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DEPARTMENT OF METEOROLOGY

MASTER OF SCIENCE IN CLIMATE CHANGE

RESEARCH PROJECT

Assessment of the Potential for Integration of Ecosystem Based Approaches and Local Indigenous Knowledge into Climate Change Adaptation in the Taita Hills, Kenya

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A Research Project submitted in partial fulfillment for the Degree of Master of Science in Climate Change in the Department of Meteorology at the University of Nairobi.

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Dedication

This report is dedicated to my parents for their unwavering support and prayers, and for my *Kukhu.*

Abstract

The integration of indigenous knowledge and science through and ecosystem based adaptation provides a basis for the formulation of culturally acceptable and sustainable adaptation practices. This study aims to determine sustainable climate change adaptation strategies for the Taita Hills in Kenya and assess their potential for integration with ecosystem based adaptation. It uses a mixed methodology that involves literature review, participatory methods and household surveys. As a result it emerges that adaptation to climate variability and change in the Taita Hills, takes on both an anticipatory and reactive approach. The household survey indicates that 68% of the farmers have taken up climate change adaptation strategies. The study shows that the unpredictability of the long and short rainy seasons, the poor rainfall distribution within the seasons and inadequate rainfall during the growing season constitute their perception of climate change. However, with regards to farm water management as an adaptation strategy only 51% of the households have initiated farm water management measures. Furthermore, socio-economic parameters such as farm sizes and dependency ratio render the households vulnerable to climate change. Finally, the Taita people possess sufficient indigenous knowledge for climate change adaptation that can be utilized together with EBA approaches for an integrated approach to climate change adaptation. The smallholder farmers' in the Taita Hills possess sufficient knowledge on climate change adaptation. The study recommends the diversification of livelihoods by the smallholder farmers' in the Taita Hills, the inclusion of the smallholder farmers in decision making regarding climate change adaptation practices, implementation of policies that have been validated through research and improvement of agricultural extension services to the smallholder farmers.

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Abbreviations

ASAL	Arid and Semi-arid Lands
CBD	Convention on Biological Diversity
CBO	Community Based Organization
CHIESA	Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa
DAO	District Agricultural Officer
EBA	Ecosystem-based Adaptation
EWS	Early Warning Systems
FGD	Focus Group Discussion
GOK	Government of Kenya
GPS	Global Positioning System
HIV	Human Immunodeficiency Virus
ICIPE	International Centre of Insect Physiology and Ecology
IK	Indigenous Knowledge
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JJAS	June July August September
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
MAM	March April May
M.A.S.L	Meters above sea level
NGO	Nongovernmental Organization
OND	October November December
SAR	Second Assessment Report
SRES	Special Report on Emissions Scenarios
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1
INTRODUCTION

1.0 Background

The fragility of mountain ecosystems has been studied with emphasis on the impacts of climate change on biodiversity and resources and the provision of ecosystem goods and services (Diaz H., 1997, IPCC SAR, 1996; IPCC 4AR, 2007). The Second Assessment Report of the IPCC (1996) notes that mountain ecosystems are mostly affected by changes in temperature, precipitation and soil moisture. Additionally, anthropogenic factors have been noted to impact mountain ecosystems through diminished biological diversity and land use and land cover changes. The anthropogenic effect of climate change on mountain ecosystems has been projected to include fragmentation of habitats and the destruction of crucial habitats. In addition, projections made on agricultural systems show an upward shift in pests and diseases occurrences due to the increasing average annual temperatures in higher altitudes.

What do climate change impacts mean for mountain ecosystems especially in Africa? The communities that are found in mountainous areas in Africa often rely on natural resources and the ecosystem services on the mountains for their livelihoods. As a result, mountain ecosystems in Africa face continuous environmental stresses due to ecological and socio-economic factors. The socio-economic factors include growth in population, intensification of market-based agricultural systems and clearing of forests for cultivation. The effects of climate change are compounded in mountain ecosystems due to weather and climate changes within short distances, at varying altitudinal gradients (Whiteman, 2000). The presence of insect pests at new altitudes will most likely present a challenge in the sustained productivity of agriculture at higher altitudes. This is because of the limited knowledge on how to deal with the emerging insect pests.

It is important to formulate and use climate change adaptation strategies that are sustainable and acceptable by the local communities in an ecosystem. The Ecosystem approach is a strategy for the integrated management of land, water and biotic resources that promotes conservation and sustainable use in an equitable way. Ecosystem approach entails the application of the correct scientific methodologies that are mainly based on levels of biological organizations, which centers on the essential processes, functions, and interactions among organisms and their environment. Ecosystem approach involves goods, services and functions provided by ecosystems (CBD, 2004).

Local knowledge entails practices that could have been adopted from other areas and incorporated into the societies' practices over a long period of time whereas indigenous knowledge refers to the information that is unique to a certain group of people and has been used and perfected over a long period of time. Therefore, local and indigenous knowledge with reference to climate change adaptation is the means that a community uses their unique cultural practices that have been perfected over time through observation and experience and combine it with knowledge from other regions that work in their local situation. This knowledge is then used to generate coping and adaptation mechanisms to the impacts of climate change.

It is important for communities affected by current climatic variability to adapt to the long term impacts of climate change to maintain their food security and their livelihoods and to ensure that their environment is not irreversibly damaged by the impacts of climate change. Community adaptation involves behavioral shifts and is not only about coping with the consequences of climate change impacts. It involves changing their activities and livelihoods to suit prevailing climate conditions. This is not a new ideology as communities have adjusted their behavior over time as a response to the weather variability especially in Sub-Saharan Africa. For example, Ngigi (2009) noted that communities adapt at the farm level, whereby families switch their crops to suit prevailing weather conditions and take up such measures as irrigation to counter the effects of inadequate rainfall. Brooks (2003); Smit (2006) concur that adaptation entails a level of adjustment on the community's part.

Adaptation is defined as the adjustment that takes place in both human and natural systems as a response to actual or expected climatic stimuli and/or their effects so as to regulate the potential harm or to take advantage of the opportunities that may be of benefit (IPCC, 2001). Adaptation is further defined as a system's behavioral and characteristic adjustment that enhances its ability to cope with external stress (Brooks, 2003). On the other hand, Smit *et al.*, (2006) defines adaptation as adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts. Based on timing, adaptation can be anticipatory or reactive, and depending on the degree of spontaneity, adaptation practices can be autonomous or planned (Fankhauser, 1999). Easterling (1996) notes that planned adaptation measures are characteristically consciously made policy options or response strategies which are multi-sectoral in nature and they are aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. For example, farmers make deliberate crop selection and distribution strategies across different agro-climatic zones, substitution of new crops for old ones and resource substitution induced by scarcity. The multi-sectoral nature of planned adaptation strategies ensures that diverse sectors of the ecosystem are included as opposed to autonomous adaptation which caters to adaptation in a specific sector of the environment and/or natural resource. Autonomous adaptation strategies do not adequately cater for the needs of the community with the changing climate; planning for adaptation offers a wider scope in catering to the needs of the community and it anticipates the impacts of climate change and provides possible adaptation strategies to the projected impacts. It may involve building of infrastructure and capacity building to ensure that the adaptation process is effective and efficient. Adaptation should therefore not be limited to reactive responses and should be planned for to prevent climate change impacting them negatively and on a larger scale.

It should be noted that there is an interrelationship between the climate and ecosystems with both of them affecting each other. This interrelationship is crucial for the smallholder farmers who depend mostly on natural resources and rain-fed agriculture for their livelihoods. For example, climate change has impacts on ecosystems services such as regulation of water flows and nutrient cycling and adds further pressure on the people who are already impacted by land degradation, and deforestation.

The climate change adaptation strategies currently in use by smallholder farmers in the Taita Hills include, planting of maize seed varieties according to the altitudinal gradient, early land preparation, small scale irrigation, and soil moisture conservation. The main aim of this project is to identify sustainable climate change adaptation strategies for the Taita Hills community through the integration of ecosystem based adaptation and local and indigenous knowledge on climate change adaptation.

1.1 Problem Statement

The Taita Hills in Kenya hosts endemic flora and fauna which is important for the global and regional biodiversity and livelihoods of the smallholder farmers in the area. However, increased depletion of the forest cover and intensive land subdivision in the area has led to the loss of the flora and fauna and the degradation of water resources. Furthermore, climate variability has resulted in crop failure and consequently the farmers in the area have suffered losses; these coupled with the reactive climate change adaptation strategies taking place in the area necessitate this study.

1.2 Research Questions

1. How do the households perceive the impact of climate change and climate variability in their ecosystem and how does this compare with climate impact studies conducted in the area?
2. Which socio-economic factors are increasing household vulnerability to climate variability and impacts at the local level?
3. How has the community in the Taita Hills coped with climate variability in the past 30 years to the present, and what existing local knowledge on adaptation to climate variability exists coupled with applied climate change adaptation strategies?

1.3 Objectives

The overall objective of the study is to assess the potential for integrating ecosystem based adaptation practices and local knowledge on climate change adaptation in the Taita Hills, Kenya. To achieve this overall objective, the specific objectives will be:

1. To determine the household's perception of the impacts of climate change in their ecosystem and how their perception compares with climate impact studies conducted in the area.
2. To determine the social economic factors that increase the households' vulnerability to the impacts of climate variability and change.
3. To determine the adaptation strategies that are in use in the Taita Hills and to assess the climate change adaptation strategies in place.

1.4 Justification of the Study

Climate change and variability pose great challenges to the environment at the local and global scale. This study aims at elucidating how mountain ecosystems can be better managed and indigenous knowledge of a community integrated with science to carry out successful adaptation to climate change. This study will not only benefit the Taita Hills community in sensitization and awareness creation on the impacts of climate change and appropriate adaptation strategies, but will also serve as a bridge in knowledge gaps for other communities that are dependent on their natural resources, biodiversity and ecosystems for their survival. It is important for communities to sustainably use locally available resources to adapt to climate change. As it has been noted by Colls *et al.*, (2009) most ecosystem based approaches fail to include local knowledge in practice in the formulation of climate change adaptation strategies. Ecosystem based approaches are usually successful as they are accessible by vulnerable communities using resources that are already in their possession; therefore, adequate information on ecosystem based approaches is needed to address crucial link between climate change, biodiversity, ecosystem services, sustainable resource management and adaptation to climate change. The integration of ecosystem based adaptation strategies and local indigenous knowledge to climate change adaptation will facilitate the acceptability of the formulated adaptation strategies by the community in the Taita Hills and academia. This study is therefore important as it seeks to integrate ecosystem based adaptation with local indigenous knowledge on climate change adaptation.

1.5 Description of the Study Area

The study area is located in the Taita Hills in the Coast Province of Kenya (Figure 1) in Taita County. The 22 kilometre transect covering an area of 1 kilometre on either side of the Mwatate-Vuria road ranges from Mwatate which is approximately 900 metres above sea level (m.a.s.l) to Vuria which is approximately 2, 228 m.a.s.l in the highlands (Figure 2).

