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Full Length Research Paper

Impacts of climate change, variability and adaptation strategies on agriculture in semi arid areas of Tanzania: The case of Manyoni District in Singida Region, Tanzania

A. L. Mary[1] and A. E. Majule[2]*

[1]University of Dares Salaam, P.O. Box 35097, Dares salaam, Tanzania.
[2]Institute of Resource Assessment (IRA), University of Dar es Salaam, P. O. Box 35097, Dar es salaam, Tanzania.

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A study was carried in two villages of Kamenyanga and Kintinku of Manyoni District, central Tanzania. The overall objective of this study was to understand local communities' perceptions on climate and variability issues and establish its impacts and adaptation strategies within agricultural sector. Both secondary and primary were used. Primary data were obtained using different Participatory Research Approaches (PRA) including, focus group discussions and household questionnaires. In each village, a sample size of 10% of all households was interviewed. Findings showed that local people perceived changes in rainfall and temperature. The changes have affected crops and livestock in a number of ways resulting in reduced productivity. Empirical analysis of rainfall suggest decreasing rainfall trend between 1922 and 2007 whereas mean maximum and minimum temperature increased by 1.9 and 0.2°C respectively. The average annual temperature increase of 0.7°C between 1984 and 2004 was realized. There are different wealth groups namely the rich, the middle and the poor and these are differently vulnerable climate change. The study concluded that, the wealth of knowledge on coping and adaptation that farmer has should form a foundation for designing agricultural innovation systems to deal with impacts of climate change and variability. Further, development initiatives at community level in semi arid areas should put more emphasis on water harvesting to ensure water storage for crops and livestock.

Key words: Agriculture production, climate change, Kamenyanga village, Manyoni District, rainfall, Singida Region.

INTRODUCTION

In Sub-Sahara Africa, agriculture plays a very important role in providing food and income for the majority of the population. In Tanzania the agricultural sector is a key to economic development (Majule, 2008). Over 70% of the population depend on subsistence agriculture which is almost entirely rain fed. It accounts for an average of 50% of Gross Net Product and about 66% of total export earnings.

Climate change and variability (CC & V) is rapidly emerging as one of the most serious global problems affecting many sectors in the world and 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 most vulnerable regions to climate change in the world. 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 over dependence 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.

*Corresponding author: E-mail: amajule@ira.udsm.ac.tz. Tel.: +255 222410144. Fax: +255 222410393.

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 crops 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 semi-arid regions (Hillel and Rosenzweig, 1989), where crop production and livestock keeping 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 rain-fed 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 over-dependence on rain-fed 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.

For example, droughts and floods have been reported to cause failure and damage to crop and livestock leading to chronic food shortages (Liwenga et al., 2007; Kangalawe and Liwenga, 2005). The studies conducted by Rosenzweig et al. (2002) revealed that changes in rainfall patterns and amounts have led to loss of crops and reduced livestock production.

Increasing impacts of CC & V in particular drought and floods on agriculture have been associated with various adaptation and coping mechanisms (Gwambene, 2007). These are based mainly on indigenous knowledge also referred to as indigenous knowledge which embodies a wide variety of skills developed outside the formal education system (UNFCCC, 2003). Such coping and adaptation mechanisms include increased exploitation of non wood forest products and increased wetland cultivation (Majule et al., 2008; Majule and Mwalyosi, 2005; Kangalawe et al., 2005; Yanda et al., 2005; Liwenga, 2003), this indicates clearly how rural people adapt to climate change. Indigenous knowledge arises out of continuous experimentation, innovation and adap-tation, blending many knowledge systems to solve local problems (UNFCCC, 2003).

Climate change is a global phenomenon while adaptation is largely site-specific. A common disadvantage for local coping strategies is that they are often not documented, but rather handed down through oral history and local expertise. As site-specific issues require site-specific knowledge, experience has shown that identified adaptation measures do not necessarily translate into changes because there are context-specific social, financial, cultural, psychological and physiological barriers to adaptation (IPCC, 2007). It is very important to clearly understand what is happening at community level, because farmers are the most climate-vulnerable group.

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 accrued from the study is expected to be used by stakeholders including scientific communities and policy makers to address issues related to CC & V in similar agro-climatic conditions. The overall of this study was to examine the impacts of CC & V on agricultural systems and establish how adaptation strategies could be enhanced to improve agriculture production under 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.
iii) It established people's indigenous knowledge on CC & V and their adaptive capacity.

RESEARCH METHODOLOGY

Description of the 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 that is about 58% of the entire area of Singida Region. Manyoni District was selected for the following reasons; first, it falls within the semi-arid areas of Tanzania where there are frequent food shortages due to uncertainty of rainfall. According to URT (2005) the 2000/01 household surveys, the district fell within regions with worst assessment of food poverty.

In the district, 55% of its populations are living below the food poverty line. Average per capita earning of residents is estimated at 170 US dollars (URT, 2005). Second, the area provides an opportunity to study impacts associated with CC & V on crop and livestock and third it is within the project area on "Strengthening Local Agricultural Innovation Systems to adapt to climate change in Tanzania and Malawi Project".

