POLICY IMPLICATION FOR SMALLHOLDER FARMERS' ADAPTATION TO CLIMATE AND LIVELIHOOD CHANGE IN PANGANI RIVER BASIN

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

This study aimed at analyzing policy implications to smallholder farmer's adaptation to climate and livelihood change along Pangani river basin specifically in Korogwe district. The study intended to fill the knowledge gap of the interaction between policy made at local and government level with their associated implications to livelihood of smallholder farmers. Both primary and secondary data were collected, primary data were collected by using structured questionnaire and focus group discussion while secondary data were collected by using policy, laws and regulations documents Matrimonial logit modal MNL was used to analyze the policy (as adaptive strategy) effects on smallholder farmer's adaptation and livelihood change. The findings show significantly ($p=0.05$) that, policy and policy instruments affect smallholder farmer's adaptation to climate and livelihood change differently. This means that, other policy and policy instruments assist farmers to adapt and improve their livelihood change. This is when the policy as adaptive strategy lead to farmer`s yield size increase and it has good results to the environment example policy instrument from EMA 2004 No 75 use of improved seeds as adaptive strategy enable farmers to increase their yield size and do not have harmful impact on the environment. Other policies do not encourage use of a particular adaptive strategy due to its impacts to the environment and when do not encourage sustainable use of it as adaptive strategy example policy instrument from EMA 2002 No 14 restrict shifting cultivation as adaptive strategy because clearing of trees lead to draught and do not influence sustainable environment management and do not lead to yield size increase. And other policies do not encourage use of particular adaptive strategy while have good impact to smallholder farmer's adaptation and livelihood change like policy of restriction of any human and economic activities within 60 m from water resources. Also this study determined that farmers are facing challenges like low production level, low adaptive

capacity and low livelihood level. Study recommended that there should be participation in policy construction to all stakeholders. Also more research on smallholder adaptation, livelihood change and policy interaction, farmers training to increase awareness and farmers exchange programs to have different experiences from different areas.

DECLARATION

I, SHEGA MBOYA, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

_____ _____

Shega Mboya, Date

(MSc. Candidate)

The above declaration is confirmed;

_____ _____

Prof. J. P. Hella Date

(Supervisor)

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DEDICATION

I dedicate this study to my family, my husband, my parents and my supervisor who always have been there for me.

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LIST OF ABBREVIATIONS AND ACRONYMS

asl	Above sea level
CC	Climate Change
CCA	Climate Change Adaptation
CoC	Change of Crops
DFID	Department for International Development
EGR	Extensive Grazing
EMA	Environmental Management Act
FWR	Farming Near Water Resources
IIA	Independence of Irrelevant alternative
IISD	International Institute of Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
ISA	Improved Seeds and Agro-chemicals
IUCN	International Union for Conservation of Nature
km	Kilometer
LPM	Logit Probit Model
M	Meter
MNL	Matrimonial Logit
MNP	Mutinomial Probit
MSc	Masters of Science
NAS	National Adaptation Policy
NEMC	National Environmental Management Act
NEP	National Environmental Policy
PBWO	Pangani Basin Water Office

PRB	Pangani River Basin
R^2	Coefficient of Determination
SCU	Shifting Cultivation
SLRC	Science livelihoods Research Consortium
SLF	Sustainable Livelihood Framework
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture
URT	United Republic of Tanzania
USD	United State Dollar
VPO	Vice President Office

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Climate change is a global problem and it has a significant impact on the livelihoods of the rural poor in developing Countries (Wisner, 2004). According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) it is predicted that climate change is likely to have a significant effect on agricultural production in many African countries. Projected reductions in yield in some African countries could be as much as 50% by 2020, and net crop revenues could fall by 90% by 2100 (Boko *et al*., 2007). Over the past few decades the continent has experienced an increasing number of warm days and decreasing number of extremely cold days (New *et al*., 2006). Spatial and temporal variability of precipitation, are more intense and wide spread droughts and aggravated floods have been common during this period (Deressa, 2010).

Farmers have a long history of responding to climate variability. Traditional and newly proposed adaptation practices help them to cope with both current climate variability and future climate change. Adaptation generally takes place at the micro- and macro-levels: For example farmers introduce practices at the local level like shifting cultivation and changing agricultural production system (Hassan and Nhemachena, 2008).

The need for climate change adaptation is now widely acknowledged (Boko *et al.,* 2007). Although Tanzania has adequately mainstreamed environmental concerns into her national plans and policies, climate change is increasingly taken note off. In 1997 Tanzania adopted the National Environment Policy which aimed at making fundamental

changes that are needed to bring environmental considerations into the mainstream of decision-making in Tanzania (NEP, 1997). Also in 2004 Tanzania introduced Environment Management Act (EMA, 2004) which aim at providing and promote enhancement, protection, conservation and management of environment. However, there is a growing appreciation amongst policy makers and societal actors that the policy context in which adaptive decisions are made must also be considered (Burton *et al*., 2002), as it may have a similarly constraining effect. This study purposes into looking at the limitations of the policy environment for adaptation of the small farmers to the effects of climate change.

1.2 Problem Statement and Justification

Long term climate data for the Pangani River Basin shows that, climate is changing as characterized by decrease in rainfall during the short rain season, increase in evapo-transpiration, mostly by approximately 10 mm, increase in rainfall during the long rain season, minimum temperature increase by approximately 2°C (range of 1° to 3°C) during all months; and maximum temperature increase by 1° to 3°C in July–November (IUCN, 2009). The seasonality of stream flows in the Pangani is therefore likely to change because of climate change which disturbs the normal distribution and amount of the rainfall. The magnitude of this change varies across the sub-catchments, and its impact depends on water extraction and the characteristics of each sub-catchment (IUCN, 2009).

In Pangani river basin a number of important adaptation options have been reported to be used by farmers. Farmers practice mixed cropping, farming close to water sources, practice shifting cultivation which involves clearing of the land to large extend, extensive grazing and change of crops. So, all these have brought an impact on the livelihood of the Pangani dwellers (Sanga *et al.,* 2013).

While government policy and regulation are meant to deliver economic, social and environmental benefits, they can also entail costs in its implementations and outcomes. The focus in this study is on how policies and regulations that impede adaptation to climate change For example, regulations that restrict cultivation on the water resources may mean that farmers are not able to cultivate within 60 m from the water sources to have enough water for the crops cultivated.

Still the knowledge gap exist when attempts are made to understand the interaction between policy decisions made at national and local levels and farmers adaptation and their associated implications to the livelihood. Brooks and Adger (2005) noted that ‘‘policies designed to address issues at a regional scale can have unforeseen effects at local scales’’. In relation to adaptation decisions, this study was designed to identify the effects of policies and regulations to smallholder adaptation to climate change.

Knowing the effects of policies and regulations on adaptation and livelihood of smallholder farmers in Pangani river basin will enable farmers to know the sustainable adaptive measures like use of improved seeds and agro chemicals, use of new crop varieties that are draught resistant and disease resistant. Also will enable to have policies and regulations that encourages and favor farmers to have effective adaption and hence improve their livelihood.

1.3 Objectives and Research Questions

1.3.1 Main objectives

The main objective of this study is to analyze policy effects on smallholder adaptation in Pangani river basin.

1.3.2 Specific objectives

Specifically the study is sought

i. To collate policy for climate change adaptation at local and central level.
ii. To analyze the effect of policy on adaptation to smallholder farmers in Pangani River Basin
iii. To identify challenges of climatic change adaptation that needs Policy recommendation in the study area.

1.3.3 Research hypothesis

i. H_o: policy and policy instruments do not influence adaptation to climate and livelihood change to smallholder farmers in Pangani River Basin

   $H_{i:}$ policy and policy instruments influence adaptation to climate and livelihood change to smallholder farmers in Pangani river basin

1.3.4 Research question

i. What are policy for climate change adaptation
ii. What are Policy recommendations for smallholder farmers needed to overcome challenges of climatic change adaptation in the study area?

1.4 Organization of the Dissertation

This dissertation is presented in five chapters. Chapter one presents introduction, background information, general objective and problem statement and justification of the study. Chapter two present literature review where meaning and type of climate change adaptation, climate change in Pangani river basin, smallholder adaptation and policy instruments to climate change, policy, policy instruments and environmental regulations for climate change adaptation, challenges that need policy recommendations in Pnngani river basin and sustainable livelihood framework are presented. In chapter three research

methodologies is explained. Chapter five results and discussion and the last chapter present conclusion and recommendations'.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Meaning and Types of Climate Change Adaptation

Climate change adaptation has been defined as the process of reducing the vulnerability to current and/or projected climate change impacts (IPCC, 2007; Wiseman *et al.,* 2011). Adaptation activities may be in the form of either short-term climate-related 'shocks' such as droughts, floods, bushfires and heat waves, or long-term climate-related trends, such as shifting rainfall patterns, mean temperature changes or sea level rise. Some adaptation responses will address both shocks and trends (Mitchell *et al*., 2012).

Burton (1996) classified possible adaptation strategies into several categories. These include preventing which refers to take action to reduce the exposure to climate impacts example Building sea walls. Tolerating or sharing losses which refer to accept losses where it is not possible or cost-effective to avoid them or distribute the burden of impacts over a larger region or population beyond those directly affected by the climate event example Accept reduced crop yield and Insurance of assets. Changing use or activity like Switch of activity or resource use to one better suited to the changed climate example new business opportunities (example tourism, agriculture, insurance). Changing location and restoration as Migrate to an area which is more suitable under the changed climate example Assets moved away from areas at risk of flooding.

2.2 Climate Change in Pangani River Basin

The Pangani Basin is one of Tanzania's most agriculturally productive areas and is an important hydropower production region. Because of this, climate change threatens the productivity and sustainability of this region's resources, which hosts an estimated 3.7 million people.

Pangani river basin has reduced flow due to declining rainfall, which has had ecological and economic impacts such as water shortages, lowered agricultural production, increased fungal and insect infestations, decreased biodiversity and variable hydropower production (Orindi and Murray, 2005). High temperatures and less rainfall during already dry months in the Tanzanian river catchments could affect the annual flow to the River Pangani by reductions of 6-9% (VPO-URT, 2003).

The Pangani Basin is also fed by the glaciers of Kilimanjaro, which have been melting alarmingly fast and are estimated to disappear completely by 2015 - 2020 (Thompson *et al.*, 2002). The population living around the base of Kilimanjaro uses this melt water and the fog water from the rainforests that cover the mountain's flanks for drinking, irrigation, and hydropower.

2.3 Smallholder Adaptation and Policy Instruments to Climate Change

Munishi *et al.* (2010) outlined a number of options including, crop diversification, increased irrigation and technology improvement, improvements in soil fertility, strengthening climate information, research and training, agricultural extension improvements, building adaptive capacity, rain water harvesting and increased water storage, vulnerability assessments, and improved pest management. The mentioned adaptation strategies are also policy instruments available along Pangani river basin.

In rural areas, adaptation options include development of groundwater wells and rainwater harvesting structures. It is possible that due to socio-economic pressures, and climate change, some aquifers may subside or dry up due to high utilization rates and slower rates of recharge (Makhoka *et al.*, 1999). One way to address this is to replace shallower with deeper wells, Rainwater harvesting systems are an alternative, and these

systems could be used for domestic water supply as well as a source of agricultural water and could serve to provide storage as a buffer against greater intra- seasonal rainfall variability. Finally, given the large number of water-points that are non-functional, the need to map rural water-points to serve as an input into district-level planning has also been identified as a necessary tool to ensure sustainability (Taylor, 2009).

2.4 Policy, Policy Instruments and Environmental Regulations for Climate Change Adaptation

2.4.1 Environmental laws and climate change adaptation policies

Environmental law constitutes enforceable rules and principles regulating the activities of persons, natural or legal, which have an impact on any of the media mentioned above as forming part of the environment (Goodland *et al.,* 2005) The term 'policy' may be defined as a set of principles that guide a regular course of action (Bone and Osborn, 1963). The National Environment Management Council Act, 1983 was the first law to demonstrate the government's interest in development that takes the environment into consideration.

The Act created the National Environment Management Council (NEMC) in 1983 for the purpose of 'acting as an advisory body to the government on all matters relating to the environment. (URT, 1994) The Constitution of the United Republic of Tanzania was amended in 1984 to provide for the Bill of Rights. Article 14 of the Bill of Rights stipulates that every person has a right to life and to the protection of life by society (Bierwagen and Peter, 1992).

The National Environmental Policy, 1997 provides a framework for making fundamental changes that are needed to bring environmental considerations into the mainstream of

decision-making in Tanzania. The Environmental Management Act number 20 of 2004 was passed by the National Assembly in 2004, and in the beginning of 2005 the President assented to the Act. The Act repealed and replaced the National Environment Management Council Act, 1983. The environmental management Act of 2004 has three instruments for its implementations, environmental impact assessment, economic instruments and public participation.

2.4.2 Agricultural and land management policies

NAS (1992), OTA (1993) Development of new crop types and enhance seed banks will maintain a variety of seed types provide an opportunity for farmers to diversify, allowing them to both counter the threat of climate change and develop a profitable specialization. Avoiding monoculture and encourage farmers to plant a variety of heat- and drought-resistant crops will reduce farmers' vulnerability to climate variability. If the probability of droughts and heat waves increases with climate change, such vulnerability can be reduced. One adaptation option is for farmers to plant a wider variety of crops to reduce the risks of crop failure (Jones, 2003).

Farming technologies, like efficient irrigation systems, provide opportunities to reduce direct dependence on natural factors such as precipitation and runoff Disperse information on conservation management practice such as conservation tillage, furrow drilling, terracing, contouring, and planting vegetation to act as wind breaks will protect fields from water and wind erosion (Easterling, 1993).

Liberalization of agricultural trade by lowering trade barriers will result in higher levels of global agricultural production both under the current climate and under climate change scenarios. Farmers will receive information on changes in global market conditions faster than if trade barriers were not lowered (Rosenzweig and Parry 1994; Polaski, 2006).

Promoting agricultural drought management and encouraging management practices that recognize drought as part of a highly variable climate, rather than treating drought as a natural disaster (OTA 1993; Howwit *et al.,* 2014). Farmers can be given information on climatic conditions, incentives can be offered to adopt sound practices of drought management, and farmers can be discouraged from relying on drought relief. This type of policy is particularly useful if farm disaster relief and other government subsidies distort the market and encourage overly risky expansion of farming into marginal lands (Cohen and Diri, 2013).

