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Vulnerability of Climate Change and Adaptation Strategies on Agriculture: The Case of Morogoro Municipalities, Tanzania

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This study on assessed on the impacts of rainfall variability on crops yield in Morogoro municipality. The study was done in five wards, which were randomly selected. These include; Kihonda, Mafiga, Kichangani, Kilakala and Mazimbu. Both primary and secondary data were collected through questionnaire, documentary reviews and field observations. Questionnaire interviews were administered to 150 respondents selected at random from the five wards where 30 respondents were sampled in each ward. Then checklists were administered to 15 Agricultural Extension Officers obtained through purposeful sampling. Analysis of the secondary data of rainfall for the last 30 growing seasons from TMA and crop production statistics for the last 5 growing seasons from the agricultural department were performed using Microsoft Excel spreadsheet. Non-numeric data from the field survey were coded, summarized and analyzed using Statistical Package for Social Sciences. From that analysis, results indicate that the general trend of rainfall variability is slightly declining. Farmers and extension officers perceived these changes by the help of a series of indicators. Nevertheless, perception on the rainfall variability indicators varied depending on the type of livelihood activities which are mostly affected. As a result of that; crop production has been decreasing as well. This can be due to shrinking of the growing season, increased insects and pests all caused by climate change. Eventually this situation leads to low income and food insecurity among the members of the community. Finally, this study concludes that there are some evidences demonstrating the impacts of rainfall variability on crops yield in the study area and pose recommendation strategies to adapt with the impacts.

Keywords: Rainfall variability, Crop Production, Livelihoods

INTRODUCTION

Background Information

Climate has been a very pronounced factor affecting human livelihoods especially agricultural sector which determine the livelihoods of the majority communities (Hare et al, 1985). However, in 1970's most national economies particularly those from Sub- Saharan Africa were continuously being taken by extreme climates mainly rainfall variability (Kassasse, 1992; Ngana, 1993 & Mzengeza, 1996). The World Meteorological Organization (1998) reported on warming trends, with proof of climate change and its continuation observed from many parts of the world. Seasonal fluctuations can be great, we experience droughts, floods, severe storms, and tropical cyclones. It has been recognized that these variations in climate directly affect the growth, health, and survival of pastures, crops, and livestock. Farming operations testify to this with sowing, harvesting, lambing, calving, and shearing timed to maximize the best of seasonal conditions.

In Tanzania , agriculture account for more than 50% of the Gross National Product(GNP), 75% of the export earnings and provide employment to about 84% of the population (Mashinga, 1996,; Kashuliza & Ngaillo, 1993). According to Ashimogo (1995) irrigated agriculture account for less than 2% of the total cultivated land in Tanzania. Thus, Tanzanian agriculture greatly depends on climatic situation which varies enormously within country and across the years.

Rainfall is therefore a very important source of water for crop production (Kassasse, 1992 and Ngana, 1993) and in case of Tanzania where the rate of transition to irrigated agriculture is limited, small rainfall variability has caused a far reaching effect (Simwanza, 1996). Since the late of 1960s, it is evident that, one reason for the observed poor agriculture performance in Tanzania is a greatly attributed by drought (Mascarenhas, 1968). However, up-to-date little has been done to arrest the situation except for a few policy directives in the 1970s following a devastating drought of 1973 (URT, 1993). Therefore, famine and hunger has been mainly caused by rainfall variability especially drought and flood. Thus, there is a need to address the issue of rainfall variability so as to improve crop production and improve food security both at local and national level (Kassasse et al., 1992). Thus strategic decision in planning agricultural systems to cope with ever increasing climatic change and variability is inevitable.