Two villages, namely Kamenyanga and Kintinku were selected for this study (Figure 1). They occur in two distinct local agro-

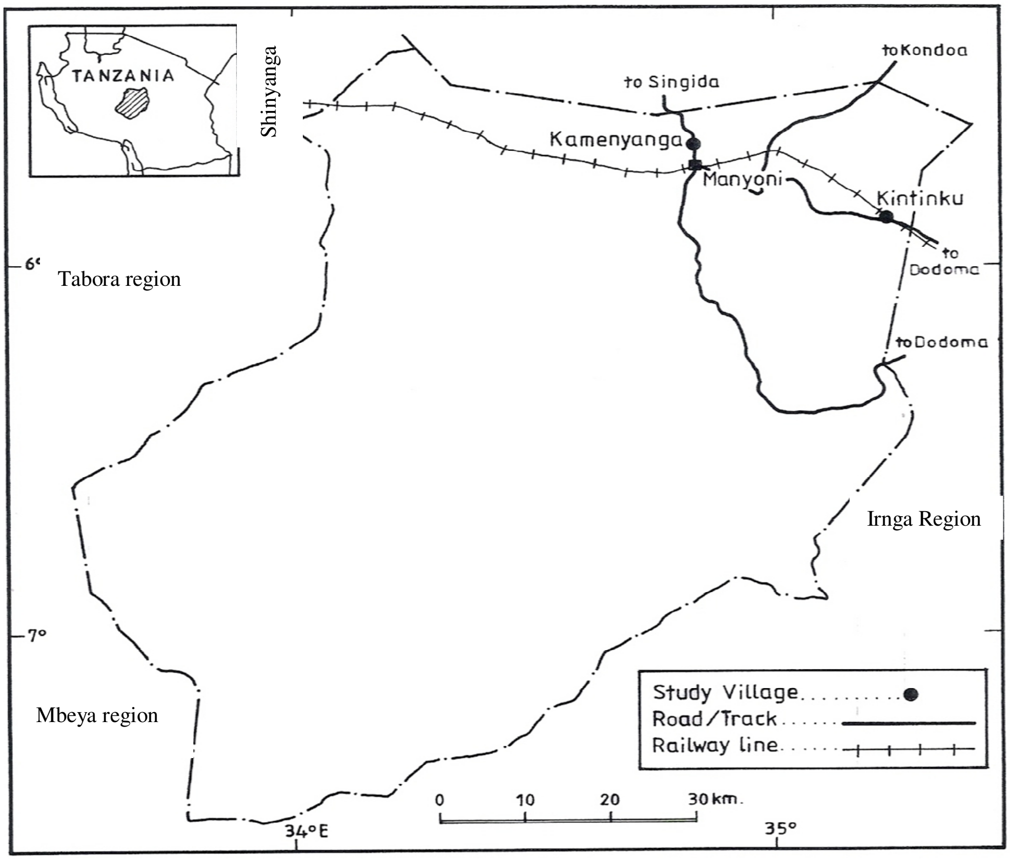

Figure 1. Map of Manyoni district showing the location of the study villages.

ecological zones, the former being located on the plateau (slight high terrain) while the latter is located in the rift valley.

Climatic characteristics

The climate of Manyoni District is basically of an inland equatorial type modified by the effects of altitude and distance from the Equator. The district forms part of the semi-arid central zone of Tanzania experiencing low rainfall and short rainy seasons which are often erratic with fairly widespread drought of one year in four. Manyoni District has a unimodal rainfall regime, which is concentrated in a period of six 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.

The annual mean, maximum and minimum monthly mean daily relative humidity is 80.6%, 86.0% (February) and 73.4% (July) respectively (Lema, 2008). The maximum and minimum monthly mean daily pan evaporation is 6.6 mm/day (November) and 5.2 mm /day (January) with standard deviations of 1.2 mm/day and 0.8 mm/ day respectively (Lema, 2008). Temperatures vary according to altitude. The annual mean, maximum and minimum monthly mean daily temperatures in the District are 22.0℃, 24.4℃ (November) and 19.3℃ (July) respectively. The average annual daily sunshine hours are 7.9 h/day. The maximum and minimum monthly mean daily sunshine hours are 9.2 h/day (September) and 6.5 h/day (January) respectively.

Data collection and processing

Both secondary and primary data were collected in order to address the objectives of this study. Secondary sources included published research papers and relevant reports, rainfall and temperature data kept at 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 with at total number of 20 participants per village, household interviews to 10% of the total number 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 then direct field observations through transect walks. The approaches used are quite similar to those used by Yanda et al. (2005) and Kangalawe et al. (2005). Four household interviews, a stratified random sampling procedure based on the locally perceived wealth categories were used. According to Kothari (2004), stratified sampling involves dividing the population into homogeneous groups containing subjects with similar characteristics.

Qualitative data from various sources were examined and presented in different forms. Quantitative were edited, coded and entered in a computer and the Statistical Package for Social Science (SPSS) software version 11.5 spread sheet was used for the analysis. Descriptive statistics were run to give frequencies and then cross-tabulation was undertaken. Multiple response questions were analyzed so as to give frequencies and percentages. Tables and bar charts were used to present different variables. Cross-tabu-

Table 1. Distribution of Wealth Groups in Kamenyanga and Kintinku.

Village name	Total number of households	Rich group	Medium rich group	Poor group
Kamenyanga	400 (100)	20 (5)	140 (35)	240 (60)
Kintinku	411 (100)	41 (10)	62 (15)	308 (75)
Total	811	61	202	548

lation allowed a comparison of different study parameters in the two villages. Temperature and rainfall data from meteorological stations were analyzed using Microsoft Office Excel 2003 to present patterns and trends of rainfall and temperature in the form of graphs.

