Impacts of Climate Change, Variability and Adaptation Strategies: The Case of Manyoni District in Singida Region, Tanzania

Climate change and variability (CC & V) is rapidly emerging as one of the most serious global problems affecting many sectors in the world. It is considered to be one of the most serious threats to sustainable development with adverse impact on environment, human health, food security, economic activities, natural resources, and physical infrastructure (IPCC, 2007; Huq *et al.*, 2006). Africa is one of the regions in the world most vulnerable to climate change. Previous assessments (IPCC, 1998; Hulme, 1996) concluded that Africa is particularly 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. Devereux and Edward (2004) reported that countries in East Africa are already among the most food-insecure in the world and CC & V will aggravate falling harvests.

According to Tanzania NAPA (2006), agriculture has been identified to be the second most vulnerable sector to the impacts of climate change. A study on vulnerability and adaptation to climate change impacts on other sectors in Tanzania clearly indicated that forestry, water, coastal resources, livestock, and human health are also likely to be vulnerable to climate change.

These sectors are closely linked to agriculture and therefore effects of CC & V on such sectors will further negatively affect both crop and livestock production systems. The impacts of climate variability are manifested by floods, droughts, erratic rains, and extreme events. URT (2005) revealed that famine resulting from either floods or drought has become increasingly common since the mid-1990s and is undermining food security. CC & V are likely to intensify drought and increase potential vulnerability of the communities to future climate change especially in the semiarid regions (Hillel and Rosenzweig, 1989), where crop production and livestock are critically important to food security and rural livelihoods.

A number of studies conducted recently in Tanzania have recognized that CC & V is happening and is coupled with significant impact on various natural resources, including agriculture, which is the main source of livelihood in rural areas (Majule *et al.*, 2008; Majule, 2008; Agrawala *et al.*, 2003). Various climate-related impacts such as floods and droughts regularly have substantial effects on economic performance and livelihood of communities in rural areas that depend on rainfed agriculture.

A study by Ngana (1983) on drought and famine in Dodoma District indicated that the presence of dry spells in critical periods for most crops contributed considerably to crop failure and famine. Given the overdependence on rainfed agriculture by the majority of people living in rural areas, CC & V has been one of the major limiting factors in agriculture production, thus resulting in food insecurity and low income generation.

This study explored indigenous knowledge on perceptions, vulnerability, adaptations, and coping strategies, coupled with scientific analysis of the prevailing climatic regimes in the areas of study and established enhanced adaptations of the agricultural systems. The information derived from the study is expected to be used by stakeholders, including scientific communities and policymakers, to address issues related to CC & V in similar agro-climatic conditions. The overall aim of this study was to examine the impacts of CC & V on agricultural systems and establish how adaptation strategies could be enhanced to improve agricultural production under a changing climate. Specifically, the study

i) identified existing agricultural systems and factors influencing production in selected villages,

ii) established the patterns and trends of temperature and rainfall and assess their impacts on agriculture production, and

iii) established people's indigenous knowledge on CC & V and their adaptive capacity.

Research methodology

Description of study area

The study was carried out in Manyoni District in Singida Region, Tanzania. The district lies between 6°7'S and 34°35'E covering an area of 28,620 km^2, which is about 58% of the entire area of Singida Region.

Two villages, Kamenyanga and Kintinku, were selected for this study. They are located in two distinct local agroecological zones, the former being on a plateau (slightly high terrain), while the latter is located in the rift valley.

Data collection and processing

Both secondary and primary data were collected to address the objectives of this study. Secondary sources included published research papers and relevant reports, rainfall and temperature data kept at the Meteorological Department, internet search, and other relevant sources. Primary data were collected using multiple approaches, including both quantitative and qualitative. PRA methods were used to collect primary data from the study area. The methods used included key informant interviews, focus group discussion (20 participants per village), household interviews (10% of households per village), historical mapping of different climate-related events over the past years that could be remembered, wealth ranking of different social economic groups based on local criteria they use, and direct field observations through transect walks.

