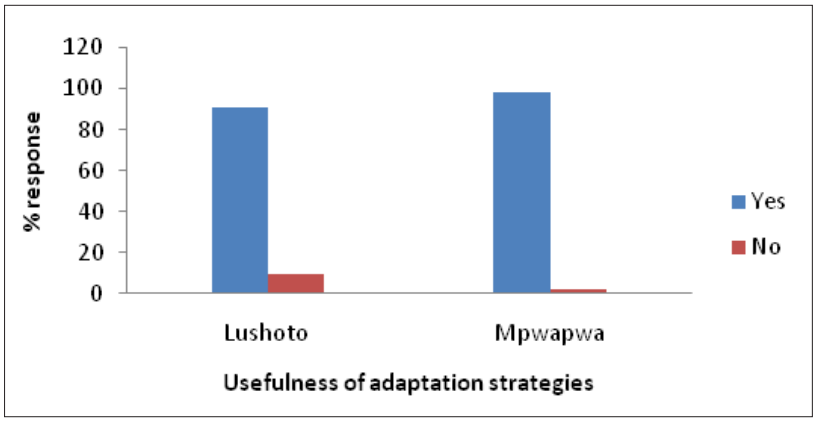

Figure 7: Usefulness of locally based adaptation measures towards impacts of climate variability in the case study areas

4.4.2 Behavioral changes towards climate change adaptation measures at individual and institutional levels in the study area

Climate change and variability has impact on communities' social well being. Community representatives interviewed indicated that majority of the people in the respective areas have changed their living and working behaviors. Issues that have been indicated to have changed include reduced grazing of cattle around water sources, reduced free grazing on farms, single meal to double meals per day from the usual three meals, eating one type of food, growing drought resistant crops, mixed cropping and crop diversification. This behavioral change is attributed to poor harvests leading to more people changing eating habit by having a single meal per day, which has been reported by 32% in Lushoto and 50% of respondents in Mpwapwa district. The prolonged drought periods experienced in the study areas have been indicated to result into poor pasture regeneration for livestock and subsequently more livestock are now grazed through zero grazing where fodder are collected from areas around water sources and from the collected crop residues. In other cases it was reported that due to poor regeneration some livestock keepers have hugely reduced size of their cattle. Of the 200 respondents in each district, 35% in Lushoto and 23% in Mpwapwa district (Tab.2) mentioned to have reduced a number of livestock being grazed around water sources. Food insecurity has been indicated to affect more people in Mpwapwa district than in Lushoto. This was mentioned by the respondents reported to have changed their eating habit due to unavailability of food caused by poor harvest that has been linked with changes in climate.

Representatives' interviewed in this study proposed a number of technological behavioral changes that should be instituted by communities in the respective areas. These include practices that will help to restore water sources including land use planning, education and awareness raising on food storage, environmental education, research on crop diseases, destocking, enforcement of environmental by laws and improvement of traditional irrigation systems. In the two study areas, teaching environmental education was found to be given highest priority. About 53% of the respondents in Lushoto district and 52% in Mpwapwa district proposed for extensive and effective awareness creation. Other suggested interventions is water sources conservation whereby 12% of the respondents in Lushoto and 19% of the respondents in Mpwapwa district proposed it as one of the interventions to be done as a way to counteract to impacts of climate change and climate variability.

Table 2: Behavioral changes as a copping strategy to climate change adaptation

	Lushoto		Mpwapwa	
Behavior	**Frequency**	**% response**	**Frequency**	**% response**
Reduced grazing around water sources	69	35	46	23
Free grazing on farms	3	1	40	20
Single meal per day	64	32	100	50
Double meals per day	20	10	0	0
Eating one type of food	26	13	0	0
Growing drought resistant crops	10	5	10	5
Mixed cropping and crop diversification	8	4	4	2
Total	**200**	**100**	**200**	**100**

Community representatives interviewed indicated a number of strategies that have been instituted by local government in their respective districts (see table 3). Such strategies include awareness creation on conservation of water sources, proper land use planning, environmental education, food storage, research on crop diseases, and awareness on the need to reduce livestock heard (destocking), enforcement of village environmental bylaws as well as improvement of traditional irrigation systems (table 3). As such these strategies if well applied by communities may result in proper use of natural resources in the respective agro-ecosystems where the climate variability and climate change has a lot of negative impacts.