RESULTS AND DISCUSSION

Socio economic and environmental profiles of the study villages: Village land resources

Resource maps are important as it shows various resources available in the village in which peoples' livelihood depend on. A village resource map Figure 2 in Kamenyanga village occupies 4480 hectares of land of which residential area is 920 ha, farm land is 1740 ha, grazing land 884 ha and 1016 ha is a village forest reserve area. Kintinku village covers an area of 3600 ha, 792 ha is residential areas, 1368 ha is farm land, 1436 ha is grazing land and 4 ha is village forest reserve area Figure 3. In terms of land resource (farmland) as well as forest cover, Kamenyanga village seems to be in a better position than Kintinku village and therefore communities are less vulnerable to impacts of CC & V.

Wealth stratification

In the study villages, three major social groups were identified. These are:

i) The rich (*Mugh'wari/Mugholi)*;
ii) The medium rich group (*Mubahu)*.
iii) The poor group (*Mutruki)*.

Their proportions of the groups were provided by the local people as presented in Table 1.

Generally the stratification of the surveyed villages indicated that the poor group embodying the largest number of households. The percentage of rich category is low in both villages which implies that a high level of vulnerability of communities in these villages (Table 1).

For comparison, the household numbers in the medium rich group in Kamenyanga were higher than those in Kintinku. Parallel to that, Kintinku led with the number of households in the poor group but also has a higher number of households falling in the rich group. Based on the characteristics of the three wealthy groups, it implies that vulnerabilities and adaptive capacities among groups vary accordingly in the two villages studied.

Table 2. Proportion (%) distribution of respondents' main occupation.

Main occupation	Kamenyanga	Kintinku
Farming	61.8	56.9
Livestock keeping	35.3	25.0
Business	2.9	18.1
Total	100.0	100.0

Source: Field survey (2008).

Major economic activities in study areas

Farming is the major economic activity for (61.8%) of the respondents in Kamenyanga and (56.9%) in Kintinku (Table 2). Although livestock is the second major economic activity in Kamenyanga (35.3%) and Kintinku (25.0%), all livestock keepers are 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 to Kintinku (18.1%).

This is due to the difference in the levels of urbanization in these two villages. Since Kintinku is more urbanized than Kamenyanga that means petty business opportunities are also higher. This implies that villagers in Kintinku stand a better chance of coping with the impacts of CC & V because they can diversify economic activities more easily than villagers in Kamenyanga. Given that, farming and livestock keeping is 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 interviews this activity has increased recently.

In addition, currently there has been an increase in the number of women involved in the production of charcoal and the collection and selling of firewood. This is unlike in the past when these activities were only undertaken by men. Also in Kamenyanga, there were few people involved in bee keeping. It was observed that most of these emerging activities are non farm activities. However, the raw materials for preparing local brew depend on the availability of crops, whereas charcoal and firewood was harvested from the natural forest, which is also affected by the CC & V. Table 3 presents the existing farming

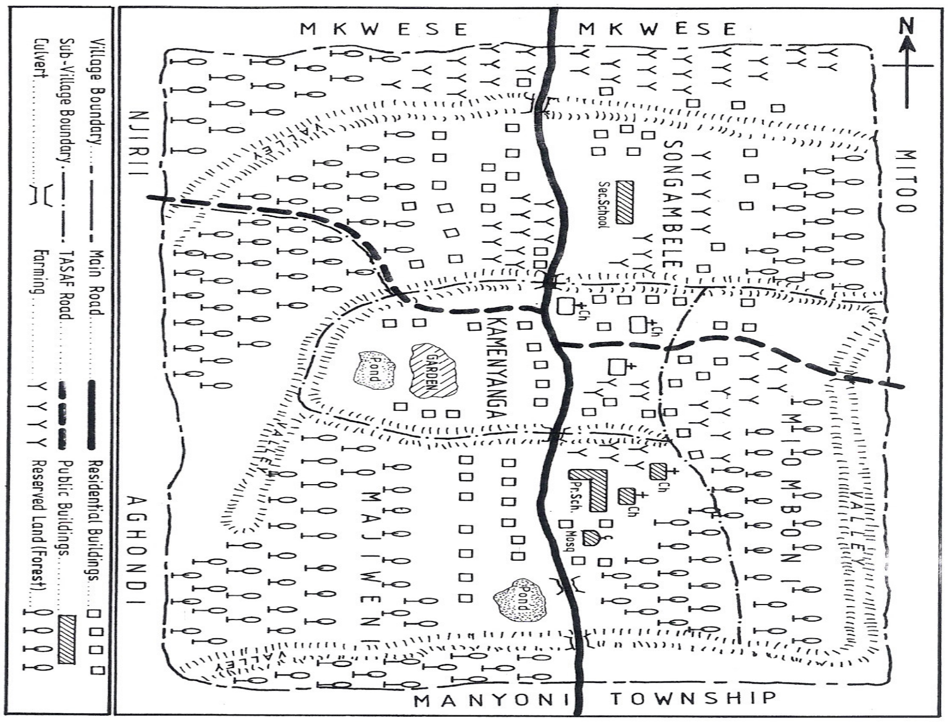

Figure 2. Resource Map of Kamenyanga village showing different land uses.