The area of study covers approximately 850km^2 and in the 2009 population census, the Taita County was estimated to have 284, 657 persons with 145, 334 being female and 139,323 being male. Taita county has 54, 732 households with a population density of 16 persons per square kilometer (Taita Development Plan, 2008-2012).

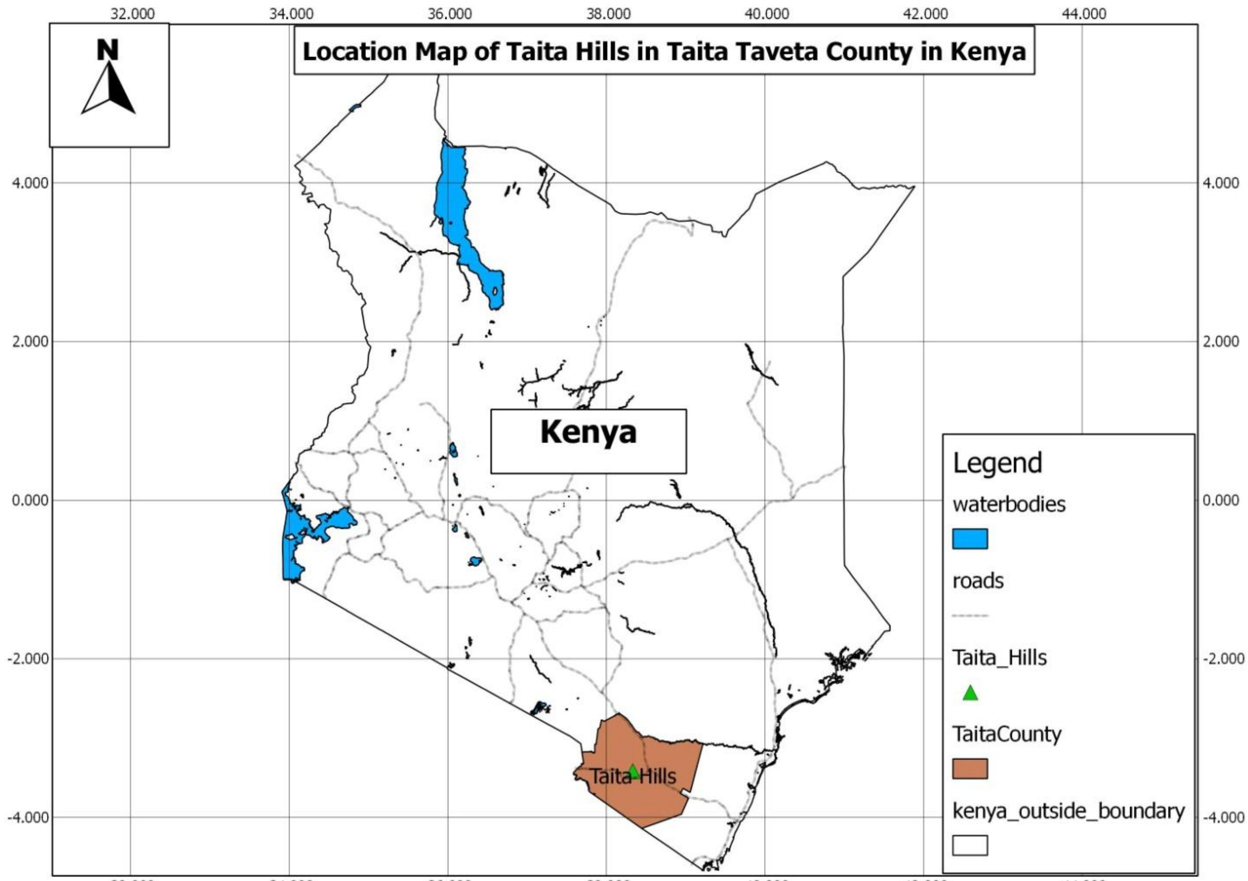
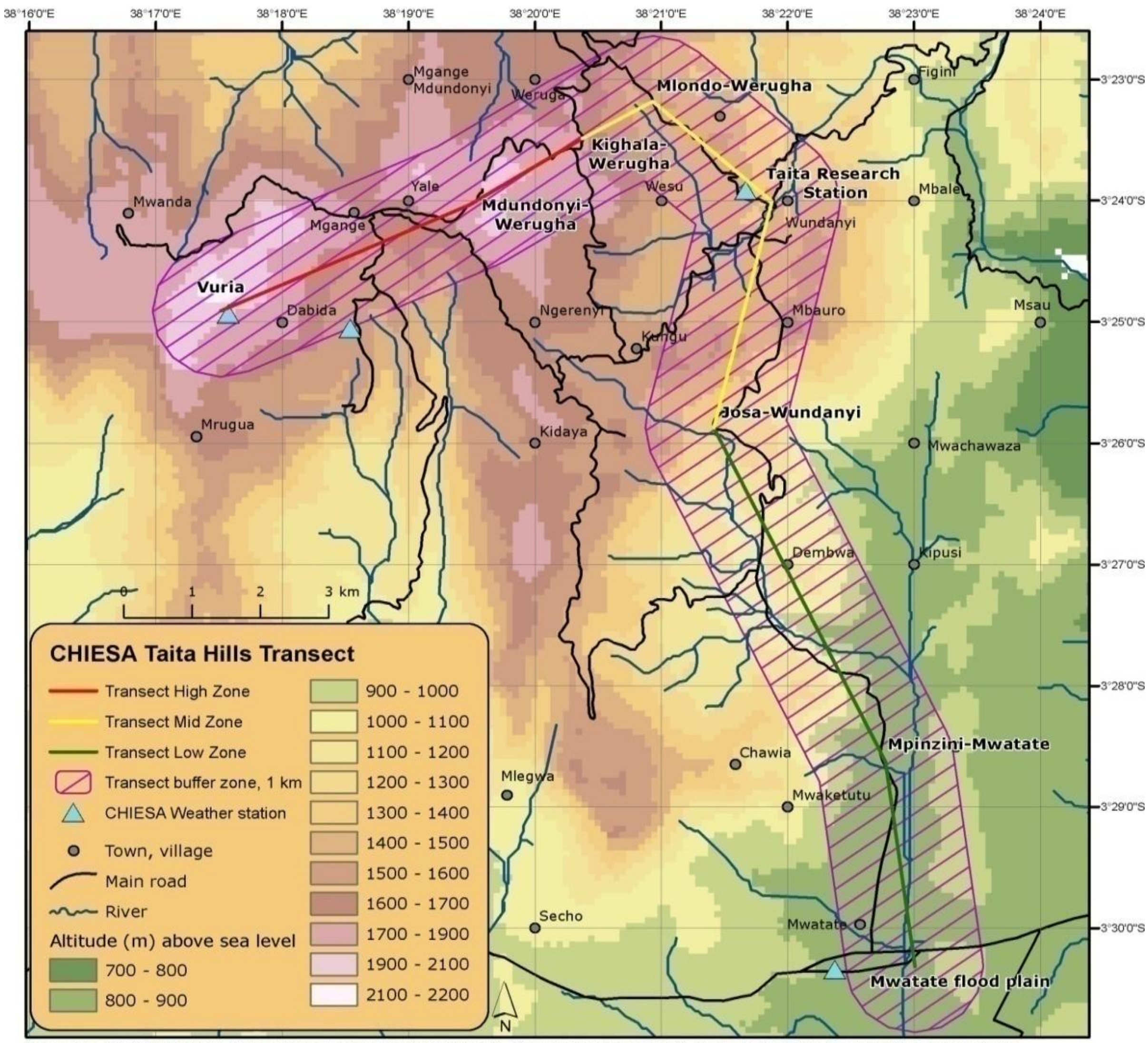


Figure 1: Location Map of the Taita Hills in Kenya

The area of study (Figure 2) is home to unique flora and fauna while portraying signs of vulnerability to the impacts of climate change. A baseline study conducted by the Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA, 2012), shows that the Taita Hills have been impacted by climate variability. Farmers have noted that there has been a decline in their farm productivity owing to successive droughts and lack of adequate farm inputs. The smallholder farmers in the area have also noted a shift in their climatic patterns with the onset of seasons (especially the rainy seasons) either delaying or being prolonged. Consequently, they have suffered increased crop failure resulting in economic losses and the increased prices of food crops in the area. In addition, they have noted that their crops are progressively being affected by crop insect pests and diseases



Base map: (C) CHIESA 2012. Source Data: Elevation (C) USGS SRTM, Rivers derived from SRTM, Roads digitized from 1:50 000 Survey of Kenya topographic maps, Gazetteer (C) geonames.org.

Figure 2: Taita Hills 22 Kilometre Research Transect from Mwatate to Vuria (Hurskainen, 2012)

The Taita Hills area experiences a bi-modal rainfall pattern with the long rains occurring in the March-May period whereas the short rains occur in the October-December period. The area is characterized by intensive subsistence agriculture with the staple crops such as maize, beans, potatoes, cassava, cabbages, tomatoes and bananas being grown (Maeda et al, 2010).

Taita Hills was chosen as a study area due to the uniqueness of the ecosystem which combines different agro-ecological zones at varying altitudinal gradients. The lowlands of Mwatate District have been classified as Arid and Semi Arid Lands (ASALs) whereas the highlands are arable lands. The southeast trade winds cause the southern and eastern slopes to receive more rainfall whereas areas such as Mwanda which are in the northern and western slopes are in the rain shadow. The highlands in the windward side receive abundant rainfall thus enabling rich agriculture and the maintenance of forests (Pellikka *et al.* 2005). Furthermore, this mountain ecosystem that has been affected by climate extremes such as drought and flooding - especially in the lowlands and local farmers - have also reported instances of crop failure and the emergence of crop pests and diseases as compared to the past. Additionally, the households in the Taita Hills are vulnerable to the impacts of climate variability and change despite the strategies that they have in place for adaptation such as dependency on food aid.

The Taita Hills as noted in the Taita Development Plan for the period 2008-2012 play a crucial role in the supply of freshwater to the lowlands like Mwatate District. The river catchment areas such as Kishushe River, are important to ensure sustained water supply to the lowlands and to the local households for domestic and agricultural purposes. The hills are also home to a variety of endemic species of birds and butterflies. With increased population and land adjudication carried out in 1984, the highlands have been degraded with cultivation occurring on the steep slopes and reclamation of wetland areas for crop production. As a result, water resources and biodiversity have been degraded as illegal logging of trees also occurs in the forests in the area. As Kohler (2009) notes, the degradation of biodiversity in mountain ecosystems ultimately impacts on the ecosystem services offered and thus on the livelihoods of the people in the area. Additionally, inadequacy of data on climate change impacts and communities' vulnerability or lack of the same impedes adaptation planning processes. As developing countries are projected to be highly impacted by climate change, it is for these countries to understand the impacts of climate change, and assess and record their vulnerabilities to climate change.