2.5 Adaptive Strategies in Pangani River Basin

In Pangani river basin efforts have been implemented to increase community adaptive capacity, including provision of alternative water sources, training and support for alternative income generating activities and strengthening of grassroots water governance institutions to manage water resources (PBWO, 1997).

Farmers in Pangani river basin have different adaptation strategies such as increase use of inorganic fertilizers, migrating from dry to wet, river banks and wetlands, irrigating farm plots, applying soil and water conservation mechanisms, change planting dates (i.e. planting at first rain), grow crops that mature faster, planting drought resistant crops, mixing crops on the same plot, focus more on non-farm activities, planting trees around the farm plots for shading and litter production for mulching (Sanga *et al.*, 2013).

2.6 Challenges that Need Policy Recommendations in Pnngani river Basin

Production challenge

Climate change has direct adverse impacts on agricultural production in Pangani River Basin because nearly 80% of agricultural production is rainfall dependent (Thornton, 2011). In recent years the area has experienced crop failure due to low rainfall and emerging animal, crop and human diseases in many parts (Mtalo *et al*., 2005). The effect is more in Pangani river basin, because the majority of the population is characterized with low means of adapting to climate change impacts (Agrawala *et al*., 2003).

Barriers to adaptation to climate change in Pangani River Basin are due to poverty. For instance, lack of information to adaptation options, lack of capital to invest on adaptation mechanisms and labor, shortage of land has also been pointed out as a barrier to adaptation (Sanga *et al.,* 2013). Farmers in area in general are very poor and cannot afford to invest on adaptation strategies such as irrigation technology not only to adapt to climate change but also to sustain their livelihood during climatic extremes such as drought and heavy rain (Fischer *et al.*, 2013).

2.7 Sustainable Livelihood Framework

The concept of ‘Sustainable Livelihoods’ constitute the basis of different ‘Sustainable Livelihood Approaches’ (SLA) and has been adapted by different development agencies such as the British Department for International Development (DFID). The DFID has developed a ‘Sustainable Livelihood Framework’ (SLF) which is one of the most widely used livelihoods frameworks in development practice. The SLF was integrated in its program for development cooperation in 1997. DFID adapts a version of Chambers Conway’s definition of livelihoods: “A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with

and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (DFID, 2000).

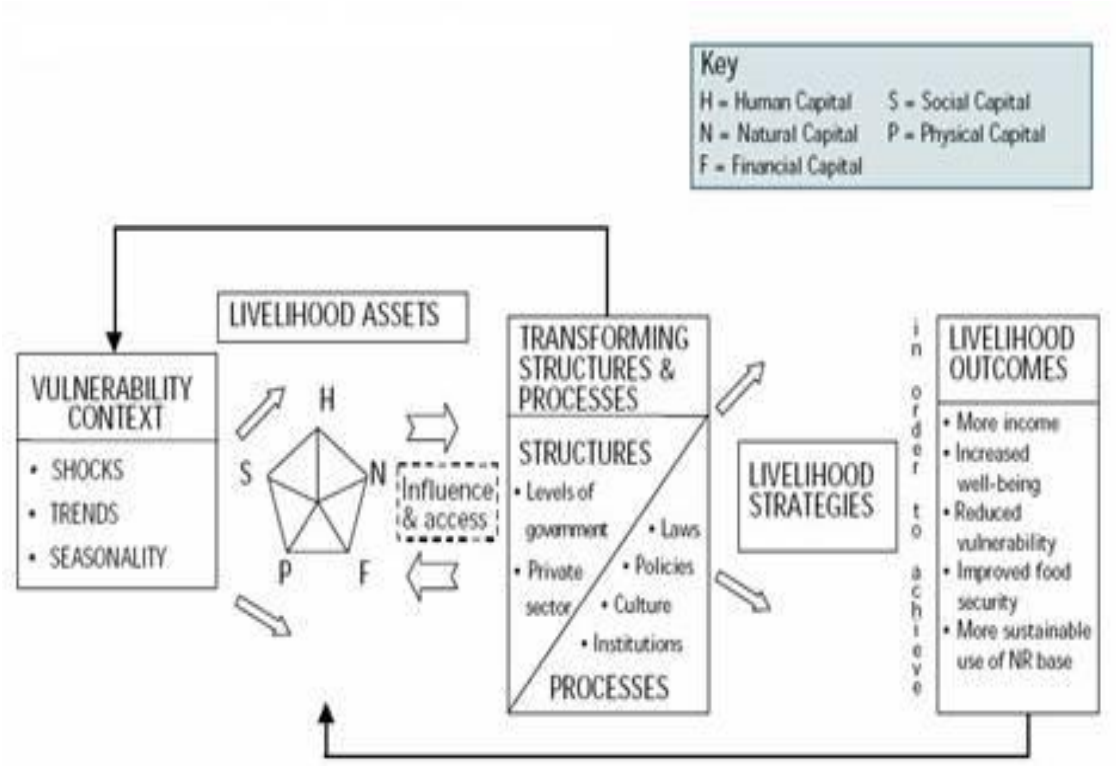

Figure 1: Sustainable livelihood framework DFID 2000

This study was analyzing policy implications to small scale farmer's livelihood and adaptation to climate change. Farmers have got livelihood assets like financial capital, social capital, physical capital and human capital. Also there is government leaders and structure, laws, policies and institution that all together affects farmer's ability to adopt and livelihoods outcomes in different ways. Then the Sustainable Livelihood Framework has been used in this study because it managed to explain and to link all the concept of the study (Achten *et al.*, 2010).

2.8 Method of Data Analysis

2.8.1 Systematic review

Systematic review is the method for collecting information from different sources and links them together. Sterne and Smith (2001) since the objective is to collate policies for climate change adaptation then the method is suitable for the objective.

Murray and Thayer (2014) adoption of broad search strategies, predefined search strings and uniform inclusion and exclusion criteria, systematic reviews effectively force researchers to search for studies beyond their own subject areas and networks. At the same time, the careful deconstruction of the research question at the outset in terms of population, intervention, comparator and outcome ensures that the review process remains tightly focused. In theory, this improves the likelihood of generating a clearer, more objective answer to the research question. Likewise, traditional literature reviews in international development research often focus exclusively on results of other studies, without considering study design, data and analytical methods used. In comparison, systematic reviews focus more strongly on evidence, impact, validity and causality. By extracting information on research design (sampling strategy and data collection methods), analytical methods and causal chains, systematic reviews are effective at gauging the robustness of evidence. Classifying the quality and characteristics of impact studies against standardized criteria also enables the possibility of producing cross-study comparisons and meta-analyses, which are valuable for evidence-informed policymaking. In other words, systematic reviews encourage researchers to engage with studies more critically and to be consistent in prioritizing empirical evidence over preconceived knowledge (Colquhoun *et al.,* 2014).

Despite the added value of a systematic review approach, a number of practical problems throughout the process have been encountered. These included the searching, screening and synthesis stages and will now be discussed in turn. Concrete examples will be provided from the systematic review on cash transfers and employment creation (Egger *et al.*, 2001). First of all, systematic reviews require access to a wide range of databases and peer-reviewed journals, which can be problematic and very expensive and it encouraging a more inclusive process of evidence building. Searching institutional websites, for example those of international organizations, is essential to ensure breadth of systematic reviews, as relevant research is often located (SLRC, 2012).

2.8.2 Matrimonial Logit Model (MNL)

Adaptation measures help farmers guard against losses due to increasing temperatures and decreasing precipitation. The analyses presented in this study identify the effects of policy to smallholder adaptation to their yield size. The analytical approaches that are commonly used in an adoption study involving multiple choices are the multinomial logit (MNL) and multinomial probit (MNP) models (Burridge, 1981). Both the MNL and MNP are important for analyzing farmer adaptation decisions as these are usually made jointly. These approaches are also appropriate for evaluating alternative combinations of adaptation strategies, including individual strategies (Hausman and Wise, 1978; Wu and Babcock, 1998). This study used a MNL logit model to analyze the effects of policy on smallholder adaptation as the effects of yield size change because it is widely used in adoption studies involving multiple outcomes and is easier to compute than its alternative, the MNP.

The advantage of using a MNL model is its computational simplicity in calculating the choice probabilities that are expressible in analytical form (Tse, 1987). This model

provides a convenient closed form for underlying choice probabilities, with no need of multivariate integration, making it simple to compute choice situations characterized by many alternatives. In addition, the computational burden of the MNL specification is made easier by its likelihood function, which is globally concave (Pratt, 1981).

The main limitation of the model is the independence of irrelevant alternatives (IIA) property, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Tse, 1987) Alternatively, the multinomial probit model (MNP) specification for discrete choice models does not require the assumption of the IIA (Randall, 1989), and a test for this assumption can be provided by a test of the 'covariance' probit specification versus the 'independent' probit specification, which is very similar to the logit specification. The main drawback of using the MNP is the requirement that multivariate normal integrals must be evaluated to estimate the unknown parameters. This complexity makes the MNP model an inconvenient specification test for the MNL model (McCullagh, 1980).

2.8.4 Application of MNL Logit Model

Despite of the above demerits, however the logit model has a number of applications. Vasisht (2007) and Logan (1983) listed the basic three applications as follows; first it can be used to identify factors that affect the adoption of a particular technology, example use of new varieties, fertilizer, pesticides on a farm. Second in a field of marketing it can be used to test the brand preference and brand royalty for any product. Third gender studies can use it to find out the factors which affect decision making status of men/woman in a family. However it's for these three basic applications the model was adopted to

determine policy effects on smallholder farmer’s adaptation to climate change in Pangani River Basin.

2.9 Descriptive Statistics

Descriptive analysis issued to calculate mean, frequency, percentage, graphs and ranges. Results are presented in percentages and graphs such as histograms and Pie charts. Statistical package for social science (SPSS) and Microsoft Excel for both qualitative and quantitative data analysis for this study (Kothari, 2008). Major advantage of using descriptive statistics is that it is very simple and more information can be obtained and well explained with graphs and figures.

2.9.1 Strength of the descriptive research method

Descriptive research is an innovative tool for researchers. It presents an opportunity to fuse both quantitative and qualitative data as a means to reconstruct the "what is" of a topic. Using a descriptive research design requires the use of specific forms of data collection. This can include case studies, observation or surveys. These data collection techniques present several advantages as they provide a multifaceted approach for data collection. For example, a survey can provide statistics about an event while also illustrative how people experienced that event. (Borsch 1986) Descriptive research designs also offer a unique means of data collection. Case studies can be based on various sources such as newspaper reports or personal accounts. These accounts provide insight into life experiences. An observational technique for data collection can be an organic means to study life experiences and can often remove the barriers of strict academic approaches as the researcher witnesses how others experience an event (Nick, 2007).

2.9.2 Weakness of descriptive research method

Confidentiality is the primary weakness of descriptive research. Often subjects are not truthful as they feel the need to tell the researcher what they think the researcher wants to hear. This is particularly difficult during interviews. Participants may also refuse to provide answers to questions they view to be too personal. Furthermore, the idea that someone is watching can turn an observation into an event where people are acting how they perceive they should act. (Goodman, 1979).Descriptive research also presents the possibility for error and subjectivity. For example, when a researcher designs a questionnaire, questions are predetermined and prescriptive. Furthermore, the study may contain errors, as the researcher may record what she wants to hear and ignore data that does not conform to the research project's hypothesis. Overcoming a research bias is an extreme difficulty for descriptive research practitioners and those who chose to use a descriptive research approach must be aware of their influence on the outcome of the research (Babbie, 2009).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

Pangani river basin has a total catchment area of about 43,650 sq. km with about 3,914 sq. km lying in Kenya (IUCN, 2003). Pangani River Basin is unique in the fact that it begins from the highest pick of Africa Mount Kilimanjaro (which is 5895 m asl) and Mount Meru (which is 4565 m asl) through the Pare and Usambara Mountains to the north and north-east respectively to the low lands of about 900 m asl and 0m asl. The low lands make up about 50% of the basin (Mbonile, 2001).

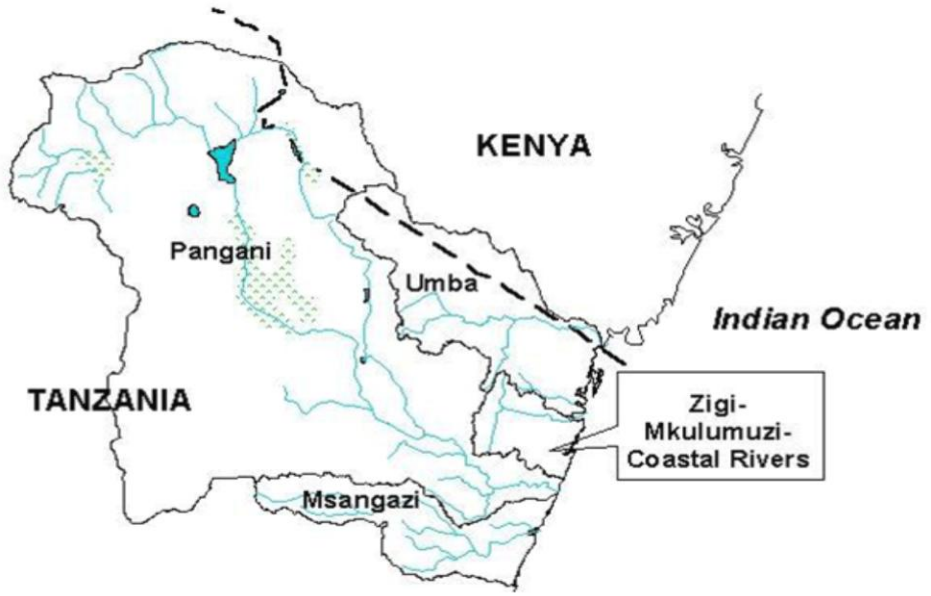

Figure 2: Map of Pangani river basin

Source: PBWO (1997).