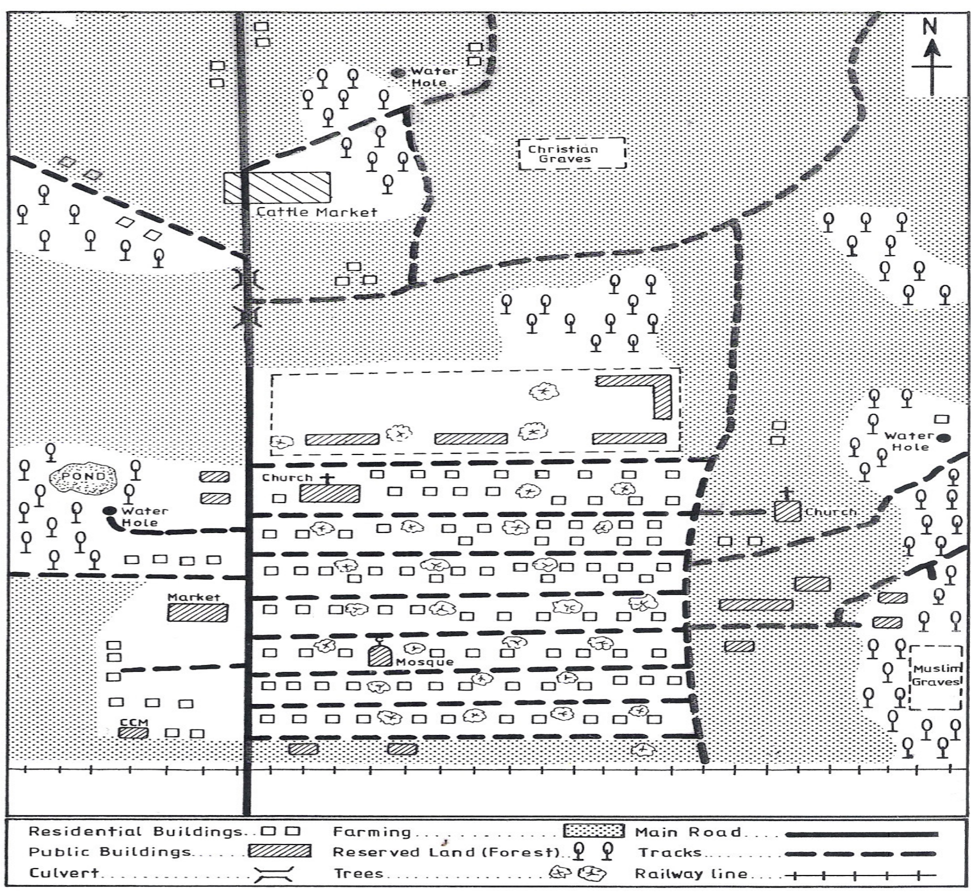

Figure 3. Resource Map of Kintinku village showing different land uses.

Table 3. Farming systems by proportions (%).

Systems	Kamenyanga	Kintinku
Crop farming	48.8	45.5
Mixed farming	25.5	29.6
Shifting cultivation	19.3	13.8
Agroforestry	6.4	11.1
Total	100.0	100.0

systems in Kamenyanga and Kintinku villages, which include crop farming (referring to production of crops alone), mixed farming (referring to crop farming and livestock keeping), shifting cultivation and agroforestry.

Local perceptions on long-term changes in temperature and rainfall

Figure 4 shows that (63.8%) of the respondents in Kamenyanga village and (73.8%) in Kintinku village perceived that there was an increase in temperature over the last 10 years. It has been reported that over the last 10 years during September to December the area becomes extremely hot, especially in Kintinku and during the night it is very cold.

Figure 5 show that, the majority of respondents (35.8%) and (36.2% perceived changes in onset of rains and decrease in precipitation (35.8%) and (24.5%) as well as increase in frequency of drought (24.7%) and (29.8%) in Kamenyanga and Kintinku respectively. The majority declared that rainfall onset has changed because they used to plant crops in October/November but nowadays they have to plant in December/January. Similar results were reported by Maddison (2006) whereby a significant number of farmers in eleven African countries believed that temperatures had increased and that precipitation had declined. Majule et al. (2008) also reported the same.

Temperature and rainfall trends based on empirical data

Local perceptions by farmers with respect to changes in temperature as well as increasing rainfall variability are closed related to empirical analysis of rainfall and temperature trends using the data obtained from meteorological station. Trend analysis of rainfall data (Figure 6) indicated that annual rainfall decreased from 1922 to 2007, more pronounced decrease being from 1982 onwards. The observations under similar climatic conditions are in broad agreement with those reported by Yanda et al. (2008) and Majule et al. (2008).

Generally in the past, rainfall in Manyoni used to starts fades away in May. Currently this is not the case (Figure 7) as indicated by decreases in rainfall amounts and patterns. Figure 7 also shows that the onset of rainfall has shifted from October to November and that the rainy season is shorter ending in March or April. What can be noted is that the area might be receiving the same amounts of rain but there are changes in distribution and therefore leading to floods and/or droughts (see for example a graph representing year 2000 – 2007). Also the figure show there was changes in rainfall peak, see for example the graph representing year 1922-29 and 1930-39 compared to 1980-89 and 2000-07.

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

Similar observations have been reported by various scholars. Intra-seasonal factors, such as the timing of the onset of first rains affecting crop-planting regimes (Tennant and Hewitson, 2002), the distribution and length of period of rain during the growing season (Mortimore and Adams, 2001), and the effectiveness of the rains in each precipitation event (Usman and Reason, 2004), are the real criteria that affect the effectiveness and success of farming. IPCC (2007) reported that changes in rain-fall amount and patterns also affect soil erosion rates and soil moisture, both of which are important for crop yields.