The study is conducted in different agro-ecological zones along varying altitudinal gradients (low, mid and high) in order to capture the impacts of climate change and the related climate change adaptation strategies that are in use in the Taita Hills.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Climate hazards and their variability influence human and natural ecosystems negatively and these impacts are felt most in the developing countries that are dependent on rain-fed agriculture. Increase in the intensity of climate extremes portrayed by occurrences such as frequent droughts and storms, increase in the tele-connections of atmospheric patterns and intensity of rainfall patterns is usually related with climate change. Adaptation takes place in ecological and human systems through adjustments that are made in order to facilitate the reduction of vulnerability or to increase resilience in response to changes that have been experienced or are expected in climate. Vulnerability is the ease with which a system is affected by change is compounded by factors such as poverty and unequal access to resources, meteorological hazards, food insecurity, conflict and incidence of disease (IPCC, 2007; Burton 2006). It is also compounded by the level of exposure a system has to hazards, therefore, it is important that for the effective planning of adaptation strategies, vulnerabilities of the target areas need to be identified and understood to facilitate effective formulation of adaptation strategies in order to increase the capacity of the community to adopt them. The vulnerabilities of the communities can most easily be identified through the expected impacts of climate change on sectors such as agriculture, forestry and fisheries and water resources. Other factors that should be considered as a means of reducing vulnerability include policies that facilitate climate change adaptation processes, the structures of the implementing institutions, governance and access to markets.

2.1 Mountain Ecosystems

The IPCC Third Assessment Report (2001) has noted that mountains are among the most fragile ecosystems and they are influenced by four critical factors, that is, continentality, latitude, altitude and topography. The climatic differences in turn affect vegetation type and cover, hydrology and even the geomorphic features. In particular, vegetation distribution in mountain regions is linked closely to climatic parameters; vegetation has therefore been used to delineate climate influences with regards to vegetation zones. Due to their varied and complex topography, mountain ecosystems may have varied climate over short distances, consequently, temperature variations which are mainly linked to altitudinal gradients may vary over short distances. Additionally, mountain ecosystems are also susceptible to human impacts which compound the effects of climate change. For example, the destruction of mountain vegetation, unsustainable and inappropriate farming techniques exacerbate soil erosion and may cause the modification of the micro-climate. As mountain ecosystems are the focal point of biodiversity and due to the aforementioned varying altitudinal gradients, varying geology and soils, habitat changes occur within short distances. Consequently, with changes in temperature and precipitation, the species are affected by the minimal changes that may be occurring in the climate system of the mountains. Furthermore, the livelihoods of people living in mountainous areas and those living in the lowlands are sustained by mountain biodiversity through the provision of ecosystem services such as freshwater, timber, medicinal plants and areas for recreation (Kohler *et al.*, 2009). With the non-linearity of mountain ecosystems and the dynamism of climate change adaptation strategies, how then can successful adaptation strategies be initiated and implemented successfully?

It is important to consider the occurrence of maladaptation as a result of unexpected changes and inadequate planning for adaptation strategies especially without the consideration of local knowledge and systems that are culturally acceptable to the community. For example, a community is likely to reject the taking up of sedentary agricultural practices if they are pastoralists traditionally, in the case of mountain ecosystems, the introduction of crop types or non-farm livelihood options such as apiculture that are culturally taboo will result in the failure of the climate change adaptation strategy that has been initiated. Reactive adaptation has been explained by the IPCC as considering only the impacts of climate change on the immediate ecosystem and it would therefore involve the community taking up coping strategies with regards to the prevailing climate conditions but no practical steps were taken to plan for the long term impacts of climate change. Is this the same case for the Taita Hills or are there anticipatory climate change adaptation strategies that have been instituted?

Whiteman, (2000) notes that mountains are important for the detection of climate change and its related impacts owing to the fact that due to the altitudinal difference in mountain ecosystems, there is a rapid change in climate over relatively short horizontal distances and this is manifested in the vegetation and hydrology. Consequently, mountain ecosystems are usually high in biodiversity and they also play host to endemic species.

Osman (2009) explains that in Africa, habitats and ecosystems are susceptible to climate change impacts which are exacerbated by poverty and human activities such as deforestation due to heavy dependence on biomass for energy production. Sectors such as agriculture, food and water are especially vulnerable to climate change impacts and anthropogenic impacts (IPCC, 2007). As noted earlier, Africa's vulnerability to climate change is compounded by factors such as low adaptive capacity, high prevalence of disease, low levels of development and increasing conflicts.

What are the possible means of ensuring that smallholder farmers in mountain ecosystems are resilient to the impacts of climate change? This is discussed in section 2.2.

2.2 Ecosystem Based Adaptation

Ecosystem based adaptation is defined as the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. As one of the possible elements of an overall adaptation strategy, ecosystem-based adaptation uses the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change (Colls, *et al.*, 2009).

Colls *et al.*, (2009) further state that practices in ecosystem based adaptation include:

- Sustainable water management which involves the management of aquifers and river basin along with their associated vegetation in order to provide storage for water and offer flood regulation services.
- Enhancement of pastoral livelihoods through the management of grasslands and rangelands. Consequently, the resilience of the pastoralists to droughts and floods will be enhanced.
- Disaster risk reduction.
- Establishment of diverse agricultural systems where there is use of indigenous knowledge of specific crop and livestock varieties and the maintenance of the genetic diversity of

crops and livestock. This will ensure food security in the areas impacted by climatic variability and change.

- Strategic management of shrublands and forests to lessen the occurrence of forest fires.
- Establishment and effective management of protected areas to ensure continued delivery of ecosystem services.

Ecosystem based approaches therefore play a crucial role in the identification of climate change impacts and the communities' vulnerability to climatic variability. In order to adequately assess the impacts and vulnerability to climate change and consequently adopt adaptation strategies, there is need for good quality information. This information includes climate data which includes temperature, rainfall, and the frequency of extreme events and non-climatic data which includes prevailing conditions for sectors such as water resources, terrestrial ecosystems and biodiversity, and coastal zones (UNFCCC, 2007). According to Leary, (2007) vulnerability to climate change is classified into four domains and these are: natural resources, coastal areas and small islands, rural economy and food systems and human health.

Ecosystem based approach to adaptation entails the integration of biodiversity and ecosystem services to aid people in adjusting to the adverse impacts of climatic variability. It therefore ensures sustainable management, conservation and restoration of ecosystems in service provision. Ecosystem Based Adaptation (EBA) is advantageous because it can be incorporated into community based adaptation strategies. Although ecosystem based approaches reiterate the need to integrate local knowledge on adaptation, this is rarely done in practice. However, in order to fully develop an adaptation strategy which is sustainable, community involvement is important; the integration of traditional local knowledge and ecosystem based adaptation strategies ensures the acceptability of the climate change adaptation strategies and their consequent sustainability.

Developing an adaptation strategy for future climate change requires a key set of objectives. These objectives should fit within a nation's development priorities such as poverty alleviation, food security enhancement, action plans under multilateral environmental agreements (Lim *et al.*, 2004). This gives a strong basis for the adaptation strategies and links them with measurable goals which can be assessed to quantify the level of success of adaptation strategies instituted in particular regions. While the linkage between adaptation strategies and a nation's development priorities is important, it should be noted that communities and individuals adapt to climate change based on their need and vulnerability; this is to say that for most communities, adaptation tends to take on a more autonomous approach than the planned approach to climate change adaptation. Consequently, individuals and communities are still faced by the damages resulting from the climate change impacts, implying a gap in the impact of climate change and the means adopted to counter them hence a deficit is found in both the planning and adaptation processes. The objectives of the communities to adaptation might not be specifically linked to the nation's developmental priorities but to their own needs such as household economic security and subsistence, but the relation of the adaptation strategies to community specific objectives still lends the adaptation strategies undertaken a basis for quantification of the level of success once they are utilized.

Indicators of successful adaptation should therefore be set and could include, increased crop yield and higher milk production on the farms, adequate and increased water storage capacity and sustainable use of water resources. For these strategies to be analyzed sufficiently, cost benefit analysis and multi-criteria analysis could be employed.

2.3 Barriers to Effective Adaptation

Adaptation generates internal benefits, consequently, individuals, organizations and communities will get the benefits for their adaptation actions, thereby creating a strong incentive for adaptation (Leary, 2007). Leary states that there are several factors which impede the adaptation process in communities and these include: competing priorities that place demands on scarce resources, poverty that limits capacity to adaptation, weak institutions, degraded natural resources, inadequate infrastructures, insufficient financial resources, poor governance and distorted incentives through implementation of policies that favour agricultural middle-men more than the smallholder farmer thereby inhibiting adaptation to climate change.

Effective adaptation planning requires; improved observations, improved regional, national, and global data as well as denser networks; the recovery of historical data; building support among user communities that have a demand for climate information and promoting greater collaboration between providers and users of climate information (UNFCCC, 2007).

There is a general lack of awareness primarily because of inadequate historical climate data in developing countries due to poor record keeping or lack of systems to record and tabulate climatic data, and where the information is available; there is limited access to the information. Furthermore, the same gap exists in data on yields and farm level changes. Consequently, they are limited in making climate change projections on their own and estimating the potential impacts of climate change, making estimates of climate risks, the causes of vulnerability, technologies and measures for managing climate risks and know-how for implementing new technologies. It is therefore important to communicate, interpret and apply knowledge for managing climate risks to ascertain whether the adaptation strategy has been successful in its implementation by the communities; (UNFCCC, 2009) notes that the success of an adaptation strategy is measured in terms of impact on the ground at local level.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.0 Introduction

The study assumes both a qualitative and quantitative design which employs the following approaches; literature review, baseline study of the research area, data collection and data analysis and interpretation. The data that was collected captured both perception of the respondents and statistical data from the Kenya Meteorological Department (KMD). In addition, data on climate change adaptation strategies that are in use in the Taita Hills was collected, demographic data from the Kenya National Bureau of Statistics (KNBS) and Annual Food and Security reports from the District Agricultural offices were also obtained.

3.1 Sources of Data

The sources of data were divided into primary and secondary sources of data.

3.1.1 Primary Sources of Data

Primary sources of data included questionnaires, transcribed voice recordings of the focus group discussion, the transect walk sheet and the interview schedule for the key informants from relevant institutions such as the government offices in the Taita Hills, District Livestock Officer, and local Nongovernmental Organizations working in the area. Handheld GPS receivers were used during the transect walk to map out the farms visited. During the transect walk the different climate change adaptation strategies in the different agro-ecological zones at different altitudinal gradients were noted.