Statement of the Problem

When talking the influence of climate change impacts on crops yields, rainfall remains a significant factor in controlling crop production (Agrawala, 2003). A number of literatures has shown that; the current problem of climate change has led to seasonal rainfall variability in a decreasing trend, in turn leading to decrease in crop production in many areas where crop cultivation is the main activity. Drought and floods are other major problems of rainfall variability that have negative impacts on crops yield. Prolonged drought lead to drying of crops while floods destroy farms, both leading to decrease in crop production. Furthermore, crop failure increases excessive poverty to the already impoverished societies as it reduces income from selling crops, and reduced food security. Not only that, but also these people with no food are ought to buy some food with little money they have instead of using for other most important uses. This scenario tends to exuberate more poverty in these societies. Therefore, rainfall variability has caused a lot of concerns over the past few decades due to the facts that it is becoming less and less predictable, thus proper adaptations strategies need to be adopted in the study area in order to improve people's livelihood.

Objectives

General Objective

The overall objective of this study is to assess the impacts of climate change on crop production and recommend some potential strategies and adaptation to reduce the climate change impacts.

Specific Objectives

(i) To assess the trend of rainfall variability in the study area.
(ii) To assess the trend of crop yield in the study area.
(iii) To assess the relationship between rainfall variability and crop production in the area
(iv) To document some coping strategies adopted by farmers and suggesting other sustainable measures to reduce the impacts of rainfall variability so as to improve crop production.

Research Questions

(i) What is the trend of rainfall in the study area for the past 30 years?
(ii) What is the trend of crops production of in the study area for the past 5 years?
(iii) Is there any association between the trend of rainfall and that of crop production?
(v) What are the strategies adopted by farmers to cope with rainfall variability?

Problem Justification

Frequent rainfall fluctuation has brought some difficulties for both farmers and government to plan and implement their agricultural activities (Muchow & Bellamy, 1991). Irregular onset and offset of rainfall make the situation even worse, also drought and floods increase the problem of reduced crops yield in the study area. The results on the assessment of the impacts of climate change will be helpful to agricultural planners to plan on agriculture. Furthermore, the application of this knowledge will diminish the magnitude of climate change impacts. Later on, the recommended adaptations strategies will be adopted to other areas to be used. Policy makers on the other hand can adopt some of the fruitful recommendation to be applied at national level as the entire pattern of rainfall and intensity of rain is observed to change and unusual amount of rainfall and flood is experienced. It is pointed out that fluctuation of rainfall is not influenced by local factors; it relies on the entire country (Raymond, 2007).

LITERATURE REVIEW

Climate Change and Climate Variability

Climate change is a variation in the climate system because of internal changes within the climate system or in the interaction of its components, or because of changes in external forcing either by natural factors or anthropogenic activities (IPCC, 1996).Climate change in IPCC usage refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Climate variability refers to observed spatial and temporal alterations in the climate record in periods when the state of the climate system is not showing changes. If the climate state changes, usually characterized by a shift in means, then the frequency of formerly rare events on the side to which the mean has shifted might occur more frequently with increasing climate variability (Salinger et al., 2000). Natural variability is a characteristic of the global climate and occurs on both long and short time scales. Many climatologists believe that both long and short-term climatic fluctuations are not random phenomena but organized events which are controlled by forces or energy resources either associated with the earth itself or with the planetary bodies of our solar system.

People's Perceptions and Awareness on Climate Change

Climate change is a multi-faceted challenge for today's societies through its impacts on human lives and the natural environment. However, awareness and quality of knowledge on existence and issues relating to climate change could reduce the impacts of the phenomenon, Doss and Morris (2001) opines that the perspectives of the indigenous people, the way they think and behave in relation to climate change, as well as their values and aspirations have a significant role to play in addressing climate change issues. A report on South African awareness of climate change by Taderera (2010) revealed that while most Africans are aware that weather patterns are changing, their understanding on global climate change is limited. Climate change terminology is poorly understood. It is often literally interpreted as 'changes in weather'.

Furthermore early works on environmental knowledge and its inclusion into ecological assessment focused on the oral histories of indigenous (Spink, 1969), Icelandic (Bell & Olgilvie, 1978) and Yukon peoples (Cruickshank, 1984) to derive information on past changes in local climate.