The basin is characterized by rapid population growth with uneven distribution; the basin is currently a home to 3.7 million inhabitants (IUCN, 2003). Ninety percent of this population lives in the highlands, leading to a population density of up to 300 people per sq. km, compared to 65 people per sq. km in the lowlands (IUCN, 2003). This rapid population growth, high population density coupled with climate change is posing pressure to the basin natural resources. The basin is well known for persisting water conflicts between farmers and pastoralists, shortage of arable land for agriculture and is also hosting precious natural resources such as wildlife which are important to the economy of the country. Nonetheless, the basin is characterized by in-migration of farmers searching for farmland, water and pasture for livestock. This study was conducted in Korogwe district one among eight district that the river basin passed through.

3.1.1 Korogwe District

Korogwe District is one of the eight Districts within Tanga Region and is centrally located, well connected to the other region, northern and the central-coastal areas of Tanzania. Korogwe District has an area of 3756 square kilometers, whereas the Korogwe District Council covers 3544 square kilometers, about 13% of the total land area of the Region, and lies in the latitude 4º15’ and 5º15’ South, and in the longitudes 38º0 and 38º45’ East. Korogwe District has variations in the topography and climate provides different cropping possibilities which can be defined into three major agro-ecological zones. Most of the district has loamy, sandy and clay soils while the natural vegetation is predominantly of the tropical type. These zones are the Mountainous, low wetlands, and Semi-Arid Zone An Irrigation zone can also be identified along the major rivers. Each zone, however, has similar topography, climate and cropping possibilities.

The mountainous zone occupies about 25% of the district area. It lies between 900-1500 meters above sea level, has a temperate climate and between 1000-2000mm of annual The Low wetland zone occupies about 35% of the district. It lies between 600-800 meters, is hot-humid, and has an average rainfall between 800-1000mm per year. Several rivers, including the Pangani and Lwengera, drain this area to provide irrigation potentials. The main food crops grown are maize, paddy, beans, cassava and potatoes while the cash crops cultivated include cashew nuts, cotton, sisal and tropical fruits like mangoes, oranges and tangerines. Livestock (exotic and indigenous) is also reared for milk and meat.

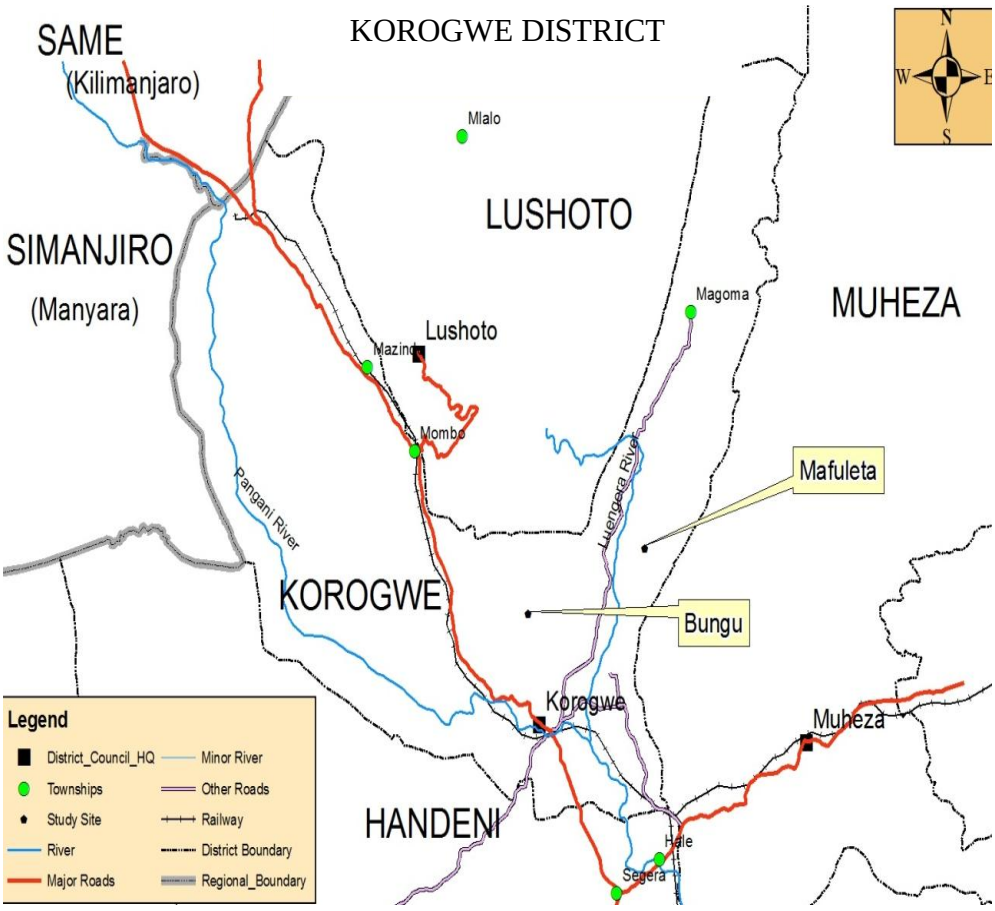

Figure 3: Map of Korogwe district showing areas where the study was done

Source: Korogwe district office

3.2 Conceptual Framework

The final framework aims to integrate existing but disparate knowledge about policy effect to agricultural climate change adaptation, into an interdisciplinary system of understanding. The framework helps identify important knowledge gaps in the current understanding of policy implications to smallholder adaptation to climate change, and thus where research and policy efforts should be focused to reduce and overcome limits and barriers to adaptation

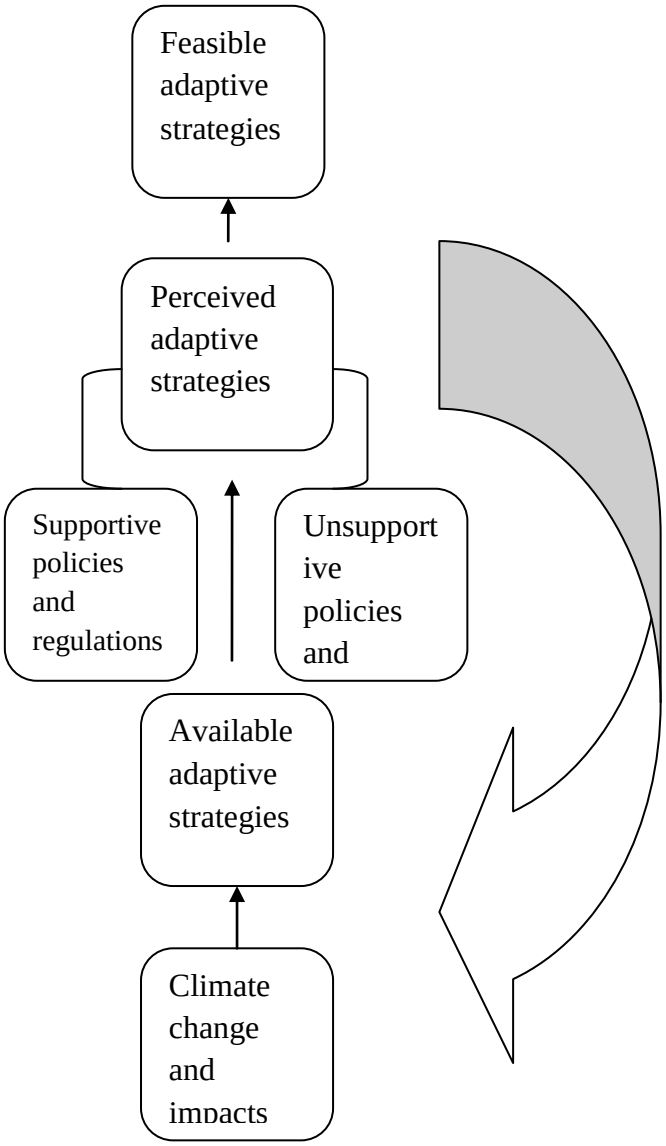

Figure 4: Conceptual framework of the study

From the framework, there is climate change and its impacts and farmers have different adaptive strategies to cope with the climate change outcomes. Government and its institutions is there with policies and rules which some of them supports available adaptive strategies and some do not support adaptive strategies available. Then due to policies rules and regulations effects to farmers adaptation to climate change farmers perceive adaptive strategies and then feasible adaptive strategies are found.

3.3 Study Design

The study used cross-sectional study design where data are collected at the single point in time using a survey method. The reason for choosing this design is because it is flexible and economic. (Babbie, 1995 and Bairley, 1998) in addition the subject was tested ones at the same time, also it is easy to manipulate data and information obtained.

3.4 Sampling Frame, Sampling Design, and Sample Size

The target population for the study was smallholder farmers along Pangani river Basin. A sampling frame is a list that identifies the target population (Binson *et al.*, 2002). Sampling frame of this study was obtained from the administrative leader in the selected area. Both purposively and systematic random sampling were employed. Purposively sampling was used to select one district that is Korogwe, where Pangani river basin passes through and selection of the wards based on the altitude they are located. Bungu located at the higher altitude and Mafuleta which is located at Lower altitude.

Furthermore stratified sampling technique with a calculated sample size fraction of 0.0126 (given from the formula) was employed to get household sample from each group where each ward gives two villages. Stratified sampling was based on the climatic

scenario in the study area. There are three scenarios, farmers with high altitude, middle altitude and lower altitude in both higher area of the valley, middle, and lower. Higher altitude from the valley includes Arumeru, Hai and Moshi Rural. Middle includes Same Mwanga and Korogwe and Lower include Pangani District. Due to resource and time constrain this study concentrate middle-middle scenario were two places were selected one from higher altitude Bungu and lower altitude that is Mafuleta Each village with 45 household that make total of 90 household from each ward, thus 180 household stratified sampling technique were used because it increase accuracy without increasing sample size. It ensures effective presentation of all farmers both from higher altitude and those from lower (Czaja *et al.,* 1982).

3.5 Data Collection

Both qualitative and quantitative data collection procedures were taken. Quantitative data collection involved questionnaire with both closed and open ended questions. Qualitative data collection also was used with the supplementary focus group discussions. With the use of questionnaire the information like social economic characteristics of farmers in the study area, sex, age, education level, experience, household size. Also awareness on climate change and adaptation strategies, selected adaptive strategies, size of yield before and after adaptation and other outcomes as the results of adaptation with reference of policy options (Enders, 2001). Systematic review of policy documents, regulations and rules at both government and local level were conducted for policy related data.

3.6 Data Analysis

3.6.1 Analysis of policy and environmental regulations for climate change adaptation

Systematic review and collation of policies, policy instruments and environmental regulations available for climate change and climate change adaptation efforts was done. And the information collected was analyzed by using cross tables.

3.6.2 Effects of policy options on adaptation to climate change

Multinomial logit model was used to analyse the policy effect on smallholder farmers adaptation, the model was employed because after using any of the selected adaptive strategies that are either positively or negatively are affected by the policy farmers expect success, failure or no change. Let A_i be a random variable representing the adaptation resulting to yield size change that a farmer will experience after employing adaptation strategy. We assume that each farmer faces a set of discrete, mutually exclusive results of adaptation as referred to change in yield size.

These results as referred to change in yield size are assumed to depend on a number of adaptive strategies that a farmer will be employed as a measure of climate change adaptation X, weather are positively or negatively affected by the policy and policy instruments available. The MNL model for adaptation specifies the following relationship between the probabilities of obtaining A_i and the set of explanatory variables X as (Greene, 2004):

$$\text{Prob}\ (A_i = j) = \frac{e^{\delta_j x_i}}{\sum_{(k=0)}^{j} e^{\delta_j x_i}}, j = 0,1 \ldots J \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where

βj= a vector of coefficients on each of the independent variables X. Equation (1) can be normalized to remove indeterminacy in the model by assuming that $\beta_0 = 0$ and the probabilities can be estimated as:

$$\text{Prob}\ (A_i = j/x_i) = \frac{e^{\delta_j x_i}}{1+\sum_{(K=0)}^{J} e^{\delta_j x_i}}, j = 0,2 \ldots J, \beta_0 = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

The MNL coefficients are difficult to interpret, and associating the β_j with the *jth* outcome is tempting and misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived as

$$\delta_j = \frac{\partial P_j}{\partial P_i} = P_j \left[\beta_j - \sum_{k=0}^{J} P_k \beta_k\right] = P_j \left(\beta_j - \bar{\beta}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

The marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable (Long, 1997). The signs of the marginal effects and respective coefficients may be different, as the former depend on the sign and magnitude of all other coefficients.

Table 1: Dependent and independent variables

Dependent variables	**Independent variables**
Adaptive strategies as policy instruments	Change in yield size
Farming near water resources FNWR	Yield increase
Shifting cultivation SHCU	Yield decrease
Extensive grazing EXGR	No change
Change of crops CHCR	
Use of improved seeds and agro chemicals UIAC	
Change f crops and use of improved seeds	

3.6.3 Identification of challenges of climatic change adaptation for Policy recommendations

Descriptive analysis was used to calculate mean, frequency, percentage, graphs and ranges. These data was used to identify the climatic change adaptation that needs Policy recommendation. Results were presented in percentages and graphs such as histograms

and Pie charts. Statistical package for social science (SPSS) and Microsoft Excel were used for both qualitative and quantitative data analysis for this study (Kothari, 2008).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-Economic Characteristics of Smallholder farmers in Pangani

The socio-economic characteristics discussed in this section include, sex, education level, household size and age.

4.1.1 Age of smallholder farmer in Pangani basin

About 35.6% of smallholder famers were aged 41-60 years in Pangani Basin while other smallholder farmers were 25.6%, 29.4% and 9.4% fall under 15-40 years, 61-80 years and above 80 years respectively. These results imply that majority of smallholder farmers in the area were above the dependent age i.e. not within the economically active age range, which means that participation in farming activities that involve adaptation activities is tending to decline towards the class of high age. This is because some of adaptive strategies include moving from one area to another like shifting cultivation, farming near water resources that require farmers to follow water sources this will cause some of the age group not to participate. Also adaptive strategy like use of improved seeds and agro chemicals which involve cost so as to afford improved seeds and agro chemicals will cause some of the age group not to afford due to productive and financial ability.