3.1.2 Secondary Sources of Data

A comprehensive literature review was carried out to get information on the research problem relevant to the existing knowledge and research gaps on ecosystem based approaches to climate change adaptation and use of local/indigenous knowledge for adaptation. Statistical data on population and development indicators was collected from the district offices of agriculture, and the Government Information Office in the Taita Hills. Additionally, socio-economic data was collected from the Kenya National Bureau of Statistics (KNBS) and research reports from socio-economic projects that have been conducted in the area were utilized for background information on the study area. Data on climate and seasonal forecasts, including monthly precipitation averages for the Taita Hills for a period ranging from 1960 to 2012 from weather stations located in the area were collected from the Kenya Meteorological Department (KMD).

3.2 Methodology

This study utilizes a mixed-method approach (Caracelli and Greene 1993 as quoted by Bazely, 2011) as it combines different data collection and analysis methods. Participatory methods (Thomson and Schoonmaker, 1997), which include seasonal calendar mapping, focus group discussions and transect walks used to identify and assess the households' perception of climate variability and climate change. Household surveys, interviews, and secondary data analysis were employed in order to fulfill the objectives of this study. The key informants and respondents of this study were drawn from various social classes and age groups and they included: local farmers, traditional leaders and village elders, government officers, Non Governmental Organization (NGO) workers, and members of community-based organizations (CBOs) and teachers. The participants were drawn from different agro-ecological zones of the Taita Hills.

The methodology employed in the data collection for this research project consisted of surveys and participatory rural approaches such as transect walks, drawing of seasonal calendars and development of timeline of major climatic events in the Taita Hills. Secondary data on recorded precipitation over a period of 50 years (1960-2001) was also used for general time series plots for detecting trend and to draw comparison with the perception of the households on climate change.

3.2.1 Semi-structured Questionnaires

A questionnaire is a group or sequence of questions designed to elicit information from an informant or respondent when asked by an interviewer or completed unaided by the respondent. When an interviewer is involved, the questionnaire is sometimes referred to as an interview.

- *An unstructured questionnaire* is an instrument or guide used by an interviewer who asks questions about a particular topic or issue. Although a question guide is provided for the interviewer to direct the interview, the specific questions and the sequence in which they are asked are not precisely determined in advance.
- *A structured questionnaire,* on the other hand, is one in which the questions asked are precisely decided in advance. When used as an interviewing method, the questions are

asked exactly as they are written, in the same sequence, using the same style, for all interviews.

- *A semi-structured questionnaire* is a mix of unstructured and structured questionnaires. Some of the questions and their sequence are determined in advance, while others evolve as the interview proceeds.

This study utilizes semi-structured questionnaires (Annex 1) to guide both the focus group discussion and the household surveys. These were used to collect data from the relevant institutions and key informants from the District Agricultural Office (DAO), the Ministry of Water District office in the Taita Hills and NGOs such as the Taita Taveta Wildlife forum which works on conservation activities. The semi-structured questionnaires (Annex 2) were used for the household survey from the highlands to the lowlands.

In preparation for the actual data collection a pre-test was carried out to determine the suitability of the questionnaire to the objectives, the time it took to administer the questionnaire to enable the planning of the number of days to be spent carrying in out the data collection. During the pretest the questions that posed a challenge to both the enumerator and the respondent were noted and thereafter, the questions were restructured to facilitate better understanding of the questions by the respondents.

3.2.2 Interviews

Interviews are a systematic way of talking and listening to people and are a way to collect data from individuals through conversations. The researcher or the interviewer often uses open questions (Kvale, 1996).

Face to face interviews were conducted with key informants in the Taita Hills and they were guided by semi-structured questionnaires. The resource persons were identified from government reports on agriculture and development in the Taita Hills. The interviews were conducted with the District Agricultural Officer and Livestock Officer for Wundanyi and the Crops Officer for Mwatate District. The key resource persons were chosen purposively as they had information that was relevant to the impacts of climate variability and climate change to agriculture and livelihoods and the climate change adaptation strategies that were being instituted by the government. The interviews were conducted through face to face discussions with the responses recorded. Other types of data collected included livelihood characteristics of the households in the Taita Hills and factors that enhance their vulnerability to the impacts of climate variability and change. In addition, information on the socio-economic structure of the households in the Taita Hills was obtained. The key informants, especially the chiefs, played a fundamental role in the identification of the elders who had the expertise in the indigenous and local knowledge of the Taita people in relation to weather forecasting and adaptation to climate variability.

3.2.3 Focus Group Discussion (FGD)

Focus group discussions were conducted in six locations each representative of an altitudinal gradient in the Taita Hills (Table 1).

Table 1: Focus group discussion sites with their representative altitudinal gradient

Altitudinal Zones	**Location of FGD**	**Altitude (Metres above Sea Level)**
Low Zone	Mwatate	900
	Dembwa	1092
Middle Zone	Wundanyi	1480
	Werugha	1570
High Zone	Mgange	1605
	Mwanda	1816

The focus group discussions targeted both men and women and in total 182 persons participated in the exercise. The participants of the focus group discussion were chosen purposively and they had to be residents of the Taita Hills, above 40 years of age so as to capture any historical narratives they may have received from their grandparents regarding major climate events in the Taita Hills , male and female, head of household or be in a position to make household decisions, participants had to be from the low altitude (900 – 1100 m.a.s.l), mid (1400 -1600 m.a.s.l) and upper (1601-2000 m.a.s.l) altitudinal zones of the Taita Hill. On the other hand, literacy levels were not considered in the selection of the Focus Group participants.

The participants of the focus group discussion were required to give their contribution and only the answer received from a consensus in the group was recorded. The sessions were also recorded using a voice recorder in order to capture the discussions that went on between the members of the FGD, which helped in providing extra information on what the participants were discussing and to eliminate bias on what was eventually agreed upon.

The key questions posed during the focus group discussion included, the small scale farmers' perception of climate change and the impacts of climate variability and climate change. Furthermore, the impacts of climate change and variability on socio-economic activities and climate change adaptation options that have taken up to cope with the impacts of climate change were discussed. The focus group participants were questioned on their indigenous knowledge of adapting to the impacts of climate variability. This helped to generate a rapid assessment of the baseline information on indigenous knowledge possessed by the Taita and the utilization of that knowledge for adaptation.

3.2.4 Photography

Photographs were used to capture the ecosystem based adaptation strategies in use in the Taita Hills. Additionally, photography was used to capture the physical impacts of climate variability and change on the ecosystem in the Taita Hills. The photographs were taken during the transect walks, the participatory mapping sessions and during the focus group discussions.

3.2.5 Historical Narratives and Mapping

To assess changes in the past, use of ecosystem services and local indigenous knowledge for adapting to climatic variability, historical narratives and participatory mapping were used to indicate the different on farm adaptation strategies that are in use in the Taita Hills. Furthermore, the participants illustrated the cropping patterns in the Taita Hills and the crops that are planted during the different seasons using the seasonal calendar. Moreover, from the historical narrative, the participants were able to illustrate a timeline of major climate events in the Taita Hills from two perspectives i.e. Mwatate to represent the lowlands and Wundanyi to represent the highlands. The handheld GPS receiver was used in participatory mapping with the communities to map out points within the ecosystem that are most vulnerable to climate change and climate variability. The exercise entailed mapping of ecosystem based adaptation strategies in use in the Taita Hills. Priority areas for climate change adaptation according to community perception were also mapped out.

3.2.6 Sampling

The sampling was done to get a representative group of respondents from the different altitudinal gradients in the Taita Hills, thereby capturing any differences in the climate change impacts and climate change adaptation strategies in the different agro-ecological zones.

The target study population of the research project comprised of the households in the Taita Hills located at different altitudinal gradients from Mwatate in the lowlands to Mwanda in the highlands. The target population comprised of the smallholder farmers in the Taita Hills and the institutions that support their farming activities and livelihoods.

3.2.7 Sample Size

The study population comprised of households and institutions in the Taita Hills from Mwatate in the lowlands at 900 meters above sea level to Mwanda in the highlands at 1816 meters above sea level. The sample size of the study was determined by Equation 1 developed by (Yamane, 1967);

$$n = \frac{N}{1+N(e)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where; n= sample size

N= population size

e= 0.95 (level of precision)

Therefore, with the population of the Taita Hills totaling 284, 657, the sample size was calculated to be 399.43. The sample size of 399.43 households was rounded off to 400 households. However, only 300 households were visited as a result of time restrictions according to the time allocated for the research. The allocated research period was taken into account when calculating the number of households that could be visited depending on the maximum number of questionnaires that were administered daily. Visiting the 300 households did not introduce a bias in the study as all the households were randomly selected and the sample size was calculated for the whole of Taita Taveta and not just the Taita Hills.

3.2.8 Sampling Procedure

The study employed both probability and non-probability sampling techniques as explained below. Due to the change in altitudinal gradient in the Taita Hills, the population was first stratified before random sampling was carried out within the identified strata. From the sample size of 100 households, 50 households were randomly sampled from within each of the 6 strata in the lowland and the highlands.

3.2.9 Stratified Sampling

Altitudinal gradient was used as the criteria for stratifying the population in the Taita Hills. Therefore, the population was divided into three strata according to the altitude of the agro-ecological zone in which the respondents resided and carried their main farming activities. Within these strata, there were two (2) representative areas for each altitudinal gradient.

3.2.10 Simple Random Sampling

Simple random sampling was used to select the households from the identified strata. The selected households constituted the respondents of the questionnaires which were administered through face to face interviews.

The random sampling was conducted by digitizing the households contained in an aerial image (Figure 3) of the Taita Hills research transect. Open source software Quantum GIS was then used to randomly select the households which were included in the household survey. In instances where the respondents were not available, the households were replaced and the replacement noted on the questionnaire.