Temperature change and variability

The average annual temperature increased by 0.7°C (Figure 8). The analysis of annual average temperature over a period of 20 years 1984-2004 showed an increase on average annual temperature by 0.7 units (Figure 8). Such a change is not surprising but it validate that global warning can be revealed even at local scales. Yanda et al. (2008) showed that the average annual temperature in Zanzibar and Arusha increased by 1.9°C and by 1.1 °C respectively between 1961 and 2005. Fischer et al. (2002) reported that changes in rainfall amount and patterns, in addition to shifts in thermal regimes, influence local seasonal and annual water balances. These in turn affect the distribution of periods during which temperature and moisture conditions permit agricultural crop production. According to IPCC (2007), increase in average temperature will adversely affect crops, especially in semi-arid regions, where already heat is a limiting factor of production. Increased temperature also increase evaporation rates of soil and water bodies as well as evapotranspiration rate of plants, and increase 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 appa-

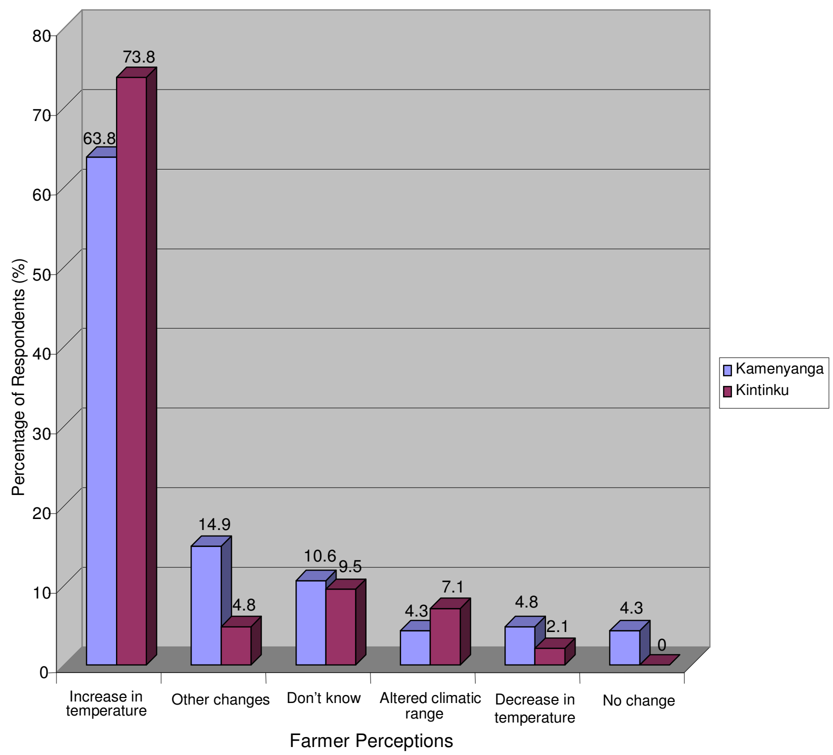

Figure 4. Perception on Temperature Changes.