Table 3: Behavioral changes towards climate change adaptation strategies instituted by the local government to the communities' district level

	Lushoto		Mpwapwa	
Awareness strategy	**Frequency**	**% response**	**Frequency**	**% response**
Water sources conservation	25	12	37	19
Land use planning	5	3	14	7
Food storage	6	3	26	13
environmental education	105	53	105	52
Research on crops diseases	6	3	18	9
Destocking	15	7	0	0
Enforcement of Village environmental by laws	18	9	0	0
Improving traditional water streams	20	10	0	0
Total	**200**	**100**	**200**	**100**

4.4.3 Communities' preferences on the local government strategies towards influencing communities to adapt to climate change

Respondents in both districts were asked to rank local government strategies towards influencing communities to adapt to climate change instituted by their respective local government in their respective districts. In Lushoto District as presented in table 4, the ranks were environmental education, environmental bylaws, improvement of traditional water systems, water source conservation and the last was destocking. In Mpwapwa districts (Tab. 4) the ranks were biased to environmental education, water source conservation research on crop diseases, land use planning and food storage. Apart from environmental education that was ranked first in both agro-ecological zones, other strategies were ranked based on the needs of the respective community in respective particular agro-ecological zone.

Table 4: Communities' preferences on the local government strategies towards influencing communities to adapt to climate change

Rank	Lushoto	Mpwapwa
1	Teaching environmental education	Teaching environmental education
2	Enact environmental by-laws	Water source conservation
3	Improving traditional water streams	Research on crops diseases
4	Water sources conservation	Land use planning
5	Destocking	Food storage awareness

4.4.4 Capacity building to the communities on climate change issues and information

In this study, different approaches used in building capacity to the communities on climate change issues in the respective districts were elucidated. Community representatives interviewed in the case study areas indicated a number of climate change related information dissemination approaches as a capacity building strategy to the communities to include mass media (radio and television), traditional groups, village meetings, artist works, seminars and teaching environmental education in primary schools (Tab. 5). Village meetings seem to be the most feasible dissemination strategy in both districts as mentioned by 28% and 49% of the respondents in Lushoto and Mpwapwa district respectively.

Table 5: Approaches used in climate change information dissemination

	Lushoto		Mpwapwa	
Dissemination approaches	**Frequency**	**% response**	**Frequency**	**% response**
Radio	23	11	24	12
Television	13	6	25	13
Traditional groups	16	9	44	21
Village meetings	56	28	98	49
Artists works	22	11	9	5
Seminars	60	30	0	0
Environmental education in primary school	10	5	0	0
Total	**200**	**100**	**200**	**100**

4.4.5 Effects of climate change on food security

Currently, food security is a global concern because majority of the people in different communities are starving particularly in Africa. In this study, communities indicated effects of climate change on food security as increased frequency of crop pests and diseases and poor crop harvests caused by poor rainfall and reduced soil fertility. Respondents in the two districts indicated pests and diseases to have more effects on food availability. About 42% and 80% of the interviewed respondents in Lushoto and Mpwapwa respectively indicated pests and diseases to negatively affect food availability in the district (Fig 8)

Poor crop harvest which is caused by poor rainfall and reduced soil fertility was indicated by 58% and 20% in Lushoto and Mpwapwa districts respectively (Fig.8) as one of the negative effects caused by climate variability to food security in the respective districts and agro-ecological zones at large.