4.1.2 Sex of Smallholder farmer in Pangani basin

As indicated in Table 2, about 52.2 percent of smallholder farmers male and 47.8 percent were Female in Pangani Basin. This implies that adaptation strategies in Pangani basin are mainly dominated by male. This implies that male participation to adaptation

activities is high compared to female. This can be supported by the fact that some of the adaptive strategy are done by household heads like shifting cultivation which involve moving from one area to another for agricultural activities. Farmers from high lands like Bungu have to move to low lands like Mafuleta for agricultural activities due to lack of enough land and to follow water sources. Then these movements are mainly done by males and household heads because females as mothers have to remain with the family and to take care of the family.

Table 2: Socio-economic characteristics of smallholder farmers in Pangani

Age	**Frequency**	**Percent**
15-40 Years	46	25.6
41-60 Years	53	29.4
61-80 Years	64	35.6
Above 80 Years	17	9.4
Total	**180**	**100.0**
Sex		
Female	86	47.8
Male	94	52.2
Total	**180**	**100.0**
Education		
Informal Education	90	50.0
Primary Education	27	15.0
Secondary Education	49	27.2
Tertiary Education	14	7.8
Total	**180**	**100.0**
Household size		
1-5 Households	76	42.2
6-10 Households	52	28.9
Above 10 Households	52	28.9
Total	**180**	**100.0**

4.1.3 Education level of Smallholder farmer in Pangani Basin

Empirically, education has been proven to be related to early adopters and to greater productivity of improved varieties. (Braund and Reiss, 2006) Findings indicate that 50% of smallholder farmers had Informal Education, 15 % had Primary Education, 27.2% had Secondary education and 7.8 % had Tertiary education in Pangani Basin. According to de Freitas, *et al.* (2006) reported that education in agriculture is more important as among of determinants for Technology adoption. Now from these findings willingness to adapt in the study area is not law. This implies that smallholder farmers in the study area had education at least to know that climate is changing and it has effect to their production and agricultural activities that they must take efforts to v\cope with the situation. Also having education at least informal education is very important because there are some adaptive strategies require extra understanding to accept example use of improved seeds and agro chemicals farmers must be trained on the use and importance of such adaptive strategies. Now from the findings this can be interpreted as farmers in the study area willingness and adaptation level is high due to available education level.

4.1.4 Household size in Pangani basin

Rahm and Huffman (1984) finds household size to enhance the farmer's adaptive capacity to respond to climate change From the results presented in Table 2, findings revealed that 42.2 percent had 1-5 household size and 26.8 percent had 6-10 Households and above 10 Households. It is expected that small family size would have little impact on climatic change and easily adopt climatic change adaptation strategies. Therefore households with large family size are likely to support strategy for climatic change adaptation than the household with large family size. Example adaptation strategy like change of crops and diversification require enough family labor for it to succeed, because instead of cultivating one crop they must cultivate more than one crop which require more

time and labor, then for those family with many household members are likely to accomplish such adaptation strategy.

4.2 Analysis of Climate Parameters in Pangani river Basin

Rainfall and Temperature maximum and minimum data from 1980, 1981, 1982 and 1986 to 2011 were used to find climatologically mean for each area of Pangani River Basin. Rainfall data were taken from one rainfall station in each district, chosen according to availability of data. Temperature data were taken from all synoptic station within the area Anomalies were computed using Ms. excel package and hence rainfall and temperature time series were plotted

4.2.1 Rainfall Analysis

Figure 4 show the results of the rainfall analysis from Korogwe Agriculture station, rainfall analysis results from other station of Pangani River basin find them attached as appendices

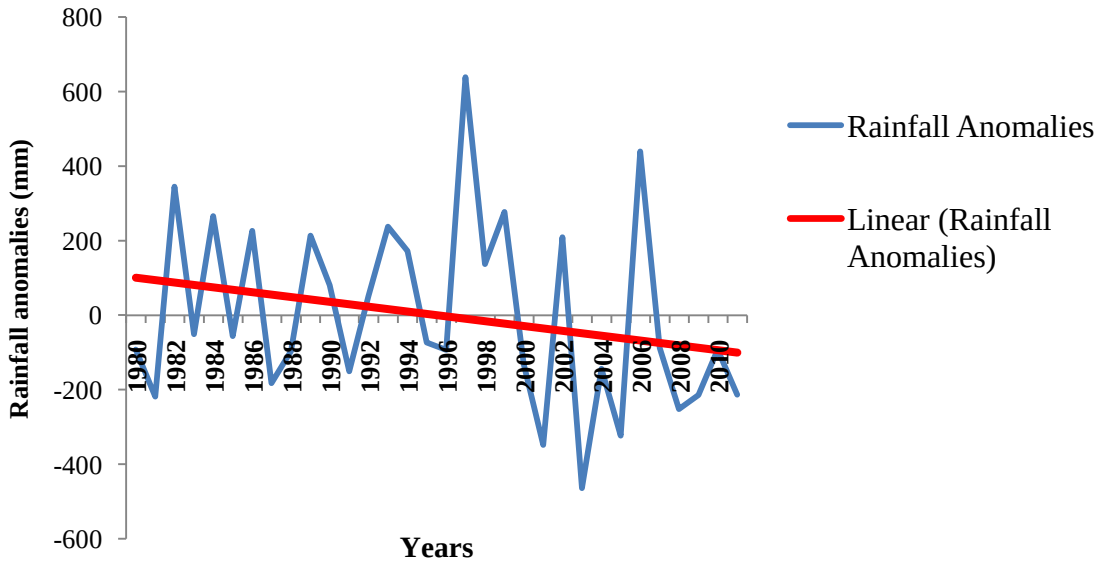

Figure 5: Korogwe trends for rainfall patterns

Rainfall patterns have been changing over time period; general rainfall trends show significant decrease as in Figure 4 Linear rainfall anomalies show general decrease in rainfall patterns from 150 mm in 1980 to negative 150 mm in 2010. Results show the evidence of climate change experience those smallholder farmers have. About 100% of smallholder farmers who were asked whether have experienced climate change in their area said yes. Rainfall trends falling in the study area mean that climate is changing and normal agricultural activities are affected because farmers in the study area depend on rainfall for their agricultural activities. Then fall in the level of rainfall because farmers to have strategies like use of improved seeds and agrochemicals and change of crops and crop diversification so as to copy with the situation as agricultural is very important to them. This means that adaptation to climate change for their agricultural activities is very important for their sustainable livelihood. And there should be supportive policy and policy instruments for the sustainable adaptive strategies.

4.2.2 Temperature analysis

Results on temperature maximum trends analysis as recorded from Tanga airport station. Rainfall is one of the important aspect of climate and weather of a given area

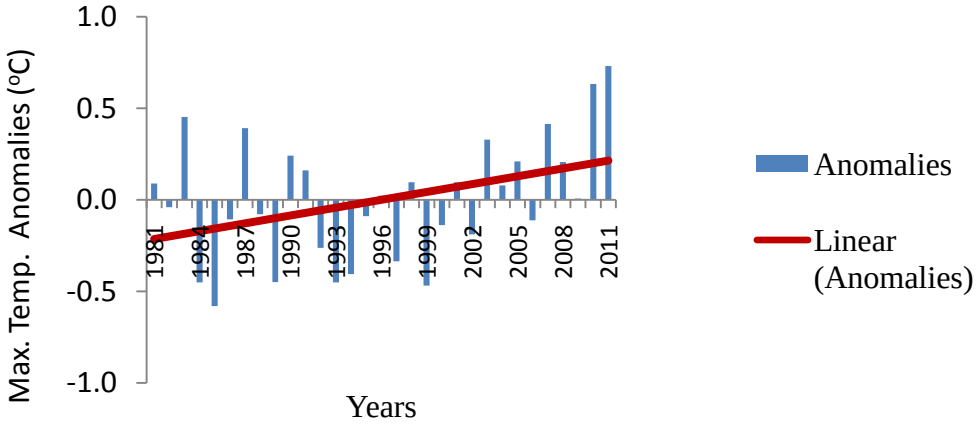

Figure 6: Korogwe Maximum Temperature trends

Generally results show significant increase in maximum temperature from negative 0.2 degree centigrade in 1981. to 0.2 degree centigrade in 2011 Figure 6 show results of minimum temperature trends as recorded from Tanga airport station.

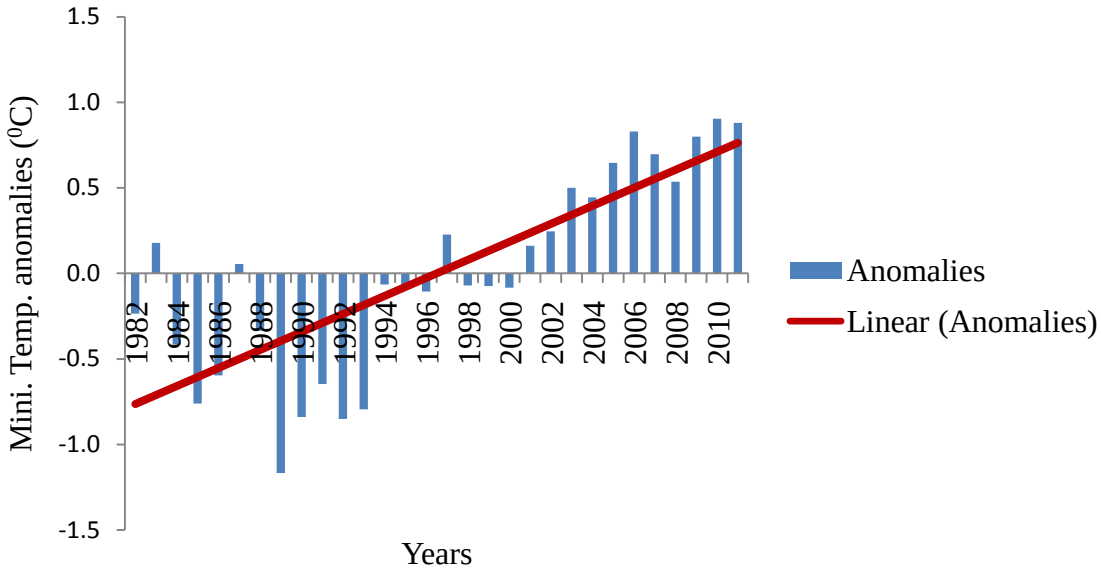

Figure 7: Temperature minimum Trends

Results from Figure 6 show significant changes in minimum temperature trends, they show that temperature has been increased from negative 0.052 degrees centigrade in 1982 to 0.815 degrees centigrade in 2010. This evidence goes with the results obtained as farmers' were asked on the climate change experience. They said the temperature has increased and the rainfall has decreased as shown infigure4, 5 and 6. General rainfall trend shows significant decrease in Pangani River basin, which drops up to about 500mm over Hai only slight increase of rainfall over Lushoto All areas shows increase of temperature for both minimum and maximum.

This implies that increase in temperature in the study area will definitely affect and disturb normal agricultural activities like draught, emerge of new crops and human diseases and loss of some crops and crops varieties. This can be supported by the truth that in Bungu village crops like cassava, yams and fruits have disappeared while crops like maize and beans yield size have been decreasing each season due to draught and diseases. In Mafuleta crops like banana, sweet potatoes and some fruits also have been disappearing while maize and local variety of rice yield size have been decreasing each season. This cause farmers from the study area to engage in adaptation activities so as to copy with the situation as they depend much in agriculture as source of food and income.

4.3 Collation of Policy and Policy Instruments for Climate Change Adaptation

Table 3 shows the linkage between policy, policy instruments and adaptation strategies for climate change. Smallholder farmers use farming near water resources, extensive grazing, and shifting cultivation, use of improved seeds and agro chemicals, and change of crops as adaptive strategies. Policies available for promoting and conservation of environments are sustainable land management, sustainable forest management, vulnerability reduction adaptation promotion and water resources conservation.

Table 3: Policy and policy instrument for climate change adaptation

Policy	Policy Instruments	Adaptive Strategy
Promote sustainable land management, planning and optimal utilization of natural resources for income generation and emissions reduction. (EMA 2004, No 74)	Support best agricultural practices that lead to reduced emissions such as soil conservation. Promote efficient crop and livestock production systems to reduce emissions associated with agricultural practices;	Extensive grazing
To promote sustainable management of forestry and wetlands as part of ecosystem based adaptation.(EMA 2002 No. 14)	Promote sustainable management of forests and wetlands in the region, Promote reforestation, afforestation and agro forestry practices.	Shifting cultivation which involve clearing of forest
Vulnerability reduction and building economic and social resilience; (EMA 2004, No 80)	Promote diversification of economies to reduce overdependence on climate-sensitive sectors promote alternative livelihoods systems,	Change of crops
Develop adaptation framework for agriculture to improve agricultural productivity and enhance food security.(EMA 2004,No75)	Strengthening agro-meteorological information generation for improved early warning systems for food security and promotes harmonization of policies, strategies and standards of agricultural, livestock and fisheries research institutions and organizations.	Use of improved seeds
Improve water conservation, efficiency and sustainable use and exploitation of regional water resources in view of the changing climate (EMA 2004(2),(57))	Restriction of economic activities within 60 m from water resources Promote transfer and dissemination of efficient water technologies Promote participation of the private sector, civil society and women in management of water	Cultivating near water resources (i.e. dams or river banks)

Source Policy documents (2004)

Interactions between policy, policy instruments and adaptive strategies as shown in Table 3 above reveal what government is doing and what smallholder farmers are doing. Extensive grazing as adaptive strategy is inevitable not only in the study area but also in most of developing countries since Over 1 billion people depend on livestock, and 70 percent of the 880 million rural poor living on less than USD 1.00 per day are at least partially dependent on livestock for their livelihoods (Bay and Morten 2002).

Shifting cultivation as adaptive strategy to smallholder farmers to them is potential as 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 (Flynn, 2005). Over 70% of the population depend on subsistence agriculture which is almost entirely rain fed. And the main reason for shifting is to search for the land that did not affected by draught. They must shift because they depend on rain fed agriculture.

Climate change has direct impact to agricultural sector as it depends on much rain. For the sector to sustain and perform farmers has to make sure that they maintain all needed conditions for production then if there is no enough rain they must go near water resources that will enable then to have reliable source of water for their successful agricultural practice.

4.4 Effects of Policy on Smallholder Adaptation

Table 4 shows the effects of significant policy options that influence yield change. The coefficients of the multinomial logistic regression only show the direction of the effects that an explanatory variable has on the dependent variable. Therefore, the marginal effects which show the magnitude of the changes that occur in the dependent variable when there are corresponding changes in the independent variables were

estimated. The three choices were the increased yield, decreased yield and no change of yield. The base was no change on yield of crops.