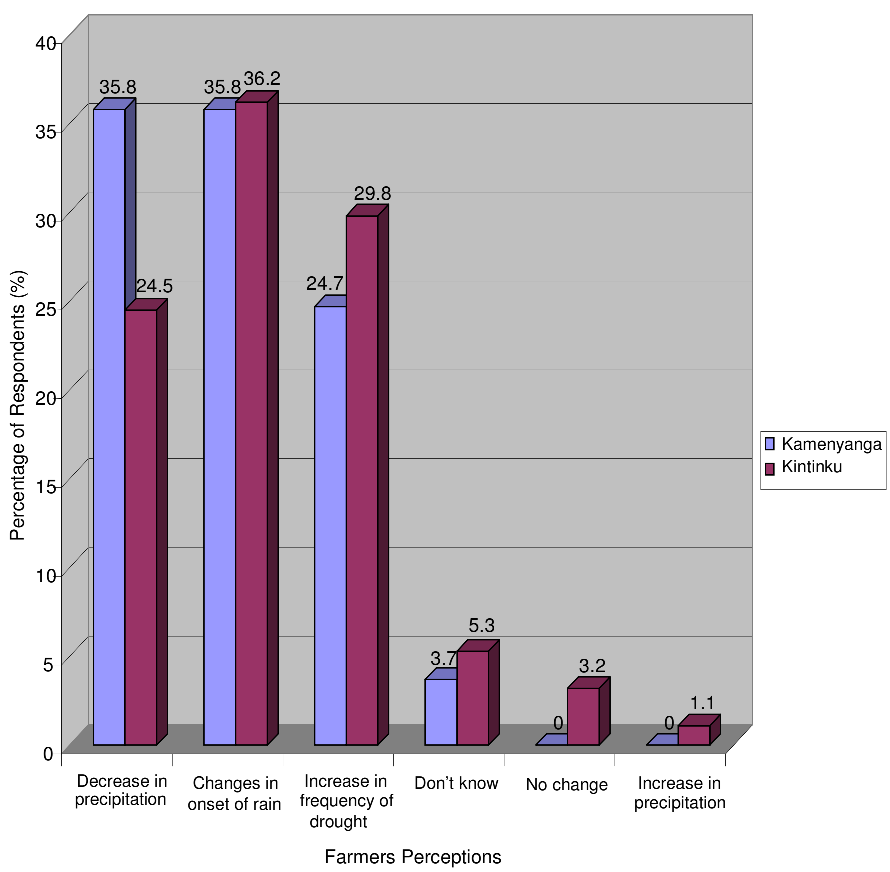

Figure 5. Perception on precipitation change

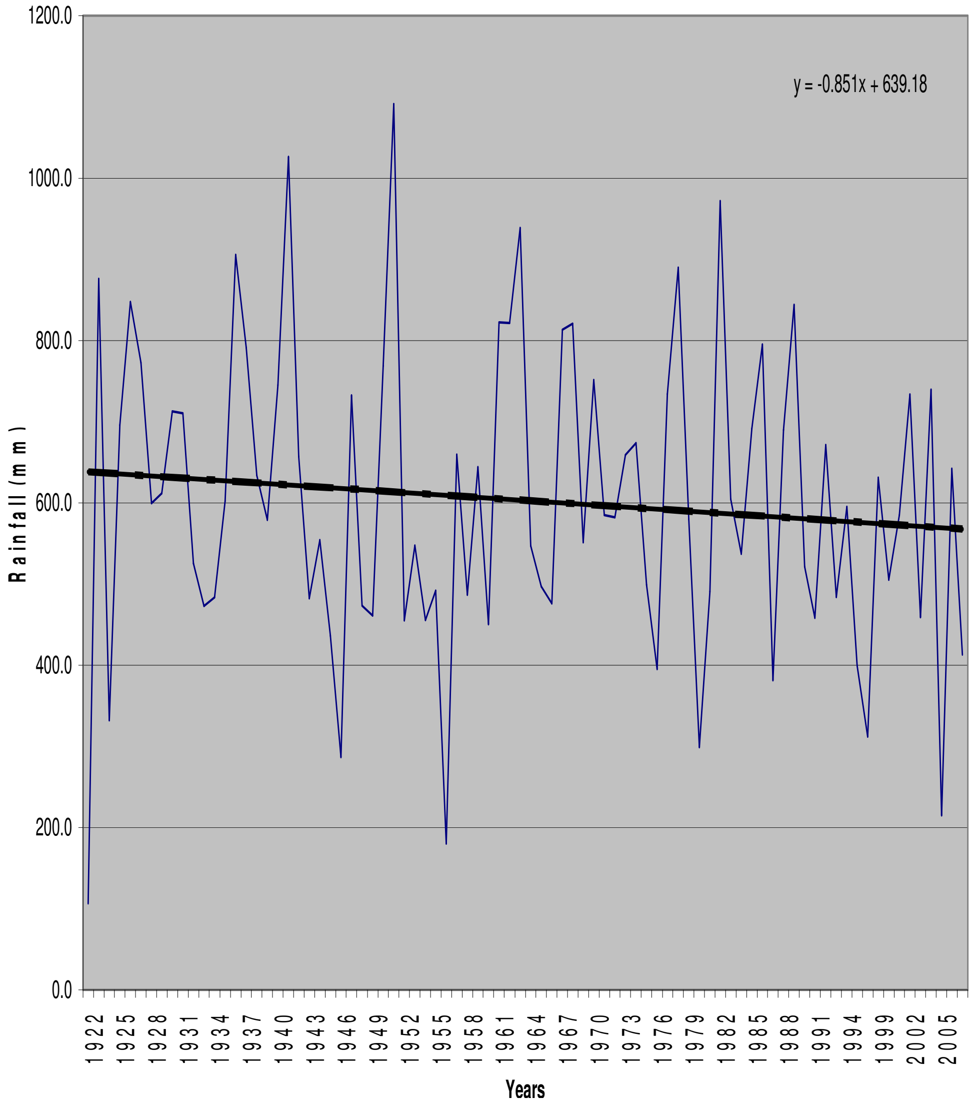

Figure 6. Annual rainfall trend in the area.

rent that climate change related factors are the most important constraints to crop production (Table 4). Ranked in the order of their importance are:

i) Rainfall unpredictable rainfall (unclear onset and ending of rains).
ii) Increasing pests and diseases incidences linked to warming.
iii) Declining soil fertility associated with frequent drought. Actual impacts are discussed in respective

Increasing unpredictable rainfall

Respondents reported experiencing delays in the star sections of the rainfall and sometimes receiving rainfall earlier than normal, leading to poor germination of seeds, requiring farmers to undergo multiple sowing of seeds. Also more frequently, farmer reported experiencing long dry spells and drought, leading to low yield or total crop failure. A study by Madulu (1996) revealed that the climatic conditions of most of the semi-arid areas of Tanzania are characterized by short and unreliable rains, which restrict the suitability of the land for crop cultivation.

Increased pests and diseases

Farmers perceived that there has been an increase inpests and disease due to warming for instance, stalk borers (*Calidea dregii)* locally called *Mpipi* which attacks maize, sorghum and rice. Also, ants locally known as *nkeki,* were reported to be a major problem in rice/paddy nurseries. In both villages *qualeaqualea* birds came out as another major pest of sorghum and rice. These