Later research examined the benefits of considering indigenous knowledge to better understand present weather and climate variability (Fast & Berkes, 1998) and to contribute to more formal assessments of climate change (Fox, 2000). Riedlinger and Berkes (2001) went on to identify how indigenous knowledge from the Canadian Arctic could complement western scientific approaches to understanding climate change. Following the examination of indigenous meteorological beliefs and knowledge in Saurashtra (Northern India), Kanani and Pastakia (2001) helped to establish the Ancient Rain Prediction Network where local experts and scientists make regular predictions on the basis of collective assessment by using both local and scientific forecasts. Analysis of the determinants of farmer's choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia revealed that education increases climate change awareness and the likelihood of soil conservation and changing planting dates as an adaptation method (Deressa, 2008).

Climate Change and Crop Production

There is a strong link between climate and East African livelihoods. East Africa depends heavily on rain-fed agriculture making rural livelihoods and food security highly vulnerable to climate variability such as shifts in growing season conditions (IPCC, 2001). Furthermore, agriculture contributes 40% of the region's gross domestic product (GDP) and provides a living for about 80% of the east Africans (IFPRI, 2004). However because temperature has increased and precipitation has decreased in some areas, many are already being affected. For example, from 1996 to 2003, there has been a decline in rainfall of 50-150 mm per season (March to May) and corresponding decline in long-cycle crops (e.g., slowly maturing varieties of sorghum and maize) across most of eastern Africa (Funk et al., 2005). Long-cycle crops depend upon rain during this typically wet season and progressive moisture deficit results in low crop yields in the fall, thereby impacting the available food supply. Increased variability of crop production is also a major concern of farmers in East Africa. Inter-annual climate variability (example, ENSO) has huge impacts on the region's climate. Warm ENSO events also referred to as El Niño events produce abnormally high amounts of precipitation in parts of equatorial East Africa and can result in flooding and decreased agricultural yields. Further south, in Zimbabwe, researchers correlated past El Niño events and warm sea surface temperatures in the eastern equatorial Pacific with more than 60% of the change between above and below average agricultural production of maize (Patt et al., 2005).

Irrigation and Agriculture

Rainfall contributes to an estimated 65 percent of global food production, while the remaining 35 percent of global food is produced with irrigation. In most parts of the world, rainfall is, for at least part of the year, insufficient to grow crops, and rain fed food production is heavily affected by annual variations in precipitation. The irrigated areas in the world, during the last three decades of twentieth century, have increased by 25 percent (FAO, 1993). Excessive use and poor management of such irrigation water has had, in some cases, detrimental effects on soil quality, causing whole areas to be taken out of production or requiring the construction of expensive drainage works (ibid). Not all rainfall that falls in a field is effectively used in crop growing, as part of it is lost by runoff, seepage, and evaporation. Under irrigated farming, irrigation can be planned using data regarding consecutive periods of rainfall to satisfy the demands for critical periods. Therefore, .there is still some challenges to adopt irrigation system in Sub Saharan Africa. It is mainly done at poor scale.

RESEARCH METHODOLOGY

Description of Study Area

Location

The study area for this project was Morogoro Municipality in Morogoro region. The region is bordered to the north by Tanga and Manyara, to the east by Pwani and Lindi regions, to the south by Ruvuma and to the west by Iringa and Dodoma. The Morogoro municipality is located at 37.4^{o}E and 4.49^{o}S. The area receives total rainfall of about 821mm to 1050mm occurring between March and May.

The region is administratively divided into six districts namely; Mvomero, Kilosa, Kilombero, Ulanga, Morogoro Urban and Morogoro Rural.

Climate

Morogoro Region experiences climate of moderate temperature and rainfall. The average annual temperatures vary between 18^{0}C to 30^{0}C in lowlands. The Region experiences moderate temperature of around 25^{0}C almost throughout the year. The warm season normally runs from July to September. Generally, the region experiences two major rainfall seasons, that with long rains between November and May and short rains between January and February. The average annual rainfall varies between 600mm and 1800mm.