The MNL logit model that used statistical test of a relationship between the independent variables which were farming near water resources (FNWR), Shifting cultivation (SHCU), extensive grazing (EXGR), change of crops (CHCR), use of improved seeds and agro chemicals (UIAC), change of crops and use of improved seeds CUIS and combination of dependent variables which were yield increase, decrease or no change. The aim was to analyze the effects of policy instrument to farmer's adaptation in terms of change in yield size of a small older farmer in farmers in Pangani River basin. From the test results, the probability of the model chi-square (80.004) was found to be 0.000 this infers a level of significance of 1%.

Table 4: Results of Multinomial regression for Climatic change adaptation strategies (Policy options) used by Smallholder farmers in Pangani

Reference category: No change in yield Variables	Increased yield				Decreased yield			
	Coefficient	SE	Wald-test	P-value	Coefficient	SE	Wald-test	P-value
Intercept	0.412	0.142	8.427	0.004	1.762	0.121	23.600	0.000
FNWR	15.629	13.13	6.005	0.042	15.377	13.10	17.005	0.029
SHCU	-13.875	11.13	7.004	0.043	12.672	10.81	10.003	0.042
EXGR	-1.398	0.287	23.676	0.000	-1.784	0.230	60.310	0.000
CHCR	-1.767	0.000	1.000	0.000	-30.884	321.6	35.009	0.023
UIAC	1.092	0.204	28.538	0.000	1.264	0.308	-16.841	0.000
CUIS	1.724	0.215	64.073	0.000	1.984	0.243	-66.848	0.000

Source: MNL regression results

n= 180, Chi square test = 80.004, significant = 0.000, Nagelkerke R2 = 0.521

Table 4 shows the effects of policy options that influence yield change through adaptive strategies. The coefficients of the multinomial logistic regression only show the direction of the effects that an explanatory variable has on the dependent variable. Therefore, the marginal effects which show the magnitude of the changes that occur in the dependent variable when there are corresponding changes in the independent variables were estimated. The three choices were the increased yield, decreased yield and no change of yield. The base was no change on yield of crops.

From Table 4, farming near water resources significantly effect to smallholder adaptation in Pangani River Basin, it has positive impact to farmers yield as it influence yield increase. But the method is strictly prohibited from EMA 2004 part 2, which restrict all human and economic activities within 60 m from water source because it restrict sustainable water resources management. The policy instrument itself has negative impact to smallholder farmer's adaption to climate change because it restricts adaptive strategy that lead to increase in their yield size so it has positive effects to smallholder famer adaptation through yield size increase.

From the results shifting cultivation significantly influences small holder adaptation to climate change because it has effect to their yield size. It is less likely to increase yield in comparison to more likely to decrease yield of smallholder farmers. It has larger effect in yield decrease than yield increasing, so it is not a good adaptive strategy. And from EMA 2004 forest conservation part that insists planting of trees and strictly prohibit clearing of trees as the results of shifting cultivation. Here policy has positive effects to smallholder adaptation to climate change as it encourage forest conservations that lead to enough and reliable rainfall hence high yield. But the adaptive strategy of shifting cultivation that legally is not allowed due to deforestation effects is not a good adaptive strategy because

it has no good results in their agricultural and productive activities also it has no good results to environment management as it is not allowed.

Result from Table 4 show that extensive grazing is significantly affect smallholder adaptation to climate change. It has negative influence on farmers yield change, as it decreases their yield size. From EMA 2004 sustainable environment management party that do not insist extensive grazing as adaptive strategy since it usually lead to soil erosion and land degradation. Then this policy instrument which is contrary to adaptation strategy has positive effects to smallholder farmers because policy itself encourages sustainable land use management and use as it benefits farmers as it conserve soil fertility hence high yield. But the adaptive strategy that is legally not allowed and do not support farmers as it leads to yield size decrease.

Result from Table 4 indicated that crop change as adaptive strategy and policy instruments significantly affects smallholder farmer's adaptation to climate change. Change of crops as adaptive strategy has positive impact to farmer's crop size as it leads to increase in yield size. Policy and policy instrument encourage farmers to adapt through changing of crops from those that require higher rainfall to give good yield or that which are not draught resistant to those which are draught resistant example from maize to sorghum. And from crops that are rain fed agricultural to irrigation system of agriculture example from depending in maize only to vegetables and paddy irrigation schemes. This policy instrument as adaptive strategy has positive effect to smallholder farmer's adaptation in Pangani River basin.

Result from Table 4 show that use of improved seeds and agro chemicals is statistically significantly and has positive effect in yield size as it increase yield of crop as it has high

impact. From the national adaptation plan NAPA and EMA 2004 NO 75 to develop adaptation framework for agriculture to improve agricultural productivity and enhance food security to smallholder farmers through use of improved seeds and agrochemicals. Then this policy instrument has adaptation strategy has positive effect to small holder farmers adaptation in Pangani river basin.

Change of crops and use of improved seeds as selected by farmers as adaptive strategy is statistically significant to affect smallholder farmer's adaptation to climate change in Pangani river basin. This adaptive which is the combination of two strategies has more pore impact to yield increase to smallholder farmers in the study area. And thus policy here has positive impact to smallholder farmer's adaptation in Pangani River Basin as it increases their yield size.

4.5 Comparing Farmer`s adaptive strategies between Bungu and Mafuleta

Smallholder farmers in Korogwe district differ in selection of adaptive strategy basing on their location though they are related. Farmers from Bungu located in high altitude differ with farmers from Mafuleta located in low altitude though the methods are related. Different in priorities of selection of these adaptive strategies can be caused by different reasons but mainly is the nature of the place.

Farmers from Bungu use improved seeds and agro chemicals this is because farmers from Bungu have high income compared to farmers from Mafuleta due to presence of tea as cash crop. Also they change of crop as adaptive strategy example from maize to vegetables because of drought so they have to stop depend on rain fed crops like maize and diversify to other irrigation crops like tomatoes and sweet pepper. Also they use shifting cultivation as adaptive strategy because farmers from Bungu face the problem of

scarce area for agriculture activities and drought so they have to shift to low lands so as to get area for cultivation and to follow area with water sources.

Farmers from Mafuleta use farming near water resources as adaptive strategy because they are located in low land with water resources around them as well as irrigation scheme. Farmers from Mafuleta also use extensive gracing as adaptive strategy because Mafuleta village has ample area that allows them to keep animals as a way of coping with climatic changes. Also they use change of crops as adaptive strategy because due to decline in rains and increase in temperature farmers have to change crops and diversify so as to copy with the situation. Change of crops like from maize to paddy meaning from rain fed crops to irrigation crops.

Both farmers from Mafuleta and Bungu put priority in use of change of crops as adaptive strategy because both areas face the problem of draught, crop diseases and poor quality and quantity of crops. So they have to use improved seeds and agro chemicals so as to have crops that resist draught, diseases resistant crops and short time growing crops.

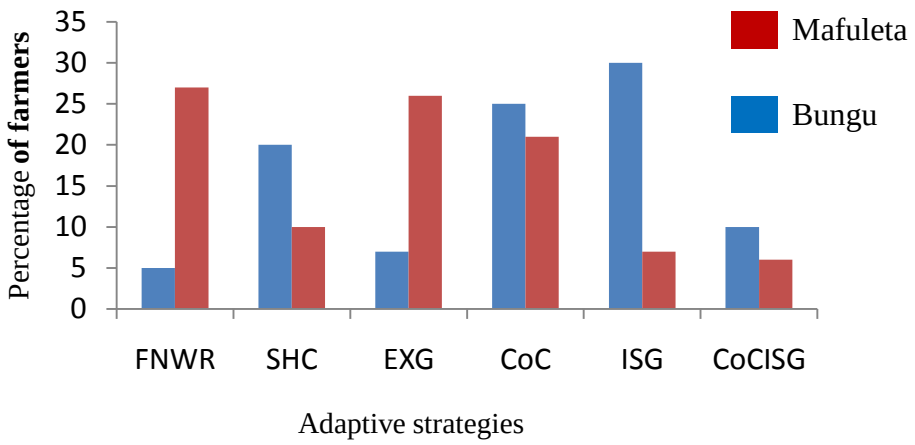

Figure 8: Farmers selection of adaptive strategies in Bungu and Mafulta

Results from Figure 8 show variations in smallholder farmer's selection of adaptive strategy from Bungu and Mafuleta. It show that from Bungu 30 percent use improved seeds, 25 percent change crops, 20 percent shifting cultivation, 10 percent farming near water resources and 5 percent extensive grazing. While farmers from Mafuleta selection is 30 percent farming near water resources, 28 percent extensive grazing, 25 changes of crops, 12shifting cultivation and 10 percent use of improved seeds and agro chemicals

4.6 Challenges of Climatic Change Adaptation That Needs Policy Recommendation

4.6.1 Low level of production

Figure 9 shows production capacity of smallholder farmers in the study area with and without adaptation. Without adaptation smallholder farmers faced different problems during the process of cultivation which lead to low level of their yields. These problems are like poor agricultural equipments, not using proper inputs and existed land. Together with results of climate change in the study area that lead to draught and crops diseases the mentioned reasons also contribute to low yield size.

With adaptation farmer's level of production have increased compared to yield size without adaptation. This is due to the fact that with adaptation means farmers have used different methods to copy with climate change results and those methods helped them to increase their yield size though the incremental level is still below the average.

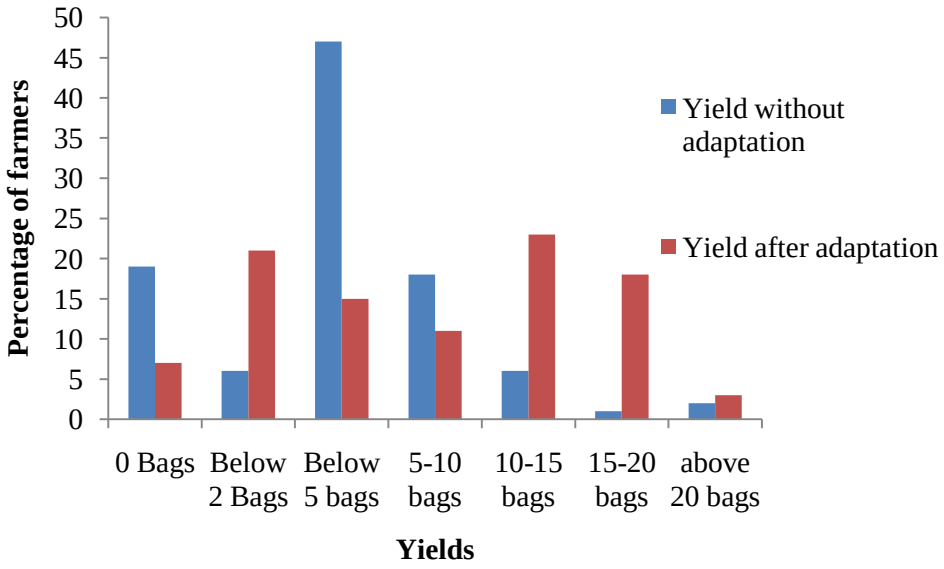

Figure 9: Yield before and after adaptation

Findings from Figure 9 revealed that before without adaptation 19%t of smallholder farmers had 0 gabs size of yield, had below 1 bags size of yield, 47 % had below 5 bags size of yield, 18 % 5 to 10 bags, 6 % 10 to 15 bags, 1 % 15 to 20 and 2 %t had above 20 bags. With adaptation results show that 7 %t had 0 bags, 22 % below 1 bag, 15 %below 5 bags, 11 %t 5 to 10 bags, 13 % 10 to 15 bags, 19 % 15 to 20 b1gs and 3 % had above 20 bags size of yield. Therefore only 56 % have managed to have at least yield size of above 5 bags with adaptation while without adaptation while without adaptation only 27 % managed to have yield size of above 5 bags. Though there is a change but still is not enough as majority of smallholder farmers depend on agriculture then it can't assure food security to the community food security.

To solve this challenge policy makers must have adequate institutional, legal and regulatory frameworks for adaptation this includes finances to support climate change adaptation activities, appropriate technological, human skills, data and tools for impact and vulnerability assessment. Also reliable infrastructures for coping strategies develop sustainable adaptive measure within policy guidelines and adaptive capacity together with high level of awareness of human vulnerability especially at community level.

4.6.2 Low adaptive capacity

Figure 10 shows capacity of smallholder farmers to adapt to climate change using different adaptive strategies. The study had different adaptive strategies common and available in the study area. This was obtained by asking how many smallholder farmers cope with climate change by using different methods. The reference methods were those which corresponds with policy instruments that are change of crops or crop diversification and use of improve seeds and agro chemicals as shown in Figure 5 and 6

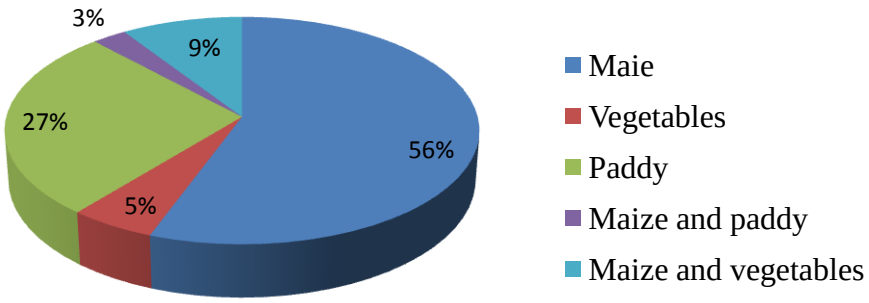

Figure 10: Crop Cultivated by smallholder farmers in Pangani

Findings from figure 10showthat many of smallholder farmers cultivated only single crop. Results show that about 84 percent of the smallholder farmers in the area cultivated maize. 41 % of cultivated paddy, 14 % cultivated maize and vegetables, 8 % cultivated maize and paddy while 4 % cultivate vegetables only. Therefore most smallholder farmers had cultivated only maize while in adaptation strategy smallholder farmers had advised to cultivate more than one crops for minimizing risks as well as increasing income.