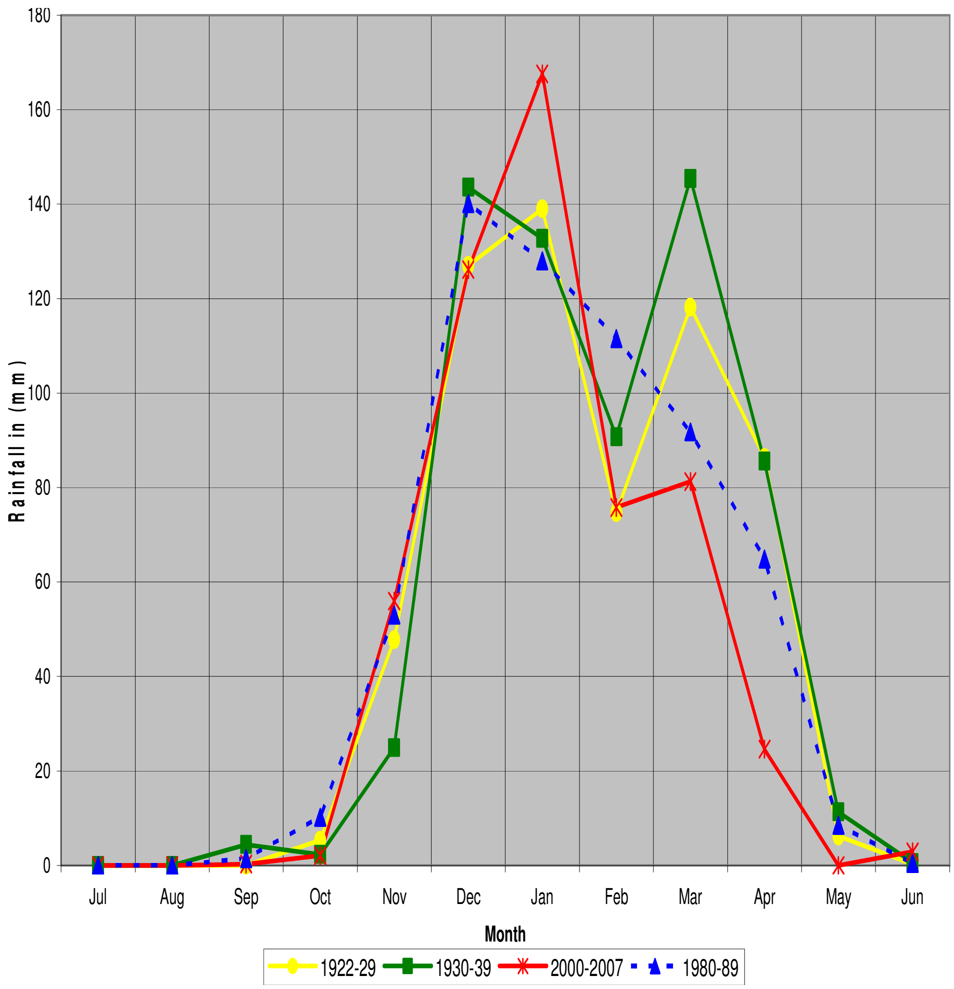

Figure 7. Monthly rainfall trend in the area

Table 4. Factors Influencing Crop Production by Proportion (%).

Factors Influencing crop production	Kamenyanga (n=42)	Kintinku (n= 41)	Total
Unpredictable rainfall	35.7	43.4	39.2
Increased pests and diseases	20.4	31.3	25.4
Low soil fertility	25.5	2.4	14.9
Lack of farm implements	6.1	14.5	9.9
High price of farm implements	4.1	1.2	2.8
Low access to farm inputs	3.1	1.2	2.2
Shortage of labour	3.1	1.2	2.2
Poor agricultural practices	1.0	2.4	1.7
Inadequate farm land	1.0	2.4	1.7
Total	100.0	100.0	100

Source: Household survey (2008).

findings are also supported by results reported by Shao (1999) that pests and diseases are among the critical factors contributing to unsustainable agriculture in semi-arid areas. Increased pest damage may arise from changes in production systems, enhanced resistance of some pests to pesticides and production of crops in