Climate characteristics

The climate of Manyoni District is basically an inland equatorial type modified by the effects of altitude and distance from the equator. The district forms part of the semiarid central zone of Tanzania, experiencing low rainfall and short rainy seasons, which are often erratic, with fairly widespread drought of 1 year in 4. Manyoni District has a unimodal rainfall regime, which is concentrated in a period of 6 months from

November to April. The long-term mean annual rainfall is 624 mm with a standard deviation of 179 mm and a coefficient of variation of 28.7%. The long-term mean number of rainy days is 49 with a standard deviation of 15 days and a coefficient of variation of 30.6%. Generally, rainfall in the district is low and unreliable.

Results and discussion

Major economic activities

Farming is the major economic activity for 61.8% of the respondents in Kamenyanga and 56.9% in Kintinku. Although livestock is the second major economic activity in Kamenyanga (35.3%) and Kintinku (25.0%), all livestock keepers were also farmers and none of the respondents was keeping livestock alone. Petty business ranked as the third economic activity. However, the activity appeared to be of less importance to Kamenyanga (2.9%) as compared with Kintinku (18.1%).

Given that, farming and livestock keeping were the main economic activities in both villages. This implies that CC & V will have a far-reaching effect on the livelihoods of these communities.

Other minor economic activities included selling of local brew, which was common in Kamenyanga and was mainly done by women. According to interviewees, this activity has recently increased.

In addition, there has been an increase in the number of women involved in the production of charcoal and the collection and selling of firewood.

Local perceptions on long-term changes in temperature and rainfall

Respondents in Kamenyanga village (63.8%) and in Kintinku village (73.8%) perceived that there was an increase in temperature over the last 10 years. It has been reported that during this period, from September to December, the area becomes extremely hot, especially in Kintinku, and during the night it is very cold.

Most of the respondents in both villages perceived changes in the onset of rains (35.8% and 36.2% in Kamenyanga and Kintinku, respectively) a decrease in precipitation (35.8% and 25%, respectively) and an increase in frequency of drought (24.7% and 29.8%, respectively). The majority declared that onset of rainfall has changed because they used to plant crops in October/November but, nowadays, they have to plant in December/January.

Temperature and rainfall trends based on empirical data

Local perceptions by farmers with respect to changes in temperature as well as increasing rainfall variability were closely related to empirical analysis of rainfall and temperature trends using the data obtained from the meteorological station. Trend analysis of rainfall data indicated that annual rainfall decreased from 1922 to 2007, having a more pronounced decrease from 1982 onward.

Generally, in the past, rainfall in Manyoni used to start fading away in May. Currently, this is not the case as indicated by decreases in rainfall amounts and patterns. The onset of rainfall has shifted from October to November and the rainy season is shorter, ending in March or April. What can be noted is that the area might be receiving the same amount of rain, but there are changes in the distribution, therefore leading to floods and/or droughts. Also, there were changes in rainfall peak.

For farmers, this implies increased risk of crop failure due to poor seed germination, washing away of seeds and crops, stunted growth, and drying of crops caused by changes in rainfall pattern and amount. Sometimes, this leads to replowing and replanting, thereby increasing production costs. For livestock, this implies decreased pasture and increased incidence of parasites and diseases due to decreased rainfall (drought) and increased rainfall (floods).

Temperature change and variability

The average annual temperature increased by 0.7 °C. The analysis of annual average temperature over a period of 20 years (1984–2004) showed an increase in average annual temperature by 0.7 unit. Such a change is not surprising, but it validates the observation that global warming can be revealed, even at the local scale.

According to IPCC (2007), this increase in average temperature will adversely affect crops, especially in semiarid regions, where already heat is a limiting factor of production. Increased temperature also increases evaporation rates of soil and water bodies as well as evapotranspiration rate of plants and increases the chances of severe drought. It means that, with warmer temperatures, plants require more water.