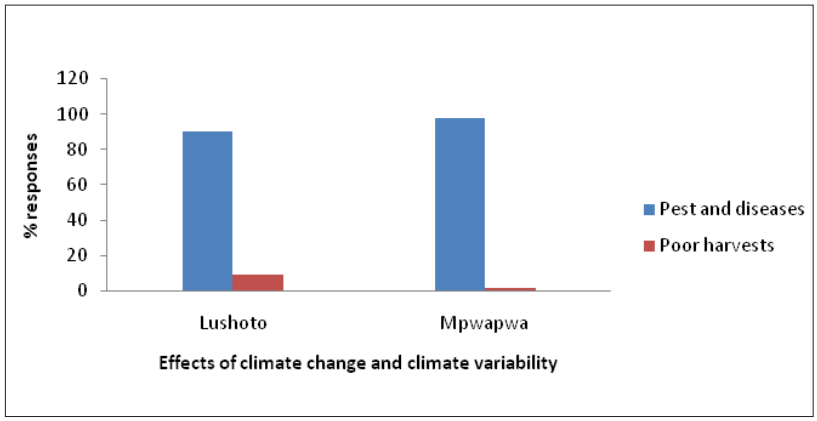

Figure 8: Effects of climate change on food security

n the case study areas, communities have developed some strategies to address the problem associated with the pests and diseases and those from poor crop harvest. Such strategies include: spraying pesticides, application of fertilizers, destocking, growing drought resistant crops, irrigation farming and shifting to non-farming business. All these measures have cost implications and therefore add more burdens to the already poor and marginalized communities.

As indicated in table 6, a fairly good number of respondents (38% in Lushoto and 37% in Mpwapwa) indicated the growing of drought resistant crops as the most useful strategies in the case study areas. The crops mentioned include millet, sun-flower, cassava and cereal crops. These crops are reported in Shemdoe et al, (2009a & b) to be the main crops planted by farmers in different areas in central Tanzania as a strategy to counteract impacts of drought. Short term growing crops such as African egg plant (ngogwe) has been introduced in the vegetable production in Lushoto district. Due to prolonged drought periods the communities shifted from depending only on rain-fed agriculture to irrigation agriculture especially in those areas having access to water sources. This was reported to be practiced by more farmers in Lushoto district than in Mpwapwa district (Table 6) this is due to the fact that the topography in Lushoto is suitable for easy flow of water downstream as reported by Ngware et al, (2006).

Table 6: Climate change adaptation measures for food security

	Lushoto		Mpwapwa	
Strategy	**Frequency**	**% response**	**Frequency**	**% response**
Spray pesticides	14	7	70	35
Application of Fertilizers	16	8	28	14
Destocking	11	5	0	0
Growing drought resistant crops	77	38	74	37
Irrigation farming	44	23	28	14
Shifting to off-farm activities	38	19	0	0
Total	**200**	**100**	**200**	**100**

4.4.6 Effects of climate change on human health and livestock

As it has been stated in a number of literatures (FAO, 2007), climate change has effects on human health and livestock in different areas. In the two agro ecological systems in Lushoto and Mpwapwa districts the large majority 99.5% and 98% of respondents respectively acknowledged to have experience of the effects of climate change on human health and livestock. Climate change is linked to death of livestock due to shortage of drinking water, pests and diseases; and drought causing poor pasture availability. Pests and diseases were mentioned to have high effects on human health and livestock (Table 7).

Table 7: Effects of climate change on health and livestock

	Lushoto		Mpwapwa	
Effects	**Frequency**	**% response**	**Frequency**	**% response**
Poor pasture regeneration	34	17	17	9
Pests and diseases outbreaks	79	40	108	54
Food shortage	71	35	58	28
Death of livestock	16	8	17	9
Total	**200**	**100**	**200**	**100**

4.4.7 Effects of climate change on human health

In the case study areas, respondents linked change in climate variability to have resulted into several diseases. The diseases mentioned include skin, stomach, cancer, malaria, and malnutrition diseases. In both case study areas, Malaria was indicated to be in the increase as reported by 44% of the respondents in Lushoto and 53% of respondents in Mpwapwa districts (Tab. 8). Results from this study is supported by Parry (1990), reported that the increase in temperature may extend the geographic range of some insect pests currently limited by temperature to thrive in a particular area. Also FAO (2007) reported that, changing temperatures and rainfall in drought prone areas are likely to shift populations of insect pests and other vector borne diseases in both human and crops.