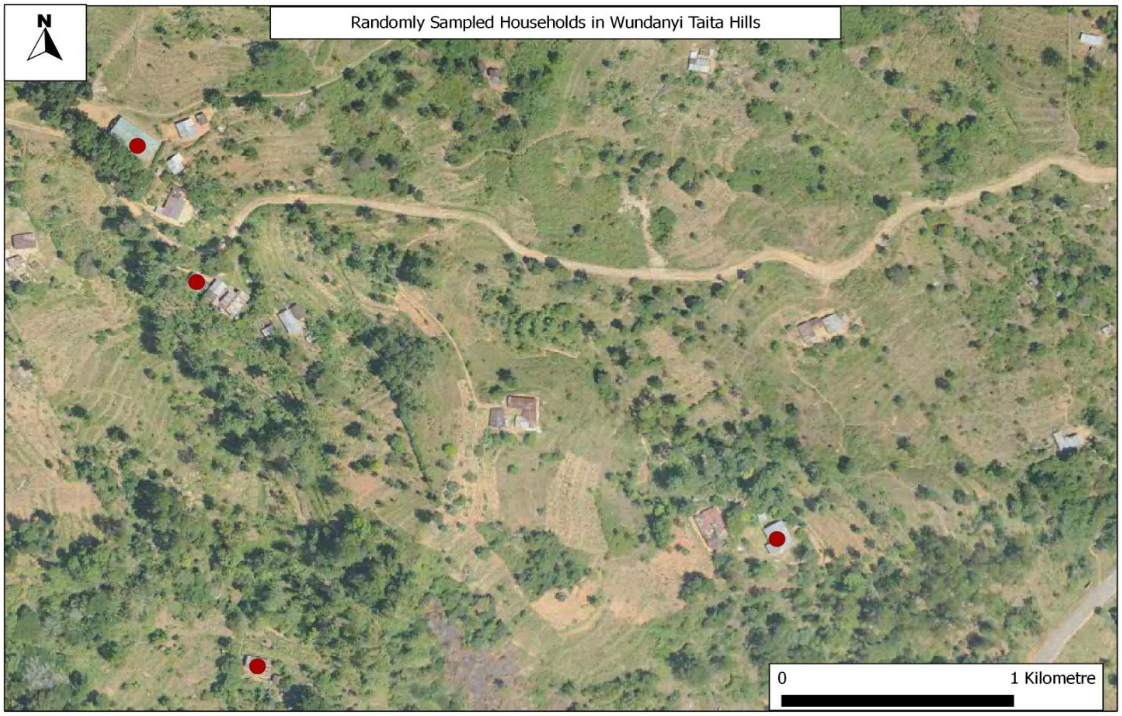


Figure 3: Orthophoto Map of the Wundanyi Area showing Randomly Sampled Households (CHIESA 2012)

3.2.11 Purposive Sampling

A purposive sampling technique was used to identify key informants who were resourceful on the livelihoods of the households in the Taita Hills. The informants were chosen because of the knowledge they possessed on the indigenous knowledge of the Taita Hills, the agricultural practices of the smallholder farmers in the Taita Hills and the possession of key secondary data on studies carried out related to climate change and its impacts on the Taita Hills. Some of the targeted institutions included the district administrative offices (chiefs, District Development Officer, The Kenya Forest Service). Purposive sampling was also used to identify the participants of the focus group discussions held during the research phase of this study.

3.2.12 Snowball Sampling

Snowball sampling occurred when the purposively sampled respondents referred us to other resource persons who had more information on the area of study and on climate variability and its impacts on the households in the Taita Hills. In addition, snow ball sampling enabled the identification of elderly respondents who had knowledge of the traditional weather forecasting and adaptation techniques used by the Taita in the past.

3.3 Conceptual Framework

The conceptual framework (Figure 4) developed for this study entails the use of community participation and integration of their local knowledge on climate change adaptation. It aims to foster the acceptability and the sustainability of the identified and proposed climate change adaptation strategies by the community in the Taita Hills. The outcome entails the integration of ecosystem based adaptation strategies and local indigenous knowledge for sustainable climate change adaptation strategies.

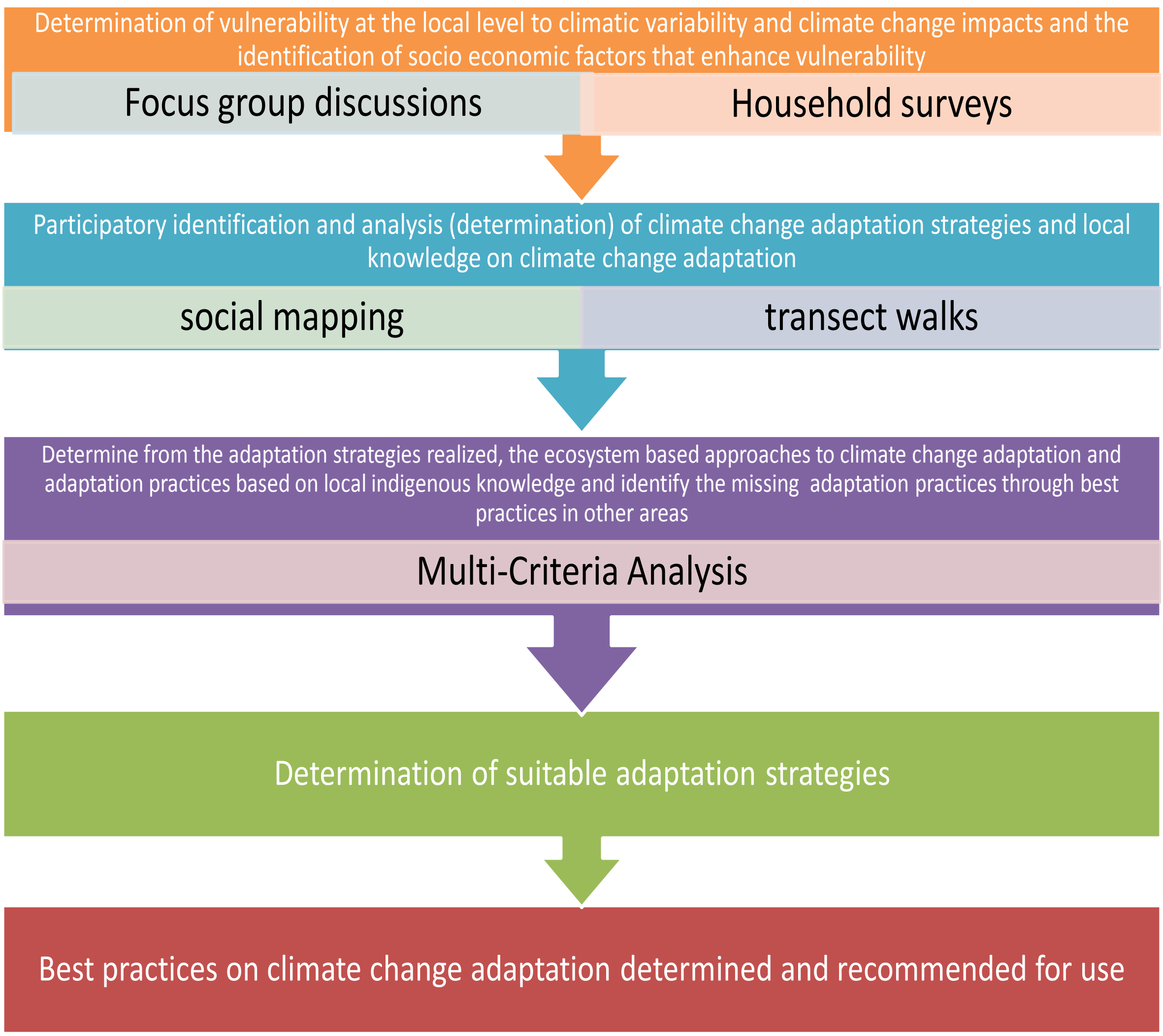


Figure 4: Conceptual Adaptation Framework for Taita Hills, Kenya

3.4 Data Analysis

Data analysis of the questionnaires was conducted at 2 levels. First the questionnaires were sorted out to determine the percentage of null responses from the households, or enumerator errors. There were 7 invalid questionnaires which were then set aside and they constituted 2.3% of the total number of questionnaires administered in the Taita Hills. The factors that led to the disqualification of information from the analysis included:

- Failure of the enumerator to note the location and date when the questionnaire was administered.
- Lack of response from the respondents on more than half of the module of the questionnaire
- Poor reporting of the answers from the enumerators by writing in short form that could not be understood

The remaining questionnaires were divided according to the locations that they were collected from and the information contained was transcribed to ascertain whether a pattern would emerge from the responses received. The second level of analysis of the questionnaires occurred during the transcription of the results. It entailed the analysis of individual modules within the questionnaire and it constituted examining the number of non responses per question within the remaining questionnaires. Lastly similar responses were then grouped together and the data entered into an Excel spreadsheet to generate the frequencies of the responses per question within the questionnaire modules. The close-ended questions were analyzed using Excel spreadsheet and the data presented in terms of percentages and graphs. Information received from the KMD was also analyzed using Excel spreadsheet and the data presented as time series plots. The rainfall data was sorted according to the identity of the weather station which captured the data and grouped them according to the altitudinal zone. The data was sorted to represent March-May, June-September and October-November. Separate time series plots for the aforementioned periods were generated.

The data obtained from the transect walk was used to draw a cross-sectional diagram of the Taita Hills and the related climate change adaptation strategies that are in use at different altitudes in the Taita Hills. The open-ended questions were manually analyzed by grouping responses with similar themes and tallying them. Frequencies and the perceived causal relationships were determined from the responses. The seasonal calendars which were originally drawn by the by the focus group participants were developed into a table detailing the seasonal activities and this is used to display the agricultural and livelihood cycle of the households in the Taita Hills. It contains both on-farm and off farm activities.

Questions were also analyzed on a number to number basis, as there were instances of no responses from the respondents and invalid answers given which did not lend credence to the question posed to them. Furthermore, there were questions that the respondents did not want to answer and these were left out of the analysis.

3.4.1 Limitations

Data analysis was limited by the lack of site specific long term historical temperature data for the Taita Hills which would have been used to establish a comparison between the households' perception of climate change and the recorded data. The temperature data available was from the Voi meteorological station and this was not sufficient to illustrate the temperature ranges for the high ranges of the Taita Hills. In addition, data analysis on the health characteristics and its impacts on climate change adaptation was not included as the respondents did not feel comfortable revealing their health information to the enumerators. This was attributed to a voluntary Human Immunodeficiency Virus (HIV) testing initiative that had been launched in the area two months prior to the household survey. The respondents explained that their HIV status had been tested and revealed to them without their consent; consequently, most of the respondents did not give any responses to the health module in the questionnaire.

Additionally, there were missing records from 3 of the representative weather stations that had recorded rainfall data. Therefore, comparison of rainfall data received in the past 10 years with the smallholder farmers' perception could not be carried out. Furthermore, the perception of a shift in the onset of rainy seasons could not be carried out due to the lack of data on daily precipitation for the Taita Hills for the period 1961-2012.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the perception of climate change by the smallholder farmers in the Taita Hills, the climate change adaptation strategies that are in use, the socio-economic variables that increase the vulnerability of the smallholder farmers to the impacts of climate change and the integration of indigenous local knowledge with ecosystem based adaptation. It discusses the indigenous knowledge of the Taita in relation to weather forecasting and climate change and how this knowledge can be linked with Ecosystem Based Adaptation (EBA) for climate change adaptation. This chapter is structured to detail the different climate variables that define the perception of climate change according to the smallholder farmers in the Taita Hills. Furthermore, the chapter discusses the rainfall trends in the Taita Hills at different altitudinal gradients and how this is related to the perception of climate change by the smallholder farmers. The data on observed seasonal rainfall is presented in form of time series graphs and the observed seasonal rainfall trend compared with the perception of the smallholder farmers.

4.1 Perceptions of Climate Variability and Climate Change

The households in the Taita Hills are aware of climate variability and identify drought and floods as the most destructive climate factors. They attribute poor crop production and declining farm productivity and emergence of insect pests to climate factors especially increased temperature and declining rainfall amounts. Understanding smallholder farmers' perception of climate change is an important precondition in understanding their climate change adaptation choices (Gbetibouo, 2009). Hartter *et al.*, 2012 concurs stating that in order to formulate appropriate policies and responses to climate change, it is fundamental that in addition to anticipating expected changes, the perception and interpretation of climate change of local communities should be taken into consideration.