To solve this there should be water management**,** includes increased water abstraction for various uses, adequate water distribution and utilization technologies with adequate water storage infrastructures. Availability of data for seasonal water flows that allows proper planning and water management to reduce conflicts over water resources. And improve water resource management at the farm level and awareness of the value of water. Figure 11 indicated that 69% of smallholder farmers not use improved seed and agrochemicals as adaptive strategy while 31% of smallholder farmers use improved seed and agrochemicals as adaptive strategy. This result implies that small holder farmers do not have access to improved seed and agrochemicals for adaptation in the area.

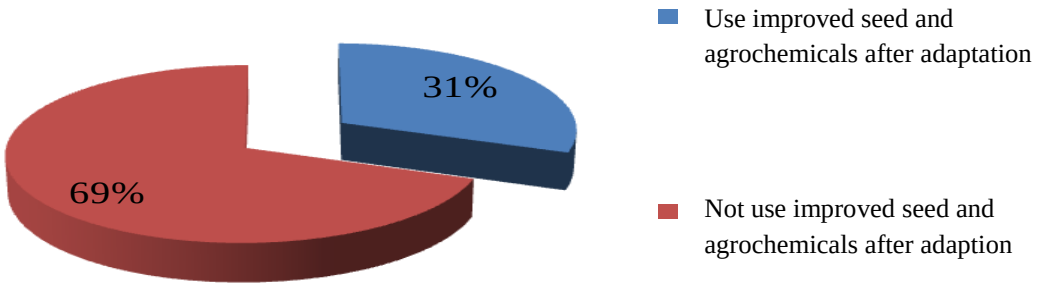

Figure 11: Use of improved seed and agrochemicals

Thus to solve this problem the following has to be done, ensure adequate data base and information sharing platform baseline for monitoring impacts of climate change, effective agricultural and agricultural related policies, skilled technicians to address climate change in agriculture sectors. Availability of improved high yield varieties, adequate farm inputs like fertilizers, and pesticides to increase productivity and financial resources.

4.6.3 Change in Livelihood level

Figure 12 show the results of livelihood level in the study area as measured by income level obtained as the results of yield size change after adaptation. Also results show social welfare of smallholder farmers in the study area as the results of success or failure of the employed adaptive strategy and assurance of food security and food availability as the result of performance of employed adaptive strategy.

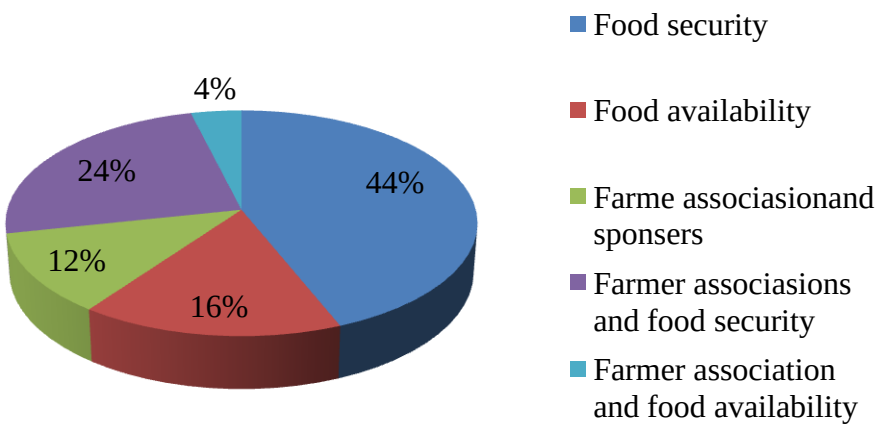

Figure 12: The status of success socially of smallholder farmers

Findings from Figure 12, it shows that 44 percent of smallholder farmers had success in food security, 24 percent of the smallholder farmers had success in association and food security, 16 percent of smallholder farmers had success in food availability, 12 percent had farmer association and sponsors, 4 percent had success in farmer association and food availability Therefore majority of smallholder farmers had success in food security after adaptation to climate change in adaptation. Still there are some farmers with food availability, and food security is what is needed.

Then, crop, livestock and fisheries control of crop, livestock and fish pests and diseases affecting yield potentials, restore and sustain aquatic ecosystems to prevent depletion of fishing stocks in all the sources. Means to manage extreme weather conditions to improve crop, fish and livestock productivity and availability of suitable infrastructure to enable accessibility of livestock feeds, fisheries and crop products and crop and livestock storage facilities.

4.6.4 Awareness to environmental laws and regulations

Figure 13 show the awareness level of smallholder farmers in the study area, to practice sustainable adaptive methods farmers must have knowledge on the laws and by laws available at the community. It is important at the community level because it enable them to have direct control and to be able to participate in making those by laws. Unless at national level where they cannot have direct control with them.

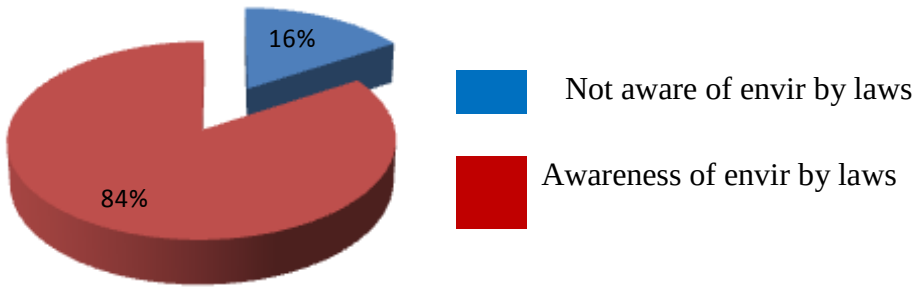

Figure 13: The status of awareness of environmental laws by smallholder farmers

From the Figure 13, finding revealed that only 16 percent of smallholder farmers were aware with environmental laws while 84 percent of smallholder farmers were not aware of environment laws. Therefore, majority of smallholder farmers were not aware of environment laws. This level of awareness is high compared to those with no awareness due to regular meeting at the village level that enhance good environmental management practice. Also presence of different NGO`s that sensitize farmers on sustainable management of environment. Also the consequences that farmers faced due to climate change lead to good conduct on environmental management.

4.6.6 Suggestion of the smallholder farmers on climatic adaptation

Figure 14 show the suggestions and request made by smallholder farmers in the study area as demanded in the questionnaire. Most of smallholder farmers demand to be educated on sustainable adaptive methods and seminal that will help them to cope with changes in climate as it has direct impact to their yield as well as livelihood.

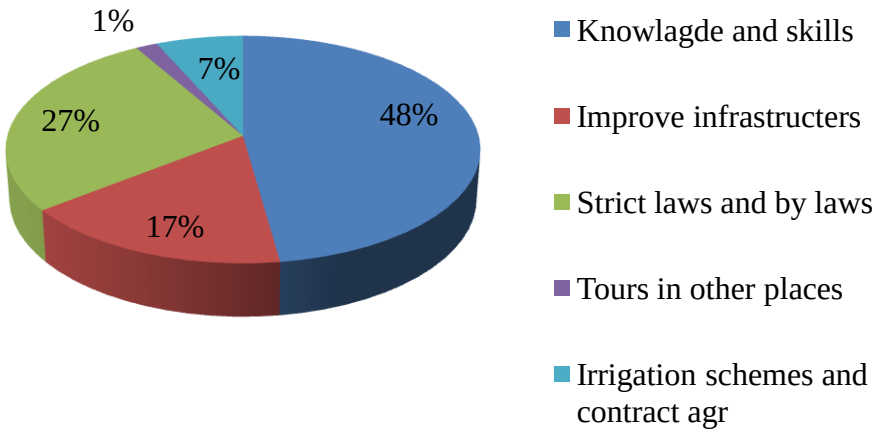

Figure 14: Suggestion of the smallholder farmers on climatic adaptation

Results from Figure 14 shown that 48 percent of smallholder farmers suggested more knowledge and skills are required, 27 percent of smallholder farmers suggested to strict laws and by-laws while 17 percent of smallholder farmers suggested to improve infrastructure. Therefore most of smallholder farmers suggested that more knowledge and skills need for climatic change adaptation. Land Use and Soil Protection include agricultural practices that reduce decrease of land and soils productivity, improved land and soil management practices, strong land use and land use change policies and plans and harmonized Policies on land use at community level.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The overall objective of the study was to analyze the effects of policy on adaptation and livelihood in Pangani River Basin. By using MNL model the study found that policy and policy instruments have got impact on smallholder adaptation and livelihood in Pangani River Basin. At R Square = 0.521 we have enough evidence to reject null hypothesis (H_o) which states that, policy instruments do not influence climate change adaptation to smallholder farmers in Pangani River Basin.

From objective number one the study concluded that, there are policy and policy instruments for climate change adaptation made by government at central and local levels. Theses policy and policy instruments are made to support and influence sustainable management of environment and enhance use of sustainable climate change adaptive strategies that are environmental friendly. Also these policies and policy instruments enhance use of adaptive strategies that enable smallholder farmers to get good results to their agricultural activities example use of improved seeds and agro chemicals as a way to copy with climate change. Also the study found that there are adaptive strategies in the study area used by farmers which are either corresponding with policies and policy instruments or other which are against policy and policy instrument in the study area.

From the second objective study concluded that these policy and policy instruments affect available adaptive strategies differently. Other policy and policy instruments influence smallholder farmers to use particular adaptive strategies because they are either environmental friendly or they enhance sustainable environmental management and

sustainable use of such adaptive strategies. Example policy like Develop adaptation framework for agriculture to improve agricultural production and to enhance food security EMA 2004 No 75 this encourage use of improved seeds as adaptive strategy because this enable farmers to increase their yield size and do not have harmful impact on the environment. Or they are not environmental friendly and do not influence sustainable use of such adaptive strategy. Example policy like Promotion of sustainable management of forest and wetland as part of ecosystem adaptation EMA 2002 No 14 this policy do not encourage or restrict use of shifting cultivation as adaptive strategy because this involve clearing of trees which lead to draught and do not influence sustainable environment management. Also these adaptive strategies do not have good impact to smallholder farmers because do not lead to yield size increase.

Also other policy and policy instruments have got good results t smallholder farmers adaptation but not to the environment. Example policy like Improve water conservation efficiency and sustainable use and exploitation of regional water resources in view of the changing environment EMA 2004 (2) (57) this policy restrict any economic activities within 60 m from water resources because this adaptive strategy do not enhance sustainable water resources management and it just have short term good results to smallholder farmers adaptation to climate change.

From the third objective this study concluded that farmers from the study area face a number of challenges that need policy recommendations. These challenges are law production level. Low adaptive capacity, low livelihood level and awareness to environmental laws and regulations. These challenges are due to insufficient capital to farmers that can support their adaptive capacity. Lack of training to increase awareness to

smallholder farmers and ability to have reliable access to proper inputs at low cost to enhance smallholder farmer's adaptation to climate change.

5.2 Recommendations

i. Adaptation to climate change must have sustainable impacts to both farmers, government and environment as a whole, they also have to bring sustainable positive impact to agriculture sector as it contribute a lot to the national income. From the obtained results to have mutual benefits the following has to be done.

ii. Adaptation policies, policy instruments, lows and regulations for climate change adaptation have to be made in a participatory way with all stake holders. This means that central and local government leaders, farmers, environmental experts, metrological experts and all others key stakeholders must be involved in construction of these policies and lows. This will enable to have good policies, policy instruments laws and regulations that enhance good implementation and will assure good results to all stakeholders. And this participatory decision making will solve and clear contradictions of the policies and adaptation strategy like that of farming near water resources which have good implications to smallholder farmers and policy instrument of restriction of any economic and human activities within 60 m from water sources.

iii. More research and studies have to be carried out in climate change adaptation and policy issues so as to increase awareness and to discover more problems and their solution in such area. This will enable to have more policies that ensure sustainable adaptation to climate change and also will increase awareness to all

stakeholders especially farmers so as to be aware with the changing environment and to know what to do.

iv. Sensitization programs on sustainable adaptive strategies that will bring permanent impact on agriculture sector and will be permanent measure for climate change effects to smallholder farmers. This is important and will work out because large percent of famers from the study ask for education on proper adaptive strategies. Also most farmers from the study reveal that they are not aware on the laws and regulations about environmental conservation.

v. There should be construction of proper adaptation strategies tools like irrigation schemes infrastructures must be proper constructed and regular repeal so as to have proper working environments. Farmers have to have exchange programs to experience what others are doing. This is important because farmers will be able to learn what others are doing to adapt to climate change so that they can practice.

vi. Climate change and environmental committees at the village level, this is important because these committees will be responsible to make sure that there is strong corporation between smallholder farmers and government as a policy maker. Proper information between smallholder farmers who implement adaptation, at farm level and the government who are the policy makers. This will help to get the feedback for each policy that they make to see their effect to adaptation. These two actors must communicate for successive and sustainable adaptation.

vii. The above recommendations together with those from the third objective all together will lead to sustainable and successive adaptation hence high level of livelihood.

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APPENDICES

Appendix 1: Questionnaire for Effects of Policy on Adaptation and Liverhood to Smallscale

1.0 Basic Information

1.1 Date of interview…… 1.2 Region……

1.3 District…….. 1.4. Division……

1.5 Ward…… 1.6 Village……...…

2.0 Respondent Information

2.1 Name of respondent……

2.2 Sex…….. 1. Male 0. Female

2.3 Years…… 2.4. You have been in this village for how many years……..…..

2.5 For how many years you have been doing farming activities……

3.0 Adaptation to Climate Change

3.1 Are there any climatic changes in this area…….. 1. Yes 0. No

3.2 If YES in the above question, what are the adaptive strategies do you adapt?

1. Farming near water sources

2. Shifting cultivation

3. Extensive grazing

4. Change of crops

5. Others (specify)

3.3 From the mentioned adaptive strategies above, how successful they are to your farming activities?

Adaptive strategy	Crops cultivated	Yield before adaptation /ha in (kg, tins or bags)	Use of improved seeds and agro chemicals 1. YES 0. NO	Yield after adaptation/ha in (kg, tins or bags)	Use of improved seeds and agro chemicals 1. YES 0. NO

3.4. What are the problems and challenges that you're facing in using the mentioned adaptive strategies in your area?……..