Population

According to the 2002 Population and Housing census, Morogoro Region had a total population of 1,753,362 male being 873,245 and females 880,117 with a total of 385,269 households. The average population growth rate stood at 2.6 percent per annum. According to URT (2002), the Regional intercensal population growth rates between 1967-1978, 1978 -1988 and 1988-2002 were 2.9%, 2.6% and 2.6% respectively.

Transport and Communication

Morogoro is a prominent intersection for both road and railway transportation systems for the entire country. The municipality is at the crossroads of two major highways that service the western, eastern, and southern parts of Tanzania, as well as the neighboring countries of Malawi and Zambia. Rapid population growth and development have affected the public transportation sector in Morogoro.

Morogoro Drainage

The Region's drainage is formed by many rivers that flow from highlands to lowlands in the valleys. The major rivers among others include Kilombero, Ruaha, Wami, Luwegu, Ruvu, Ngerengere, Mkata, Mkondoa and Mkindo.

Topography

The region is characterized by mountainous areas with some plains and plateaus. Some of the famous mountains are Uluguru which are characterized by different plant species. However, excessive degradation has been done in these areas for the sake of the peoples' livelihoods.

Research Design

The research involved visiting the study area where 150 respondents were interviewed. Five wards were sampled for the study and each ward contributed 30 respondents to make the total of 150 respondents. As well, 15 key informants were selected for the study.

Data Collection

The secondary data about rainfall variability and crops yield were collected from Morogoro National Weather Station and the Municipal Council Agricultural Department respectively. These data were collected through key informant interviews, participant observation, literature reviews and questionnaires.

Key informant Interviews

Interviews were conducted to all individuals who seem to be experts and specialists in their professional fields, this include people from government and individuals examples of these are; the Municipal Agricultural Officer, Municipal Environment Management Officer, Morogoro National Weather Station officials and other selected agricultural and environmental experts from Sokoine University of Agriculture.

Literature reviews

This includes data which were obtained from any written document from the government such as Morogoro National Library, Sokoine National Agricultural Library (SNAL), Solomon Mahlangu Campus Library (SMC-Library) and different electronic publications such as journal and paper.

Questionnaires

This includes a set of written questions drafted to reflect the study objectives. These questions were administered to respondents sampled for the study. Generally, this method was used to collect rainfall variability and crops production data from different respondents.

Participant Observation

During the field study; a clear look to the affected study areas was done by the researcher. By so doing the researcher was able to cross check the answers given by different stakeholders especially the respondents.

Sampling

Both random and purposive sampling techniques were used to select areas and respondents for this study. The includes the selection of the five wards for the study, key informant interview and respondents to be interviewed through questionnaire.

Sample Size

The total of 30 people was randomly selected from each ward. There were five wards selected for the study, hence making a total of 150 respondents for all awards. These wards includes; Kihonda, Mazimbu, Mafiga, Kilakala and Bigwa.

Data Analysis

Quantitative data were analyzed through SPSS (Statistical Package for Social Sciences), Microsoft Excel Sheet. Qualitative data were analyzed by content analysis, summarized and presented in the text.

Data Presentation

Results of this study are presented into graphs, tables and charts.

RESULTS AND DISCUSSION

INTRODUCTION

This chapter presents analysis of data, its results and discussion of findings. This presentation includes; characteristics of the sample, biophysical and socio-economic data analysis. In the aspects of biophysical data analysis the results of rainfall in terms of their decrease, increase or fluctuation are presented and discussed.

Perception on Rainfall Variability and Crop Production

Rainfall variability is perceived differently at according to the levels of conceptualization. Through questionnaires and key informant interviews it was revealed that there is varied understanding on rainfall variability depending on the sex, age, level of education and occupation.

The main result of this study shows that local understanding on rainfall variability was that it is continuously changing and it is getting worse over time. Bad years are becoming more frequent than before, resulting in poor performance in agriculture and consequently food shortages in the area due to poor crop yield. Peasants from different age groups acknowledged an increase in rainfall variability and that this variability is becoming more unpredictable. Furthermore the result

Table 1. Sex Distribution of the Respondents

Sex	N=150
Male	48.0%
Female	52.0%
Total	100

Source: Field Survey Data, 2012.