Table 8: Human diseases linked to climate change

Disease	Lushoto		Mpwapwa	
	Frequency	% response	Frequency	% response
Skin diseases	17	8	7	4
Stomach diseases	54	27	36	18
Cancer	19	10	23	11
Malaria	87	44	106	53
Malnutrition	23	11	28	14
Total	**200**	**100**	**200**	**100**

4.4.8 Livestock diseases linked to climate variability

From the responses given by the representative of the communities interviewed in the two case study areas, livestock are also affected by diseases that are said to have emerged due to climate variability. Such diseases according to the respondents are the following: Ndigana, East Coast fever, Anthrax, Rift valley fever, Kono, Sotoka and Kideri. Ndigana and East Coast fever are the most diseases affecting livestock in both areas agro-ecological zones (Tab.9).

The names given in a local language (Kono, Sotoka, Ndigana and Kideri) were not translated to common names as the characteristics described by the respondents did not match the common names of these diseases in the literature.

Table 9: Livestock diseases linked to climate variability

	Lushoto		Mpwapwa	
Disease	**Frequency**	**% response**	**Frequency**	**% response**
Ndigana	54	26.8	55	28
East Coast fever	1	0.3	75	37
Anthrax (Kimeta)	25	12.7	52	26
Rift valley fever	2	0.9	18	9
Kono	52	26.0	0	0
Sotoka	17	8.8	0	0
Kideri	49	24.5	0	0
Total	**200**	**100.0**	**200**	**100**

4.4.9 Measures taken to reduce the impacts of human diseases linked to climate change

Due to the existence of diseases linked to climate change that affect human and livestock health, rural communities have different measures of overcoming them. For human health, the indicated measures include destruction of mosquito breeding sites, use of mosquito nets and use of traditional medicines (Tab.10).

Table 10: Measures taken to reduce impacts of human diseases linked with climate change

	Lushoto		Mpwapwa	
Measures taken	**Frequency**	**% response**	**Frequency**	**% response**
Cleaning environment surrounding homes	86	43	41	20
Use of mosquito nets and Hospital Treatment	69	34.5	159	80
Traditional medicine	45	22.5	0	0
Total	**200**	**100**	**200**	**100**

Due to the existence of livestock diseases in the study area, rural communities have developed different strategies, some have been introduced in these areas and some are community based strategies. As shown in Figure 9, majority of the respondents indicated that people in the case study areas use introduced technologies as measures to combat livestock diseases associated with climate change. These measures include vaccination and dipping.

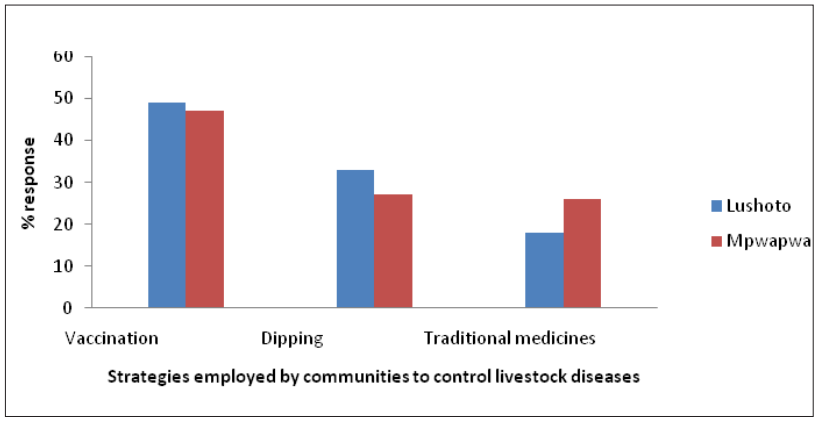

Figure 9: Strategies employed to control livestock diseases.