In order to establish the perception of climate change by the smallholder farmers' in the Taita Hills, they were asked to explain their understanding of climate change. Thereafter, they were required to state any changes they had observed with regard to specified climate variables such as rainfall intensity, the onset and cessation of rainfall, temperature, farm productivity, incidences of insect pests and diseases, and frequency of extreme climate events. The households' opinions on their understanding of climate change mainly concerned changes in the rainfall seasons and the amount of rainfall received during the rainy seasons.

The participants of the focus group discussions and the respondents of the household survey stated that they had noted changes in the Taita Hills that had been observed in the past 30 years (Table 2). Perception of climate change varies in the households with 25% citing a shift in rainfall patterns, 25% reported inadequate rainfall and 19% related it to daily weather changes. The perception of change stemmed from factors such as the decline of the amount of water in the rivers to the complete drying up of some river valleys in the area, declining farm productivity and increase in the insect pests on the farm with an increase in the frequency of droughts experienced in the area.

Table 2: **Factors related to climate change as stated by smallholder farmers based on a household survey conducted in July 2013 along varying altitudinal gradients in the Taita Hills**

Understanding of Climate Change	Mwatate	Josa	Wundanyi	Werugha	Mghange Nyika	Mwanda	Total
Shift in rainfall patterns	16	5	9	13	4	17	64
Insufficient Rainfall	18	11	9	9	6	10	63
Decline in Food Production	2	1	2	0	3	2	10
Climate Extremes	0	0	1	0	0	3	4
Increasing temperatures	0	0	4	0	0	0	4
Change in Weather	5	9	9	8	11	7	49
Changes in Environment	0	1	5	1	5	1	13
An act of God	0	0	1	0	0	0	1
No response	0	8	7	2	0	6	23
Do not Know	3	7		3	7	3	23
Total	44	42	47	36	36	49	254

Furthermore, the respondents from the households were asked to give their perception of selected climate variables and to describe any changes that they felt had occurred to the climate factors (Table 3).

Table 3: Perception of climate change from 1987 – 2013 according to smallholder farmers in the Taita Hills

Climate Factor	Variables	Perception of Past Conditions (30 year timeline 1978-2008)	Perception of Current Conditions (2009-2013)
Rainfall	Seasons	The seasons would set in on time allowing the farmer to plan his farming activities adequately	There is a change in the onset of the rainy season. Characterized in 4 ways • late onset and early cessation of rainfall • early onset and early cessation of rainfall • early onset and late cessation of rainfall • late onset and late cessation
	Adequacy	Rainfall was sufficient for their farming activities.	Rainfall amounts received fall short of the required amounts for productive agriculture
	Intensity	The rains were well distributed	The rains are unpredictable and erratic, with either intense rains in a short period of time or short rainy spells over a long period of time.
Temperature		Temperatures were much colder in the past. Could not grow mangoes in the highlands	Temperatures have become warmer. Mangoes do well in the highlands of the Taita Hills
Farm Productivity	Food shortages and Food surplus	Food shortages rarely occurred in the past and households usually had enough to store for household use during the dry season and as seed for the succeeding season. Last food surplus was in 1997 during El Nino rains	Instances of food shortages have increased. Food is mostly grown for domestic consumption and very little is left for storage
	Increase in the occurrence of insect pests	It was not necessary to spray crops in the past. Traditional insect pest management was used to control insect pests.	Crops do not do well without insect pest management through use of pesticides
Climate Extremes	Floods	-	Floods such as El Nino rains of 1997 resulted in food surplus in the lowland areas of the Taita Hills.
	Drought	Drought occurred infrequently in the past and periods of productivity were more than the dry periods.	The frequency of drought has increased. The lowland areas also experience prolonged dry seasons.

Understanding the smallholder farmers' perception of climate change helped in establishing the baseline for the identification of changes that had occurred in the Taita Hills. In order to clearly establish the perception of variability and changes in their climatic patterns, the participants of the focus group discussion were asked to state how conditions were in the past 30 years and to compare it to their observations of the present climate. Consequently, a timeline of major climatic events for the Taita Hills from the perspective of the focus group participants in the lowland and the highlands of the Taita Hills was developed (Figure 5 and 6). The timelines of major climatic activities that were developed by the focus group participants however date to approximately 68 years ago for the Wundanyi timeline and 80 years ago for the Mwatate timeline. The participants revealed that they were aware of major droughts in 1933 due to the historical narratives given to them by their grandfathers. The timeline helped to establish the frequency of occurrence of extreme climate events which is discussed in detail in Section 4.1.1. The timelines also show the intervening measures that were taken to cope with the impacts.

The timelines further establish that the two major climatic extremes that have affected the Taita Hills have been droughts and floods. The coping strategy initiated has mainly been food aid provided by the government or international institutions and food for work initiatives taken by Nongovernmental Organizations such as World Vision yet there was no report of plans put in place to anticipate for the impacts of future climate extremes. Further to this, the impact of anthropogenic activities such as the land consolidation of 1969 emerges. During this period farmers were allocated farms in the highland areas of the Taita Hills whereas in the past, cultivation was not allowed in the highland areas. Consequently, there was an increase in the clearing of forests for cultivation. Dams that existed before the land consolidation occurred were also destroyed to create farming land. The participants noted that in 1970, the year after the land consolidation, cultivation started in reserve areas such as wetlands. The degradation of water resources enhances the vulnerability of smallholder farmers to the impacts of climate change. This is discussed in detail in Section 4.6.1.

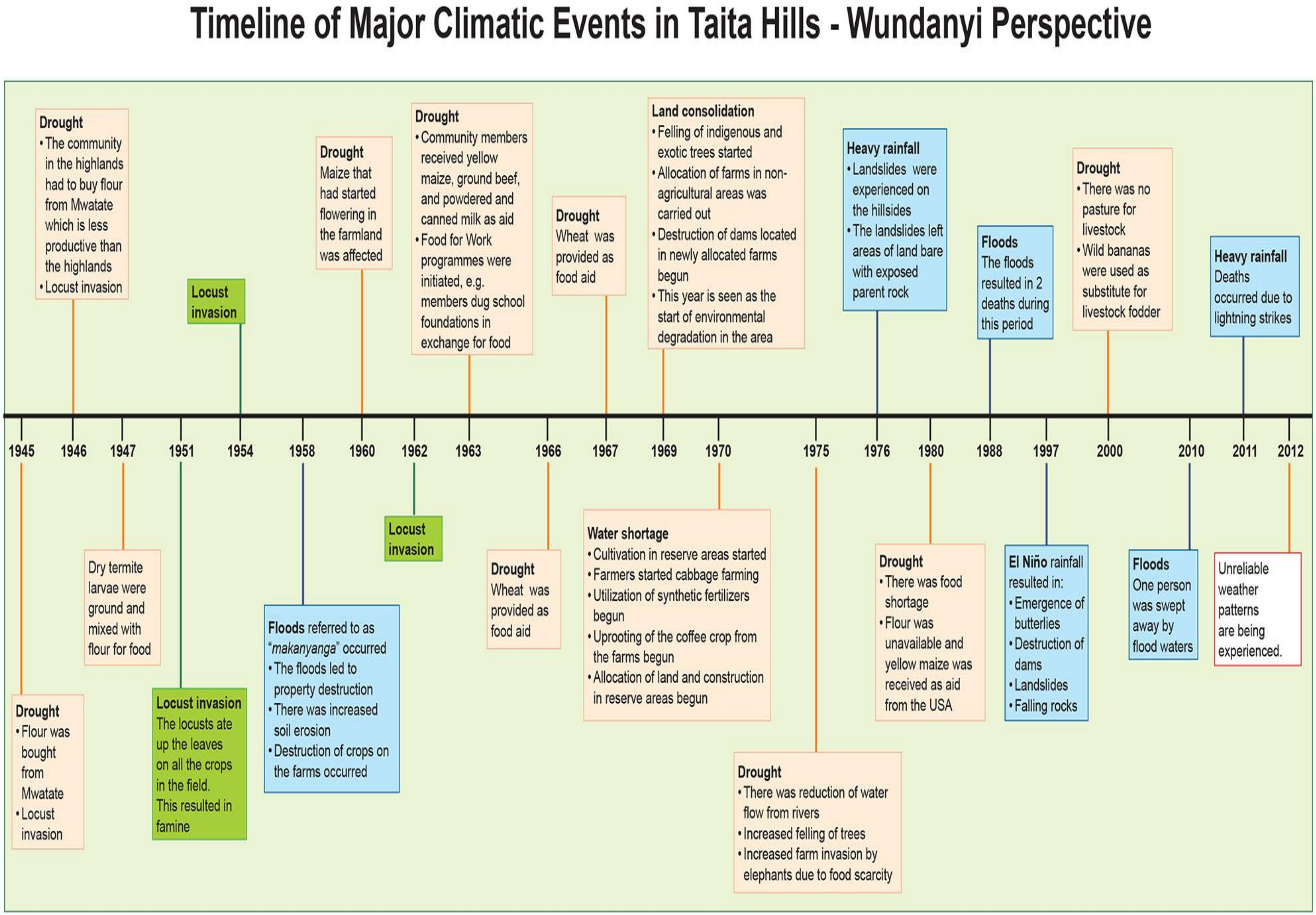


Figure 5: Timeline of Major Climatic Events in the Taita Hills based on the perspective of households in the mid and upper zones of the Taita Hills developed in June 2012