Table 2. Age Distribution of the Respondents

Age	N=150
Under 18	4.0
18-35	56.0
Above 35	40.0
Total	100

Source: Field Survey Data, 2012

.**Table 3. Education Level Distribution of the Respondents**

Education level	N=150
Primary school	30.0
Secondary school	38.0
College/University	32.0
Total	100

Source: Field Survey Data, 2012

Table 4. Occupational Distribution of the Respondents

Occupation	N=150
Employed	24.0
Peasant	46.0
Student	30.0
Total	100

Source: Field Survey Data, 2012

shows that experienced farmers at ages of above 35 perceived the current rainfall trends to be more changing relative to old days.

Basing on the results presented in tables above (Table 1-4), the results shows that the level of participation was a bit relative according to sex, age, level of education and occupation. In tems sex (48% were males and 52% were women). Age wise, fewer than 18 was 4% while those between 18-35 were 56% and those above 35 were 40%. In terms of education, Primary school 30%, Secondary school was 38% and those with tertiary education were 32%. Lastly, occupationally 24% of the respondents were employed in formal sector, 46 were peasants and 30% were students

Therefore, basing on table five below stakeholders' perception on rainfall trends was more consistent across education levels and occupation. More than 90% of the respondents' perceived rainfall to be declining. The majority of respondents linked the declining rainfall to climate change and variability. Therefore, generally the perception of rainfall was treated as mentioned above.

Table 5. Perception of the Respondents on Rainfall Variability

Rainfall Variability	N=150
Increasing rainfall	8.0
Decreasing rainfall	90.0
Do not know	2.0
Total	100

Source: Field Survey Data, 2012

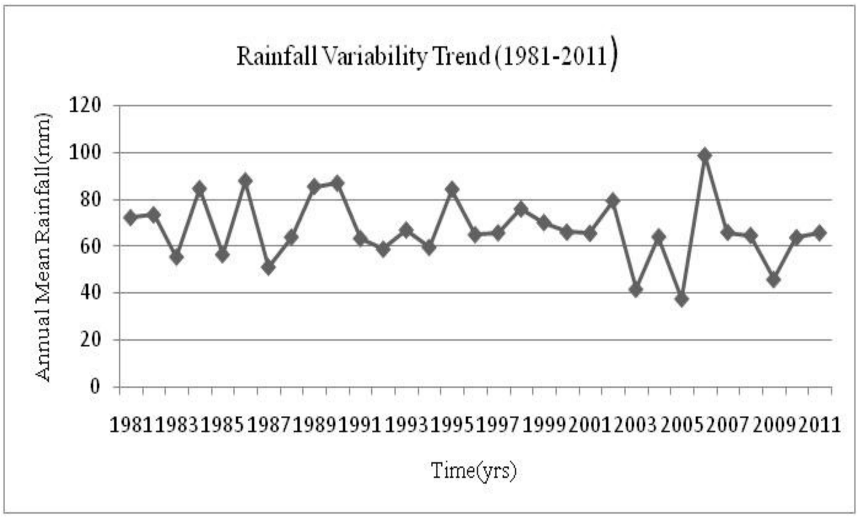

Figure 1 Rainfall Variability Trend of Morogoro Municipality from 1981-2011
Source: TMA-Morogoro (2012).