5. Conclusions & Recommendations

5.1. Conclusions

As in most cases, communities are found to complain and link failure of their expectations to climate change and climate variability in many areas of the developing countries, results from this study that are supported by the data obtained from both the field and the literature, have indicated that there exists impacts of these changes and variability to the communities. These impacts have forced communities to device strategies to allow them survive in such changing environment. In the two agro-ecological zones where this study was conducted, there exists a number of indigenous and emerging technologies and innovations for climate change adaptation that are working better as a way to counteract to the impacts of climate change and climate variability. Communities in the case study areas have changed their behavior due to the impacts of climate change and climate variability. Some of the changes are positive to the environment and should be scaled up to more people in other areas with similar conditions in Tanzania. It has been observed during the whole course of the study and also reported by the community representative interviewed that, there exist impacts of climate variability on food production and on health of farmers in the two agro-ecological zones which forced communities to develop a number of short and long term adaptation strategies.

From the findings obtained in this study, to aid decision making on ensuring that the impacts of climate change and climate variability is reduced to the communities, a framework (adapted from Descheemaeker, et al 2009) with two entry points that should have a mutual interactions is recommended.

The first entry point of the framework is through strengthening local communities' effective copying strategies that has been indicated to work better and that the communities in the respective agro-ecological systems have indicated to work better. This will help in improving the resilience of the ecosystem towards climate variability. Practices such as traditional terracing, destocking, tree planting, traditional food storage, drilling of traditional wells and constriction and maintaining of traditional water reservoirs as well as crop diversification will help the communities in different agro-ecological systems to cope with the impacts of climate variability and climate change and this will also reduce vulnerability to different societies in different ecosystems.

The second entry point of the framework is on the interventions geared to influence policy and institutions that are dealing either direct or indirectly with the impact of climate change and climate variability be improved. Main issues such as providing evidence based scenarios of the impact of climate change to the policy makers, developing a harmonized unit to work on issues related to climate change, lobbying for increased budget to the climate change impacted sectors, i.e. agriculture, forestry and health, enhancing

awareness creation to the societies, stabilizing and lowering the prices of alternative energy sources, provision of alternative income generation to the communities in different agro-ecological zones, exploring current opportunities such as the Payment for Ecosystem Services (PES) and carbon market through the Reduced Emission from Degradation and Deforestation (REDD) will help communities in different agro-ecological systems to reduce degradation hence improving the quality of ecosystems which will have impacts to the reduced impacts of climate change to the livelihoods of the communities in different agro-ecological zones of the country.

5.2 Policy recommendations for building climate change resilience at local and national levels

- Integration of indigenous technologies that communities in the respective areas are applying in different local plans and national developmental plans.
- Formation of a platform for different stakeholders dealing with issues related to climate change to facilitate wider circulation of the effective technologies that farmers and livestock keepers have indicated to work better. Moreover, the platform will also assist in lobbying for more research to improve the effective traditional technologies and integrate them with the modern technologies that will help farmers and livestock keepers cope with the impact of climate change and climate variability in different ecosystems in the country.
- Local institutions should be strengthened or formed where such institutions are not available to work with farmers in the respective agro-ecological zones to build capacity to farmers and livestock keeper to develop robust are resilient strategies that will help the respective communities towards coping with the impacts of climate change in the country.
- Developing suitable alternative income generating activities in these communities in order for the community members to cope with the impacts of climate variability and climate change in the respective agro-ecological zones.
- At the national level, there has to be special efforts to develop a systematic longer term climate change adaptation strategies that should be integrated in the national plans that will help the state to help its people to cope with the impacts of climate change and climate variability.

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African Technology Policy Studies Network
Contact the Executive Director at
The Chancery, 3rd Floor, Valley Rd.
P O Box 10081, 00100-Nairobi, Kenya
Tel: (254 020) 2714092, 2714168, 2714498, 2723800
Fax: (254 020) 2714028

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