4.0 Liverhood

4.1. Among these adaptive strategies which one(s) have been successfully to you?

1. Farming near water sources

2. Shifting cultivation

3. Extensive grazing

4. Change of crops

4.2 What have been the impacts of its successfulness to your livelihood in term of?

1. Social capital

Name of crop	Adaptive strategy used	Success obtained

2. Financial capital

Name of crop	Adaptive strategy	Income from yield /ha before adaptation	Income from yield /ha after adaptation	Incremental

3. Physical/ human capital

Name of crop	Adaptive strategy used	Success obtained

4.3. Among these adaptive strategies which one(s) have not been successfully to you?

1. Farming near water sources

2. Shifting cultivation

3. Extensive grazing

4. Change of crops

4.4. What have been the impacts of its failure to your livelihood in term of?

1. Social capital

Name of crop	Adaptive strategy used	Failure obtained

2. Financial capital

Name of crop	Adaptive strategy	Income from yield/ha before adaptation	Income from yield /ha after adaptation	Decrement

3. Physical/ human capital

Name of crop	Adaptive strategy used	Failure obtained

4.5 Mention any laws and by laws concern with environment and climate change in your area……

……

5.0. What are your suggestions and recommendations on adaptive strategies and laws and by laws that are sustainable to your area and farming activities?

i. ……

ii. ……..

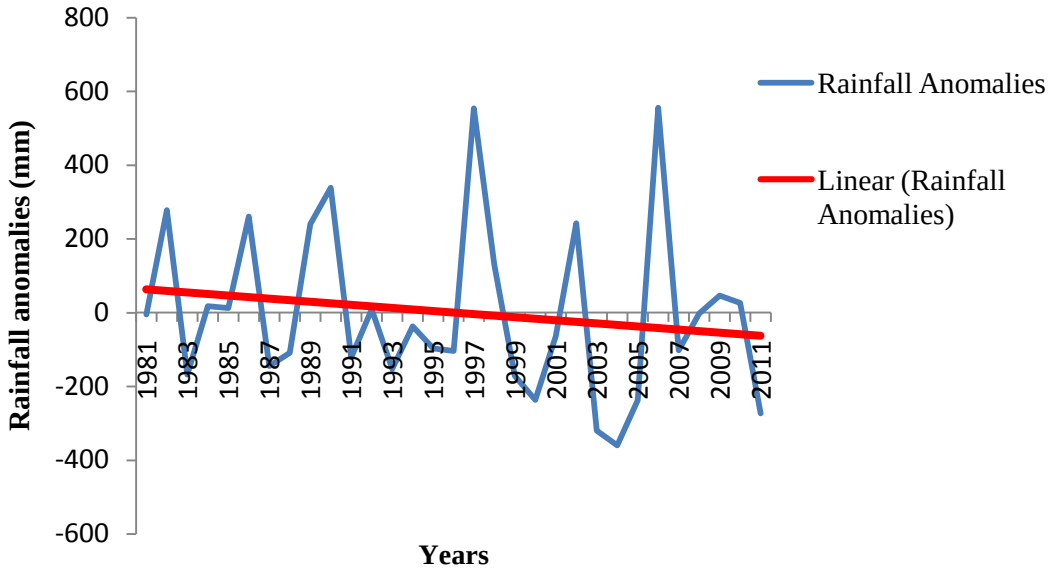
iii. ……

iv. ……..