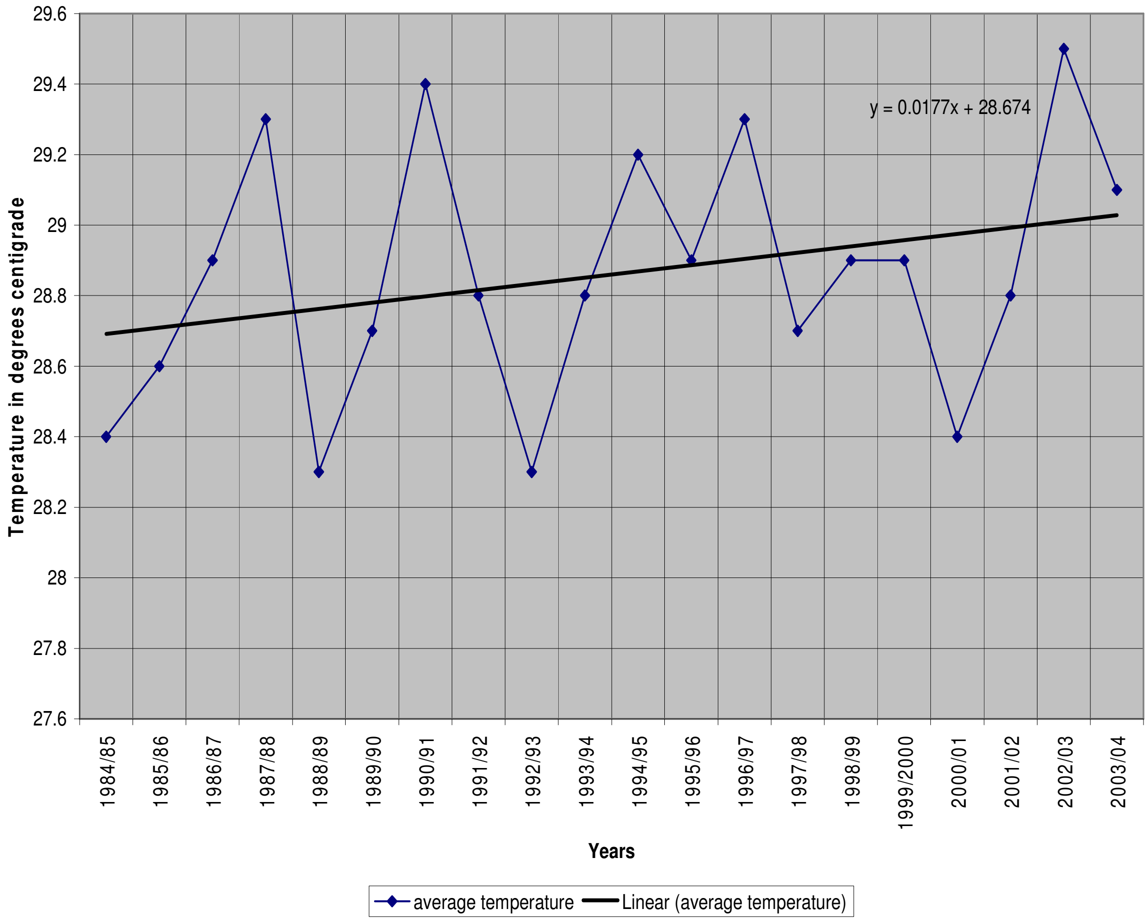

Figure 8. Trends of average annual temperature.

warmer and more humid climatic regions where plants are more susceptible to pests.

The two most important climatic elements determining the occurrence and localization of pests and diseases appear to be moisture and temperature. In general, pests and disease vectors do better when the temperature is high under conditions of optimum water supply. CC & V may increase the incidence of pests and diseases. FAO (2007) reported that changing temperatures and rainfall in drought-prone areas are likely to shift populations of insect pests and other vectors and change the incidence of existing vector-borne diseases in both humans and crops.

Declining soil fertility

There are a number of factors that contributes 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. Mkeni (1992) in a study of farming systems in Tanzania reported that in all cropping systems more nutrients are leaving the system than are being added.

In the study villages, the removal of soil nutrients was mainly 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. On the other hand, increasing temperature observed is contributing to a rapid decomposition organic matter and thus a loss through the production of CO_2 (Rowell, 1995).

Impacts on the management of major crops

According to Table 5, farmers have changed most of their cropping practices due to changes in rainfall pattern and amount. Planting methods for some crops such as maize and sorghum have also changed from broadcasting on flat land to row planting on ridges. This

Table 5. Impacts of changes in rainfall pattern on cropping practices in Kamenyanga and Kintinku villages.

Farming operations	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 March/April	On onset of the rainfall	Shifted from Nov to Dec/Jan	January to February	Shifted from Nov to Dec/Jan
Planting method	Shifted from broadcasting to Ridges	Shifted from broadcasting to Ridges	No change	No change	No change	Spacing on flat or ridges	No change
Changes in crop 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)*
Pests and diseases 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 June/July	May to June/July	March to August	No change	May to June/July	May to June	May to June/July
Harvest amount	Decreased (from 20 – 10 bags /hactare)	Decreased (from 22.5-17.5 bags/hectare)	Mkombozi is high yielding variety	Relatively decreased	Relatively decreased	Fair	Relatively decreased
Storage methods	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/20kg	Increased market	Increased market	5,000 TSH/20kg	Oil price 28,000 TSH/20l	700 TSH/kg
Utilisation	Food and cash, l pasture	Food, cash and local brew	Food and cash	Food and cash	Food and cash	Food, cash, livestock feed	Food and cash

Source: Field survey, 2008.

is basically aimed to encourage moisture conservation and reduce competition arising due to many plants per area. Another common practice is planting early and late maturing crop varieties on the same plot. A study by Thornton et al. (2007) in parts of East Africa indicated that, reduction in the length of the growth period is likely to result in substitution of some crops species, for example, maize might be substituted by sorghum and millet since they are more suited to drier environments. This implies that CC & V might result into changes in plants and crops in certain agro-ecological zone to suit the prevailing conditions. This will impact peoples' livelihood and economy as a whole.

Adaptation strategies to climate change impacts

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

Soil fertility improvement 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 (mid of July) to avoid unnecessary competition for labour 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. Similar findings were reported by Majule, (1999) and Sakala, (1998). Also burning of residue is done to ease cultivation and is a way of controlling crop pests such as stalk borer. There was Small proportion of farmers who allowed livestock to to graze on farmlands after harvesting crops. Adaptation to impacts of CC & V in farming systems requires are silience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). The study by FAO (2007) concluded that a key element in response to both problems is to improve soil organic matter. Soil organic matter stabilizes the soil structure so that the soils absorb higher amounts of water without causing surface run-off, which could result in soil erosion and, or flooding downstream. Soil organic matter also improves the water absorption capacity of the soil during an extended drought.

Soils tillage practices

Farmers classify soils locally by using color, natural fertility, depth and moisture-holding capacity. Two major dominant soil types are *mbuga* and sandy (*kichanga*) soil. *Mbuga* soil is darkish in color, sticky, fertile and holds moisture for a long time whereas 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, bambaranuts and groundnuts are planted in flat bed.

Farmers use contour ridges as a strategy to minimize soil erosion to encourage better root penetration and enhance moisture conservation. The findings are inline with a study by Mahoo et al. (2007) which indicated that, farmers adopted tillage methods, agronomic practices and crop diversification approaches to maximize yield from available water. In this case, tillage tends to improve infiltration rates of water and thus reducing surface runoff associated with short but heavy rains which are usually common in study areas. More research needs to done on tillage practices in response to climate change impacts.

Staggered seed crop planting

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

Mixed cropping

Mixed cropping involves growing two or more crops in proximity in the same field. The system is commonly practised 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 wide field knowledge on 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 insurance against rainfall variability.

Conclusions

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

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

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