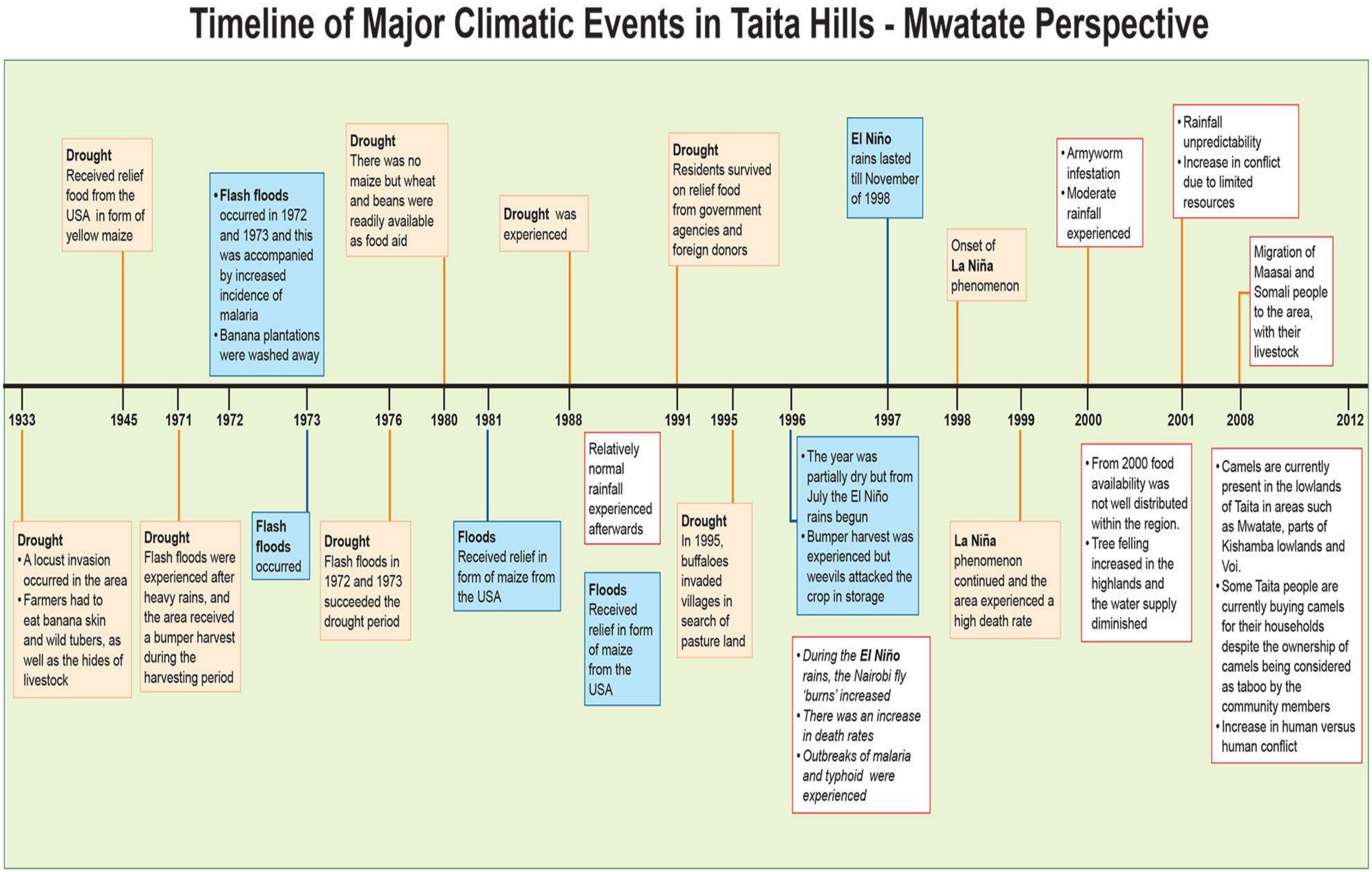


Figure 6: Timeline of Major Climatic Events in the Taita Hills based on the perspective of households in the Lowland areas of Mwatate developed in June 2012

4.1.1 Frequency of Climate Extremes

The frequency of climate extremes is also portrayed in the timeline of climatic events in the Taita Hills (Figure 5 and 6). Droughts and floods are the most common extreme events witnessed in the Taita Hills. However, the projections of El Nino rains did not occur in the Taita Hills in the year 2012. The lowlands were reported to experience prolonged dry seasons even when the highland areas of the Taita Hills received rainfall.

The timeline of climatic events for Wundanyi (Figure 5) shows that drought has been a major climatic event in their agro-ecosystem. The frequency of drought in the Mwatate timeline (Figure 6) is evident with droughts having occurred in the following years, 1933, 1945, 1971, 1976, 1980, 1988, 1991, 1995 and 1998. The Mwatate timeline indicates that from 1971, droughts have been occurring after every 3-4 years. The participants noted that there has been a general decline of rainfall received in the area from 2009 as they have experienced prolonged dry periods. In addition, Amissah-Arthur (2002) reports 5 distinct El Nino years in Kenya. The years included the second growing season of the October – January growing season in 1982-1983 and 1997- 1998 which were the most intense El Nino years in the country. The other El Nino years included 1986-1987, 1987-1988 and 1991-1992. Amissah-Arthur adds that the highlands recorded a significant increase in rainfall during these years. The aforementioned years correspond with years in the timeline that had been cited as being flood years such as 1988 and 1997 (Figure 5 and 6).

4.2 Climate Patterns

The Taita Hills have a bimodal rainfall pattern with the long rains setting in from March to May (MAM) while the short rains set in October to December (OND). However, the farmers in the Taita Hills recognize the seasons according to temperature as portrayed in Table 4. The seasons in the Taita Hills are based on temperature and are termed as, *kwari* (winter) and *sumeso* (summer) - *kwari* represents the cold season which runs from April – August, whereas *sumeso* represents the hot season which runs from September to April. The long rains occur in the *kwari* season whereas the short rains occur during the *sumeso* season and these would be used to determine when to plant crops in the highlands and in the lowlands. The crops grown would therefore be compatible with the expected rainfall amounts and temperature in a season.

Table 4: Cropping Seasons in the Taita Hills and the Related Crops Cultivated Seasonally

Region	Season	Characteristic Temperature	Months	Crops Grown
Taita Hills	*Kwari* (Winter)	Low temperatures	April – August	Maize, beans, green grams, pigeon peas
	Sumeso (Summer)	High temperatures	September - April	Maize

Compared to the current situation whereby the rainy season is characterized by delays in the onset, the onset of the rainy season was predictable and timely in the past and thus farmers could plan their farm activities in advance. Farmers also reported experiencing light showers in July locally known as *sunda* to help with the germination of their crop as they awaited the short rains. Currently, they rely on both the long and the short rainy seasons for maize cultivation but in the past, maize cultivation was carried out in the short rainy season alone. The focus group discussion attributed this to maize failure in the long rainy season but agricultural officers stated that this was due to the infestation of maize stem-borers during this season which caused the maize to fail. The Annual Food and Crop Situation Report for 2012, states that generally, the short rainy season has been more reliable for farming activity as compared to the long rainy season.

Traditionally, cultivation in the lower zones of the Taita Hills was carried out during the long rainy season while cultivation in the upper zones of the hills occurred during the short rainy season due to the high intensity of the long rainy season which proved detrimental to agriculture in the highlands. They explained that this led to water logged farms and an increased rate of crops being destroyed in the germination stage. A phenomenon referred to as *kighuo in* the Taita language was experienced and it was characterized by seven (7) days of continuous rainfall. *Kighuo* signified the cessation of the long rainy season and was noted to occur in the last stage of the development of the maize crop. Failure to receive these rains would portend poor yield for the season.

The focus group participants were asked about the onset and cessation of rainy seasons considering a 30 year time period from 1982-2012. They noted that, the seasons were well defined in the past and this ensured that there were particular crops planted during the seasons. Presently, there is uncertainty as to when to start planting as the rains received are often inadequate or cease suddenly in mid-season therefore resulting in a failed crop. The lowland areas such as Mwatate, Kishushe, Landi and Kishamba referred to as "*sehemu za nyikani"* to refer to the dryland lower altitude areas and are perceived to be the most vulnerable to the impacts of climate change. This was exemplified by a description of the climatic conditions experienced in the lower zones such as insufficient rainfall amounts, high temperatures, prolonged dry season and the lack of vegetative cover which results in the accelerated loss of soil moisture in the lowlands as compared to the highland areas. The lack of vegetative cover was specifically noted as compounding the failure of their farming activities as their farms could not retain water in the soil when there was no rainfall. The Crops' Officer for Mwatate also stated that the rainy seasons in the lowlands are usually below the optimum level for productive agriculture and this is compounded by poor agricultural practices such as late land preparation and the failure to plant the recommended crops for the season.

Data from the KMD shows that rainfall distribution is uneven in the districts with the highlands receiving higher rainfall than the lowland areas. This coupled with cooler temperatures (on average about 18.2^{o}C makes the highlands more suitable for production of horticultural crops, maize and beans. The lowland areas which are mainly ASAL are only suitable for planting crops which can withstand water stress like sorghum and millet together short series maize varieties such dryland hybrid maize.

4.2.1 Rainfall Variability and Intensity

Rainfall availability and intensity is recognized as one of the important climate factors for the smallholder farmer with regards to his livelihood. 25% of the respondents stated that they have observed a decline in the rainfall amounts and the subsequent decline in farm productivity. According to the household survey, the rainy season is characterized in 4 ways: Delay in the onset of the rainy season, timely onset of the rainy season but early cessation, early onset of the rainy season but early cessation and inadequate total rainfall received in a season. It is however important to note that there are more than 4 ways of characterizing the rainy season in the Taita Hills.

Declining farm productivity in the Taita Hills was attributed to the unpredictability of the rainy season. Early or delayed onset of the rainy season leads to poor planning of farm activities especially land preparation thus affecting the growing season of the crops. Additionally, the sudden cessation of rainfall affects crop production as the crops wilt and suffer from water stress due to insufficient water supply.

The distribution of rainfall was also noted to be poor with the farmers reporting that they experienced either a lot of rainfall within a short period of time or little rainfall spread out over a long period of time. The food and crop situation reports for Mwatate District (GoK, 2010-2012) tallies with the farmers' perception of inadequacy of rainfall to sustain a cropping season. The report shows that for three (3) consecutive years, the district had failed to meet its target production of maize which is the staple crop (Table 5). The focus group participants reported that only the short rainy season would be utilized for farming in the past as the long rains would destroy their crop but currently they utilized both seasons for farming as the intensity of the long rains had reduced. Currently, the short rains are also considered to be productive as the long rainy season is usually inadequate and is characterized by early cessation of the rainfall. This is however contradictory to the analyzed data which shows that yield per hectare in the short rainy season is lower than the yield per hectare during the long rainy season. However in 2012, the yield per hectare during the short rainy season (8 bags/ha) was higher than yield per hectare in the long rainy season (4.69 bags/ha).