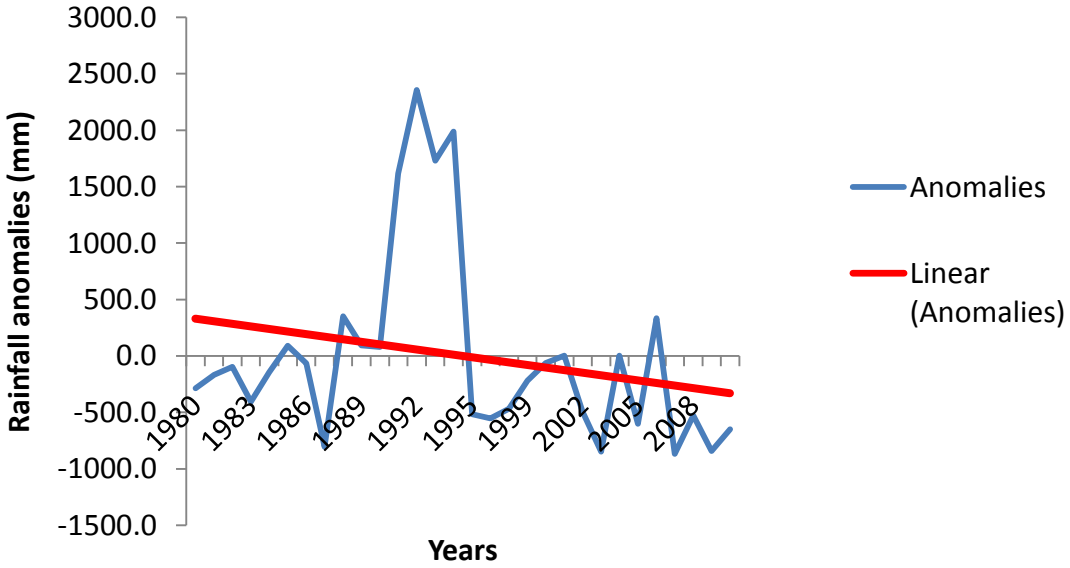
THANK YOU FOR PARTICIPATION

LONG TERM CLIMATE PATTERNS IN PANGANI RIVER BASIN

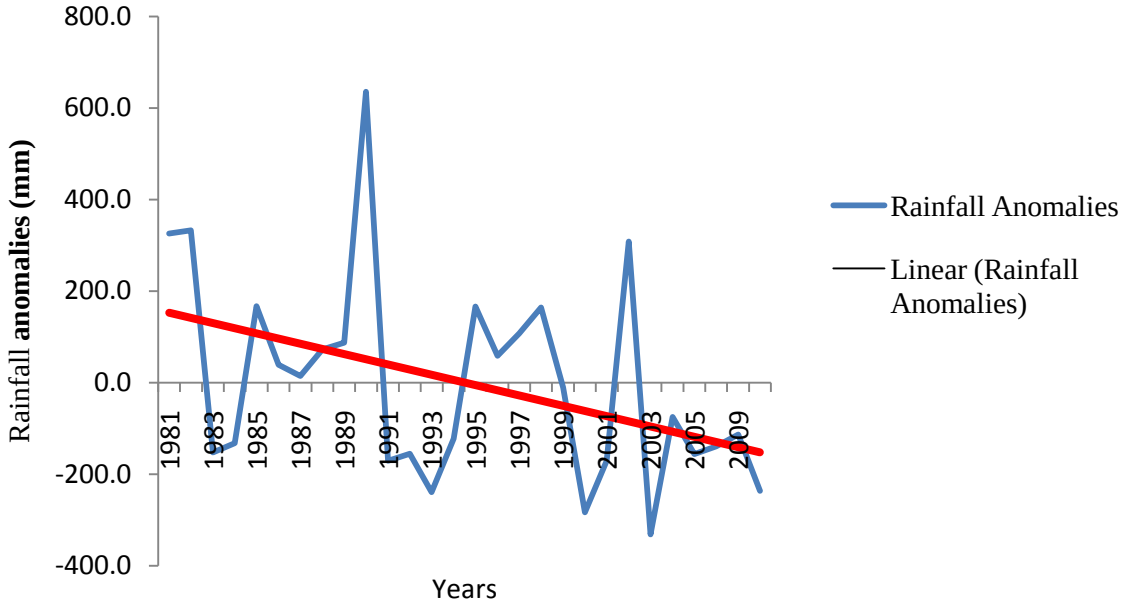
Arusha Trends For Rainfall Patterns



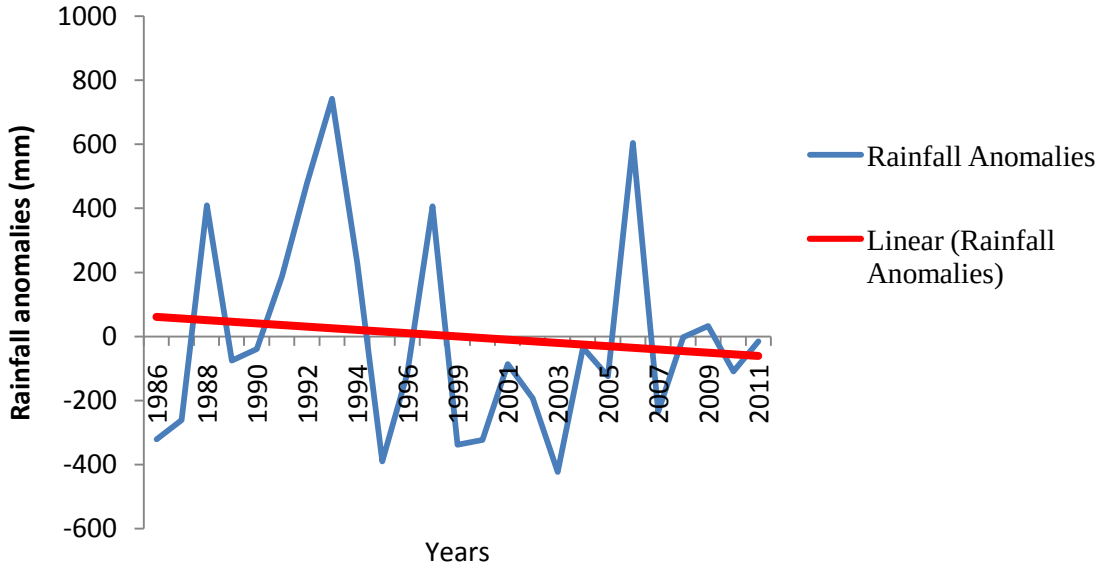
Hai Trends for Rainfall Patterns



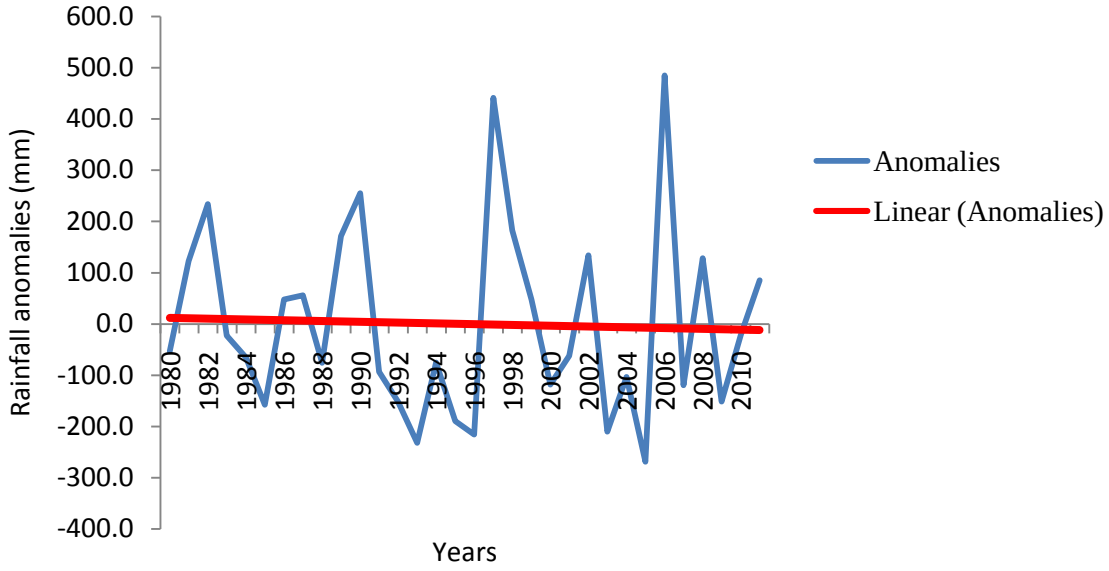
Moshi Rural Rainfall Patterns



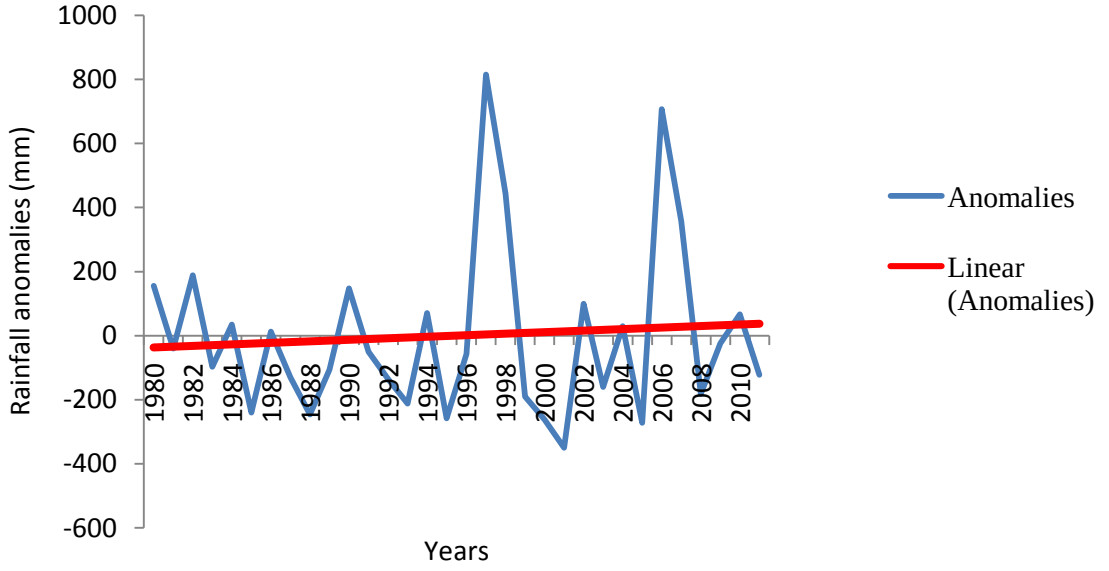
Mwanga Trends for Rainfall Patterns



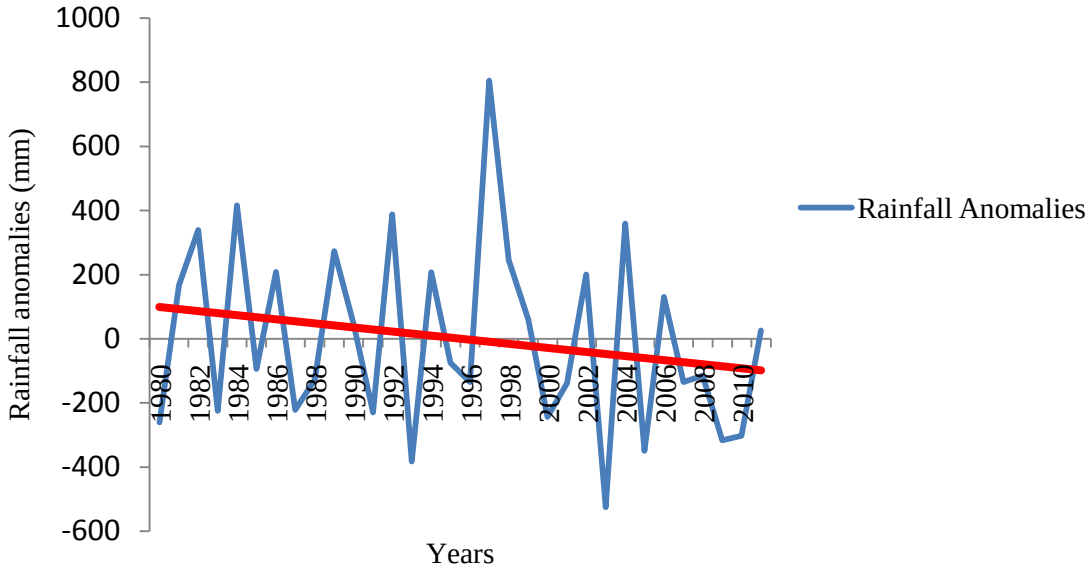
Same Trends for Rainfall Patterns



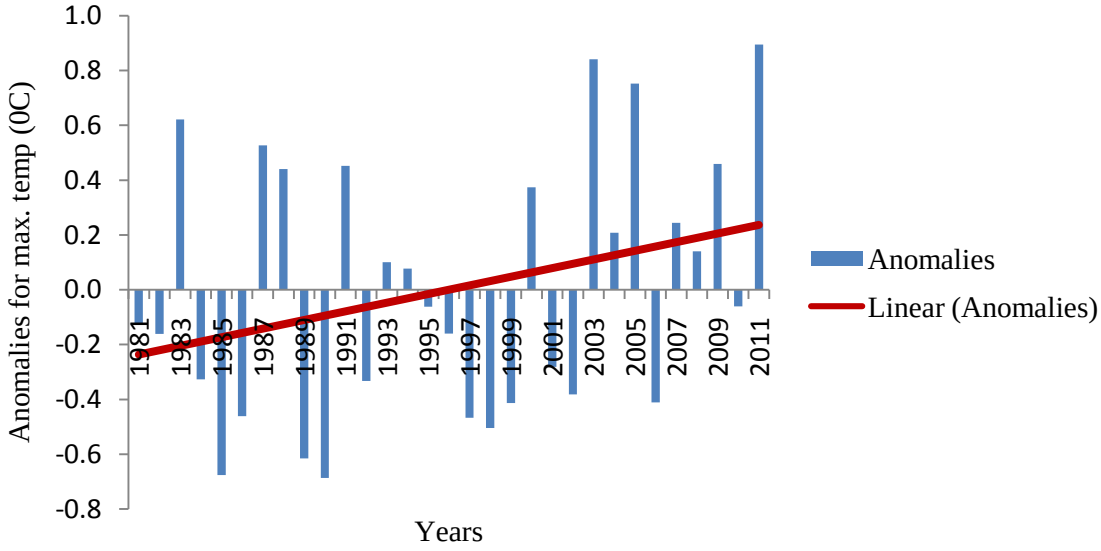
Lushoto Trends for Rainfall Patterns



Pngani Trends for Rainfall patterns



Arusha trends for Maximum Temperature



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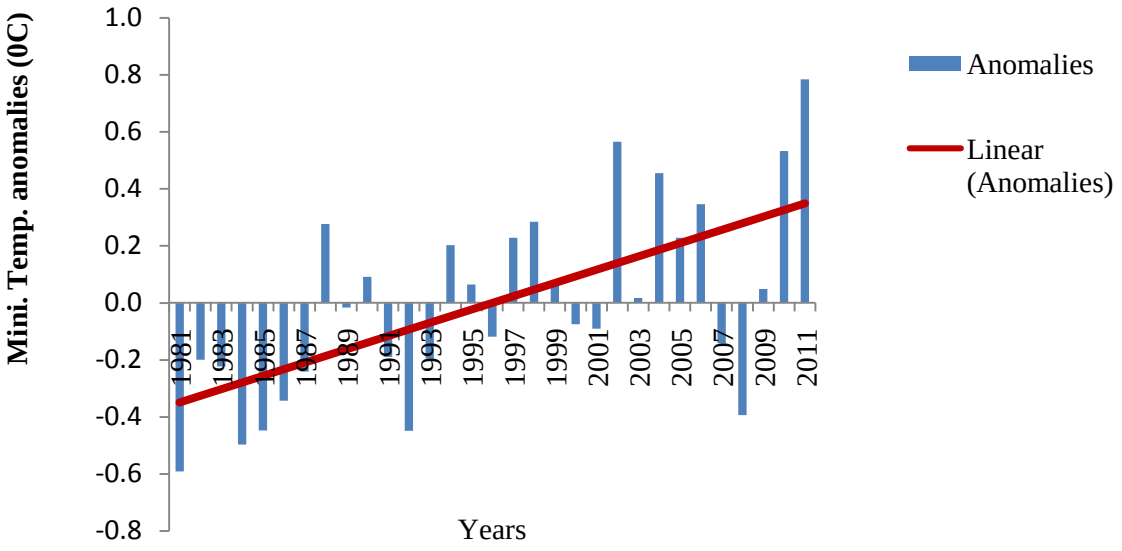
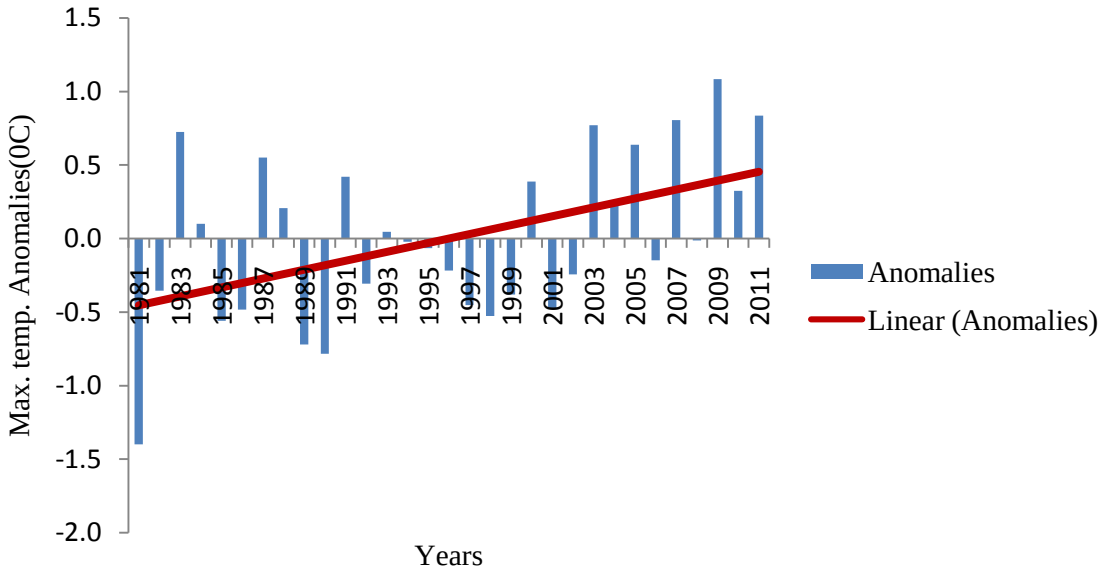
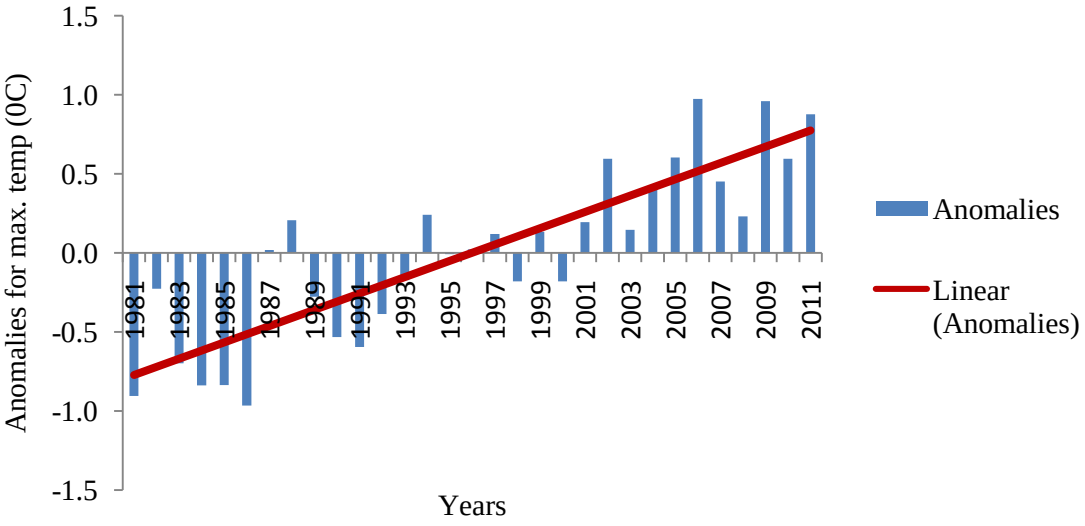


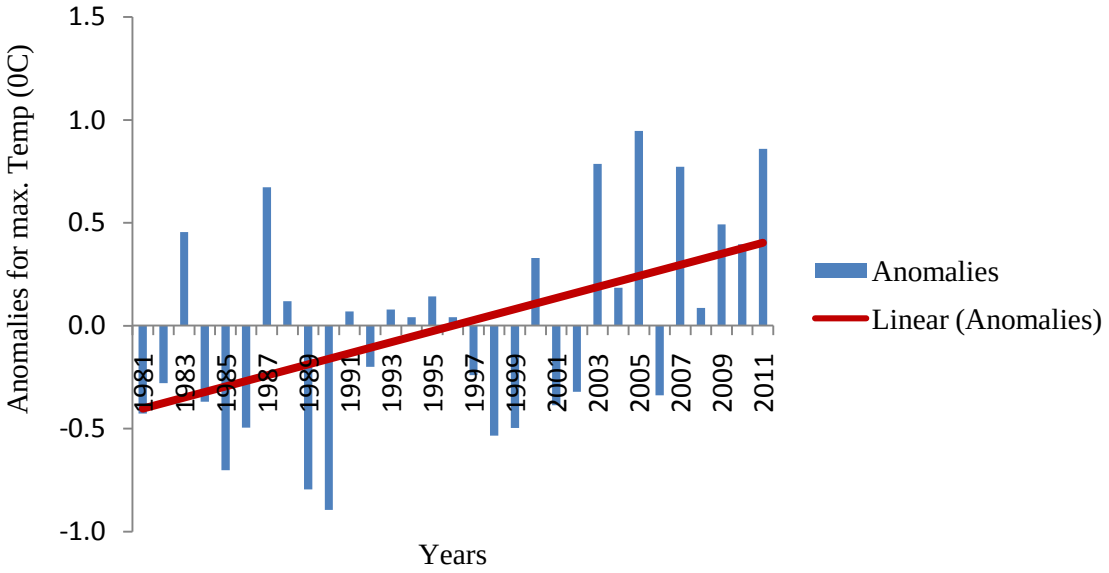
KIA Trends for Maximum Temperature



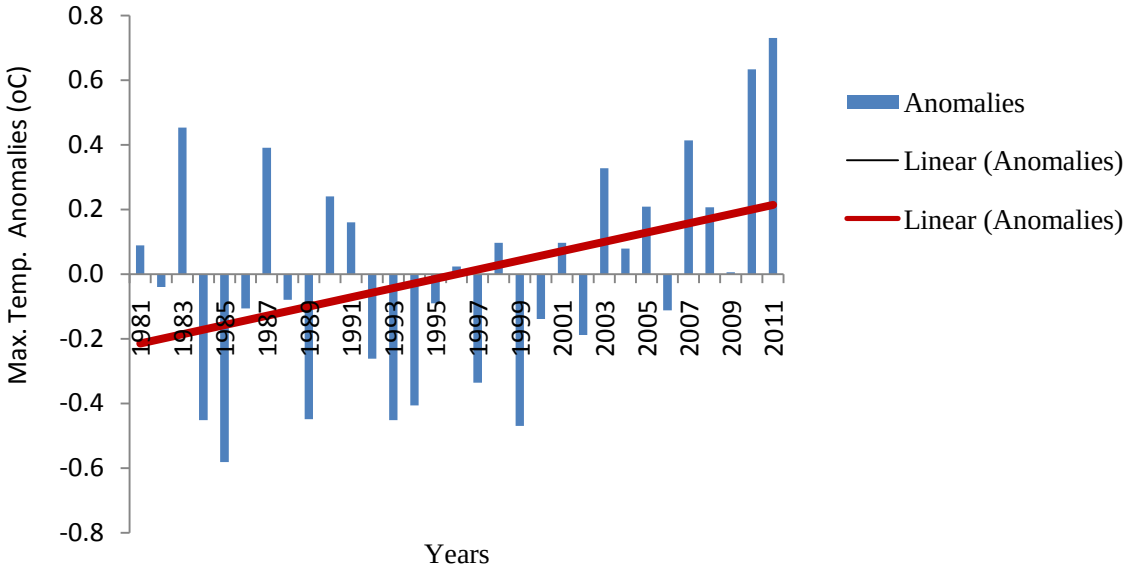
KIA Trends for Minimum Temperature



Moshi Trends For Maximum Temperature



Moshi – Trends for minimum Temperature


0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
Max. Temp. Anomalies (oC)
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Years
Anomalies
Linear (Anomalies)
Linear (Anomalies)