Factors affecting crop production

Based on household surveys in both villages, it is apparent that climate change—related factors were the most important constraints to crop production. Ranked in the order of their importance are:

i) Unpredictable rainfall (unclear onset and ending of rains)

ii) Increased pest and disease incidence linked to warming

iii) Declining soil fertility associated with frequent drought

Increasingly unpredictable rainfall

Respondents reported experiencing delays in rainfall, sometimes receiving rainfall earlier than normal, leading to poor germination of seeds. This forces farmers to do multiple sowing of seeds. Also, more frequently, farmer reported experiencing long dry spells and drought, leading to low yield or total crop failure.

Increased pests and diseases

Farmers perceived an increased incidence of pests and diseases due to warming. For instance, more stalk borers (*Calidea dregii*), locally called *Mpipi,* attack maize, sorghum and rice. Also, ants, locally known as *nkeki*, were reported to be a major problem in rice/paddy nurseries. In both villages, qualea birds came out as another major pest of sorghum and rice.

Declining soil fertility

A number of factors contribute to declining soil fertility (Majule, 1999). This occurs, for example, when the mining of soil nutrients exceeds their replenishment, resulting in a negative balance of nutrients. Poor agronomic practices such as frequent fires tend to reduce soil organic matter, which is vital for conserving nutrients.

In the study villages, the removal of soil nutrients was mainly done through harvests and burning of crop residues. Linked to climate change, drought might have contributed to low soil productivity as it tends to reduce water in the soil, consequently affecting nutrient mineralization and their availability to crops.

Impacts on management of major crops

Farmers have changed most of their cropping practices due to changes in rainfall pattern and amount (see table). Planting methods for some crops such as maize and sorghum have also changed from broadcasting on flat land to row planting on ridges. This is basically aimed to encourage moisture conservation and reduce competition because of many plants in the area. Another common practice is planting early- and late- maturing crop varieties on the same plot.

Adaptation strategies

In response to the impacts associated with climate change and variability, communities in study villagers are implementing different adaptation measures.

Soil fertility improvement and management practices

Farmers in Kamenyanga and Kintinku ensure proper timing of different farming activities. Preparation of land for planting (locally known as *kubelega*) starts early enough (middle of July) to avoid unnecessary competition for labor during the peak period, which normally occurs soon after the onset of rains. Some farmers bury crop residues in the field so as to replenish the fertility of the soil, while others burn the residue to enhance quick release of nutrients.

Also, burning of residue is done to ease cultivation and is a way of controlling crop pests such as stalk borers. There was a small proportion of farmers who allow livestock to graze on farmland after harvesting the crop. Adaptation to impacts of CC & V in farming systems requires resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods).

Soil tillage practices

Farmers classify soils locally by using color, natural fertility, depth, and moisture-holding capacity. Two

Impacts of changes in rainfall pattern on cropping practices in Kamenyanga and Kintinku villages.