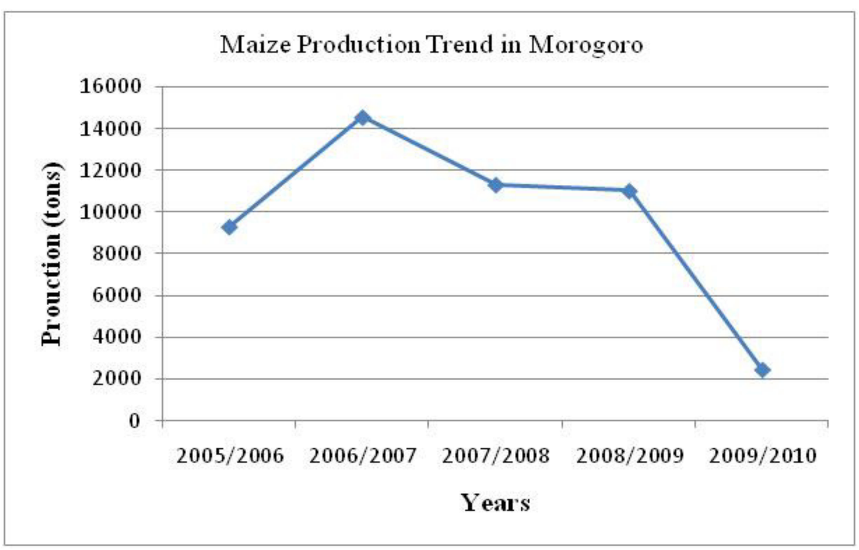

Figure 2. Maize Production Trend of Morogoro Municipality (2005-2010)
Source: Morogoro Municipal Agricultural Department (2012)

The trend shows the rainfall variability to be very unpredictable with the general trend indicating a slight decline. The difference between the highest and lowest mean annual rainfall gives the range of approximately 66mm for years 2006 and 2005 respectively. There have been alterations of dry and wet season with neither one dominating the other except for years from 1997-2000 of which the rainfall showed abnormal dry season continuously for about four years.

The trend of crop yield presented in Figure 2 above shows a general decreasing trend of crop production for the past 5 years starting from 2005 to 2011. This may be the result of the slight decline of rainfall (as presented in Figure 1 above) which is at non-significant rate or other non climate factors like pests, diseases and low soil fertility resulting from land degradation.

Effects of Rainfall Variability on Crops Yield

From the field survey the respondents agreed that rainfall variability affect the crop production where by 70% of the respondents revealed that there is severe effects, 28% of the respondents said the effect is just slight and 2% of the respondents said the extent of effect very low. This is presented in Figure 3 below. However this effect might have been exacerbated by other non climatic factor like decrease in soil fertility, outbreak of pests and diseases in the area as well as poor agricultural practices such as monoculture. These non climatic factors when coupled with the variability in rainfall affect tremendously the yield of crops leading to food insecurity and low income among the community members.

Implications of the Observed Trend of Rainfall on Crops Production

Recurrent seasonal shift and shrinking of the growing season are reported by farmers as major threats to crop production. Figures 1, 2 and 3 have presented the results and explained much on the trends and relations between rainfall trends and crop production. Monthly rainfall in the season indicated slightly declining trends. This implies delayed propagation for such crops like maize, rice, and beans consequently declining yield. According to questionnaire survey, the majority farmers have developed mechanisms of responding to unreliable rainfall through transplanting crops within a growing season. Although this practice could be one of local adaptation measures, it resulted into further fragmentation of the already small fields and sometimes led to counter productivity as distribution of input resources in the farm may not be the same.

Again, the increase in dry spells was connected to increased incidences of crop pests and diseases. Some farmers and the agricultural officers acknowledged the link between climate change and increased incidences of crop pests and diseases. It was revealed that, new pests and diseases were out breaking. They perceived increase in drought and dry spells as being associated to climate change. According to their perception, such changes have occurred in the recent years as compared to the previous decades. This implies that thousands of farmers in the study area who depend on rain fed agriculture as a sole livelihood activity are at risk of becoming food insecure. It was also revealed that majority farmers in all wards under study acknowledged the decreasing trend of crop production. The majority farmers associated the declining food crop production with the impact of climate change and variability. However, the declining trends of food crop could also be due to other non climatic related factors such as declining soil fertility, pest and diseases and inadequate extension services. Actually, the impact of climate change and variability became more pronounced when there is interaction with other non climatic stressors. Analysis of livelihood activities in the studied wards indicates that agricultural activities are mostly affected through decrease in rainfall which also influences loss in soil moisture. Farmers in the study area have responded to the impact of climate change and variability through various local adaptations including expansion of areas under cultivation to compensate for reduced yields during droughts, partly by reducing fallows, switch to more drought-resistant crops such as sorghum and cassava. Some farmers reported growing alternative crops such as sunflower. However, increasing pests and diseases incidences has hindered such effort. Another adaptation measures reported is diversification to nonfarm activities such as brick and charcoal-making, casual labor and carpentry.