Farming operation	Maize	Bulrush millet and sorghum	Sweet potatoes	Finger millet	Paddy	Sunflower	Groundnuts
Planting time	Shifted from Oct/Nov to Dec/Jan	Shifted from Oct/ Nov to Dec/Jan	Shifted from Feb to Mar/Apr	On onset of rainfall, shifted from Nov to Dec/ Jan	Shifted from Nov to Dec/Jan	Shifted from Jan to Feb	Shifted from Nov to Dec/ Jan
Planting method	Shifted from broadcasting to ridging	Shifted from broadcasting to ridging	No change	No change	No change	Spacing on flat or ridges	No change
Changes in crops or varieties	Use both local and short varieties	Long and short variety of sorghum is used, only local variety of millet used	Local and short variety (Mkombozi)	Maintained local variety	Local and short varieties	New crop – *Pana* variety preferred	Local (ngogo) and short (Mamboleo)
Pest and disease incidence	Increased damage by *Calidea dregii*	Increased pests and disease (e.g., *Calidea dregii* and birds)	No change	No change	Increased insect pests (e.g., *Calidea dregii)*	New crop noted to be attacked by birds, rodents	Increased rodents
Harvest time	May to Jun/ Jul	May to Jun/Jul	Mar to Aug	No change	May to Jun/Jul	May to Jun	May to Jun/ Jul
Harvest amount	Decreased (from 20 to 10 bags/ha	Decreased (from 22.5 to 17.5 bags/ha)	Mkombozi is high-yielding variety	Relatively decreased	Relatively decreased	Fair	Relatively decreased
Storage method	Local storage facility and bags	Local storage facility to bags	No change	Local storage facility to bags	Local storage facility to bags	Bags	Local storage facility to bags
Storage problems	Increased pests	Sorghum attacked but not millet	*Mkombozi* has long shelf life	No change	Increased pests (e.g., rats)	Rats	Rats
Marketing	Increased market	Increased 4000 Tsh/20 kg	Increased market	Increased market	5,000 Tsh/20 kg	Oil price 28,000 Tsh/20L	700 T/S/H/ kg
Utilization	Food and cash, pasture	Food, cash and local brew	Food and cash	Food and cash	Food and cash	Food and cash, livestock feed	Food and cash

major dominant soil types are *mbuga* and sandy (*kichanga*) soil. Mbuga soil is dark in color, sticky, fertile, and holds moisture for a long time. Sandy soil is not fertile and easily loses moisture. Based on this categorization, farmers select crops and determine planting dates to match the different soils. It was reported that farmers plant maize and cassava crops on contour ridges, whereas bulrush millet, bambara nuts and groundnuts are planted in flat beds.

Farmers use contour ridges as a strategy to minimize soil erosion to encourage better root penetration and enhance moisture conservation.

Staggered seed crop planting

In both villages, most of the farmers use more than one plot for crop production. To avert crop production risks due to rainfall variability and drought, staggered planting is commonly done by most farmers, whereby crops are planted before rain onset (dry land) on uncultivated land. Others were planted immediately after the rains, while still other plots were planted a few days after the first rains. Tilling begins in fields that were planted prior to cultivation on the third week after the onset of rain, which also the destroys the early-germinating weeds and reduces weeding. These were done purposely to distribute risk by ensuring that rainfall was utilized to the maximum by the crop planted in the dry field (Liwenga, 2003).

Mixed cropping

Mixed cropping involves growing two or more crops in proximity in the same field. The system is commonly practiced in both villages where cereals (maize, sorghum), legumes (beans), and nuts (groundnuts) are grown together. From discussions with farmers, it was noted that they have a wide field knowledge of the advantages of mixing crops with varying attributes in terms of maturity period (e.g., maize and beans), drought tolerance (maize and sorghum), input requirements (cereals and legumes), and end uses of the product (e.g., maize as food and sunflower for cash). The study revealed that farmers diversify crop types as a way of spreading risks on the farm (Orindi and Eriksen 2005; Adger *et al.*, 2003). Crop diversification can serve as an insurance against rainfall variability.

Conclusions

Crop production and livestock keeping are the major agricultural activities in the semiarid areas of Tanzania. The study has been able to establish that rainfall and temperature in the study area have been decreasing and increasing, respectively, negatively affecting production and management of different crops. Different forms of changes in rainfall have been identified, including shrinking of rain season by a month due to late onset of rainfall period—shifting from October to November and ending in April instead of May.

The analysis and perception of the local people indicated a shift in the onset of long rains from October/November to December/January with shortening of rainfall period and increased frequency of drought. They used a combination of strategies to adapt: proper timing of agricultural operations, crop diversification, use of different crop varieties, changing the planting dates, increased use of water and soil conservation techniques and diversifying from farm to nonfarm activities. However, this study recommends that such measures need to be strengthened.

Source

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