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

This study concludes that, farmers at ward level have revealed that rainfall is continuously varying and it is getting worse over time because of the unpredictability of this variability. There is a concerns that rainfall amount has been decreasing over time. Bad years are becoming more frequent than before, resulting in food shortages in the area. This could also be due to other factors such as trends of rainfall and dry spells which provide evidence that rain fed agriculture in the study area is vulnerable to the impact of rainfall variability. Rainfall has generally been varying with a slight declining trend over the last 30 growing seasons. The nature of dry spells is very important

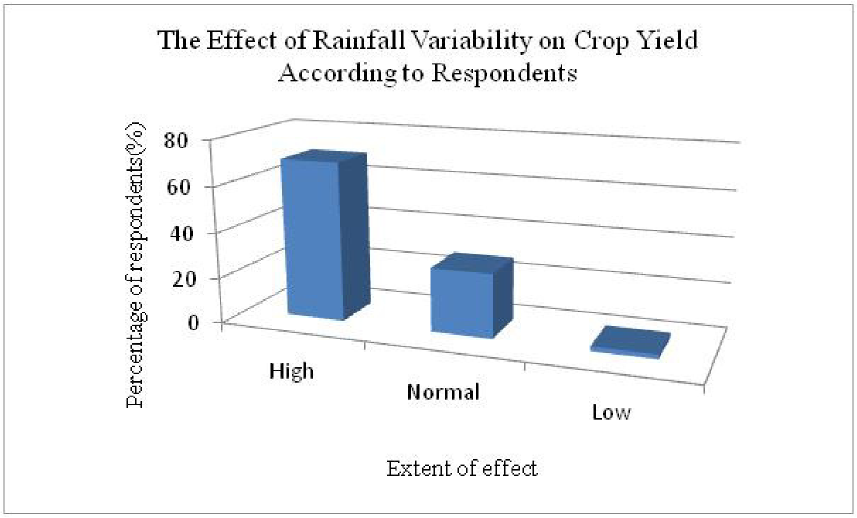

Figure 3. Effect of Rainfall Variability on Crop Yield
Source: Field Survey Data, (2012).

as it affects most crops at their crucial period of growth when they need adequate moisture. This shortage of moisture always leads to crop failure. Therefore, the findings of this study can provide useful information required by different stakeholders from local to national level. This can be more useful in Tanzania and other tropical region as they mainly depend on rain fed.

RECOMMENDATIONS

The study therefore recommends the following;

- Development of appropriate strategies for reducing the impacts of rainfall variability on crops production by helping farmers use their local knowledge in combination with scientific innovations to enhance local adaptations to climate change and variability such as adoption of drought resistant crops.
- Enabling environment should be created to allow smooth responses to other crops as an adaptation to climate change and variability and sustaining adequate food security. Enabling the environmental may involve switching to irrigation practice to counteract the inadequate rainfall, improving extension services to farmers and use of organic fertilizers which helps to improve soil fertility, soil structure and increases the water holding capacity of the soil.
- Introduction of crop species resistant to environmental stresses like drought, pests and diseases to reduce crop failures.
- Government intervention on marketing of crops is required in order to stabilize food prices during bad harvest periods. A return of the old cooperative schemes could also assist in this as cooperatives can be run by local people and therefore benefits are returned and trickled down at local level.
- The government should increase access to financial capital by increasing loan availability in the region. Loan facilities specifically targeted at women may help households more as women are predominantly responsible for agricultural operations and so could allocate financial capital according to the needs of the household. Such facilities will likely improve agricultural production by enabling households to apply fertilizers and hire tractors.
- Finally, government employment projects in the region should create cash flows and help to make non-farm income more stable. Agro-processing activities may provide such opportunities in the region.

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