Table 5: Targeted maize crop production vs. achieved maize production in 2010-2012

Year 2010																		
Area	**Target**									**Achieved**								
	Area in Ha			**Production in Bags**						**Area in Ha**			**Production in Bags**					
	Long Rains (LR)	**Short Rains (SR)**	**Total**	**LR**	**SR**	**Total**	**Yield/ Ha LR**	**Yield/Ha SR**	**Total Yield/Ha**	**LR**	**SR**	**Total**	**LR**	**SR**	**Total**	**Yield/Ha LR**	**Yield/Ha SR**	**Total Yield/Ha**
Mwatate	1600	1350	**2950**	32000	27000	**59000**	20	20	**20**	1175	872	**2047**	17675	6600	**24275**	15.04	7.57	**11.86**
Mwambirwa	250	350	**600**	5000	7000	**12000**	20	20	**20**	170	109	**279**	2500	1240	**3740**	14.71	11.38	**12.44**
Total	**1850**	**1700**	**3550**	**37000**	**34000**	**71000**	**20**	**20**	**20**	**1345**	**981**	**2326**	**20175**	**7840**	**28015**	**15**	**7.99**	**12.04**
Year 2011																		
Area	**Target**									**Achieved**								
	Area in Ha			**Production in Bags**						**Area in Ha**			**Production in Bags**					
	Long Rains	**Short Rains**	**Total**	**LR**	**SR**	**Total**	**Yield/ Ha LR**	**Yield/Ha SR**	**Total Yield/Ha**	**LR**	**SR**	**Total**	**LR**	**SR**	**Total**	**Yield/Ha LR**	**Yield/Ha SR**	**Total Yield/Ha**
Mwatate	1450	1600	**3050**	24650	27200	**51850**	17	17	**17**	964	1376	**2340**	16388	16512	**32900**	17	12	**14.06**
Mwambirwa	250	350	**600**	4250	5950	**10200**	17	17	**17**	168	324	**492**	1210	3888	**5098**	7.20	12	**10.36**
Total	**1700**	**1950**	**3650**	**28900**	**33150**	**62050**	**17**	**17**	**17**	**1132**	**1700**	**2832**	**17598**	**20400**	**37998**	**15.55**	**12**	**13.42**
Year 2012																		
Area	**Target**									**Achieved**								
	Area in Ha			**Production in Bags**						**Area in Ha**			**Production in Bags**					
	Long Rains	**Short Rains**	**Total**	**LR**	**SR**	**Total**	**Yield/ Ha LR**	**Yield/Ha SR**	**Total Yield/Ha**	**LR**	**SR**	**Total**	**LR**	**SR**	**Total**	**Yield/Ha LR**	**Yield/Ha SR**	**Total Yield/Ha**
Mwatate	1450	1600	**3050**	24650	27200	**51850**	17	17	**17**	822	1120	**1942**	4110	8960	**13070**	5	8	**6.73**
Mwambirwa	250	360	**610**	4250	6120	**10370**	17	17	**17**	95	260	**355**	190	2080	**2270**	2	8	**6.39**
Total	**1700**	**1960**	**3660**	**28900**	**33320**	**62220**	**17**	**17**	**17**	**917**	**1380**	**2297**	**4300**	**11040**	**15340**	**4.69**	**8**	**6.68**

(Adapted from Mwatate Annual Food and Crop Situation Report 2010-2012 – yield/hectare calculation added by author)

From Table 5, it is apparent that Mwatate and Mwambirwa areas have failed to meet the targeted yield per hectare for the three years – 2010 to 2012 – with the exception of the long rains in year 2011 where the targeted 17 bags per hectare in Mwatate was achieved. Year 2012, saw the poorest performance with regards to yield per hectare as only 5 bags per hectare were achieved as opposed to the targeted 17 bags per hectare in both Mwatate and Mwambirwa locations. The report attributes this failure to the low rainfall amounts received in the district and the early cessation of rainfall when the maize crop was tasselling.

4.2.1.1 Comparison of Climate Change Perception with Recorded Rainfall Data in the Taita Hills

Three representative weather stations located at low altitude, middle altitude and upper altitudes were used to represent the agro-ecological zones in the Taita Hills. Data obtained from the 3 weather stations in the Taita Hills shows that there has been a general declining trend in the amount of rainfall from 1960s to 2010. The stations were chosen based on the station with best record in terms of length of recorded precipitation data and completeness of the rainfall data – representative station with no gaps in the records.

For the low altitude agro-ecological zone, Maktau weather station was chosen as the representative station and the data available for the statio ranges from 1961 to 1996. Wundanyi weather station was taken as the representative station for the middle altitude agro-ecological zones and the data available is from 1961 to 2003, lastly, Mgange was chosen as the representative weather station for the upper altitude agro-ecological zone and the data available is from 1977 to 2006.

The analysis of the recorded data was done according to the two main rainfall seasons in the Taita Hills, that is the longs rains (March-May) and the short rains (October-December). The June-September analysis was added to ascertain whether the farmers' perception of rainfall seasonality being unpredictable and occurring in between the two main seasons corresponds with the recorded data.

Compared to the perception of rainfall variability, onset of the rainy season and rainfall amounts, the recorded rainfall data corresponds with the perception of the households in the Taita Hills. It is however important to note that farmers' perception of rainfall amounts is prejudiced by the amount of rainfall experienced during the cropping season. The weather station representing the lowland (Figure 7) shows that there has been a reduction in the rainfall amounts received in the lowland areas of Taita Hills. This corresponds with the perception of the household members who stated that the lowland areas are more vulnerable to climate change impacts due to declining rainfall amounts. The optimal rainfall conditions for productive agriculture in the lowland areas considering the variety of maize seed planted is 450mm of rainfall. However, the amount of rainfall received in the lowland areas during the MAM and OND cropping seasons has been less than the required 450 mm from 1968 to 1996 which was the last year available for the recorded data at Maktau weather station.

Pellikka *et al.* (2009) states that between 1986 and 2003, the average yearly rainfall for Mgange was 1132 mm at 1768 meters above sea level while yearly maximums may reach 2000 mm and minimums 200 mm. Orographic rainfall patterns of the Taita Hills mean that the southeastern slopes of the Taita Hills receive more precipitation than the northwestern slopes. Moreover, the Annual Food and Crop Situation Reports for Mwatate district show that rainfall amounts have been deficient for agriculture in the lowland areas of the Taita Hills ranging from Mwatate to Kipusi.

The median temperature increase for Africa is between $3^{o}C$ – $4^{o}C$ by the end of the 21^{st} century while IPCC projects that there will be an increase in precipitation amounts in East Africa by approximately 7%. However, Shiklomanov (1997) notes that between 1970 and 1995, there was a 2.8 decrease in the availability of water in Africa. Under SRES scenarios, Arnell (2004) projects that by the year 2025 about 370 million African people will experience increases in water stress, while about 100 million people are likely to experience a decrease in water stress by the year 2055, as a result of a likely increase in precipitation.

In the paper "*Adapting Agriculture to Climate Change in Kenya: Household and Community Strategies and Determinants,* Bryan E. *et a*l. (2011) note that in East Africa, there is likelihood of a decrease in rainfall in only a few areas; however, increases in rainfall are not likely to lead to increases in agricultural productivity due to poor spacing and timing of precipitation. Consequently, Kenya is expected to experience a decline in the production of staples such as maize due to the aforementioned factors and increased evapo-transpiration (Herrero *et al.* 2010). The households in the Taita Hills reported declining productivity of their maize crop due to successive failure of the rainy seasons.

4.2.1.2 March to May (MAM) Seasonal Rainfall

The time series analysis shows that the rainfall trend in the three representative areas has been steadily declining. During the March-May (MAM) rainy season, the analysis shows that Maktau (Figure 7), Wundanyi (Figure 8) and Mgange (Figure 9) display a decreasing trend in the MAM rainfall season. Recorded rainfall data for Wundanyi (Figure 8) also shows that from 1993 to 2003, the area has received below 600 millimetres which portrays a deficit for an area that receives approximately 900 mm to 1200 mm of rainfall in a season. It is important to note that rainfall on mountain ecosystems is also influenced by orography and the rain shadow effect. Through the orographic effect, rainfall amounts increase dramatically as you move farther up the mountain on the windward side whereas the rain shadow effect causes a decline in rainfall amounts on the leeward side of the mountain. The highest recorded rainfall data in the MAM season for the low altitude agro-ecological zone was observed to 626.4 millimetres. The average precipitation amount for the lowland areas of Taita Hills is considered to be 350 – 400 millimetres.

4.2.1.2.1 Rainfall Stations in the Low Altitude Agro-Ecological Zones of the Taita Hills (MAM Season)

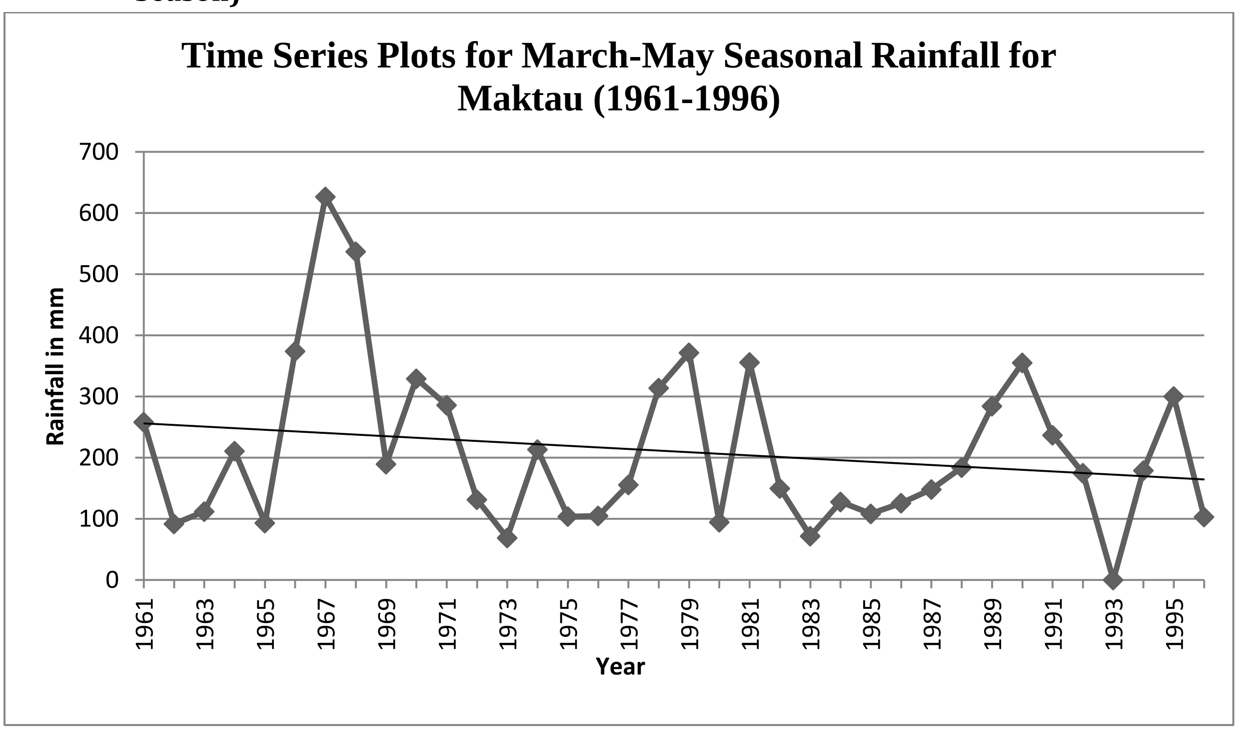


Figure 7: Time series plot for March-May Seasonal Rainfall for Maktau in the low agro-ecological zone of the Taita Hills (700 m.a.s.l) – (KMD 2013)

4.2.1.2.2 Rainfall Stations in the Mid Altitude Agro-Ecological Zones of the Taita Hills (MAM Season)

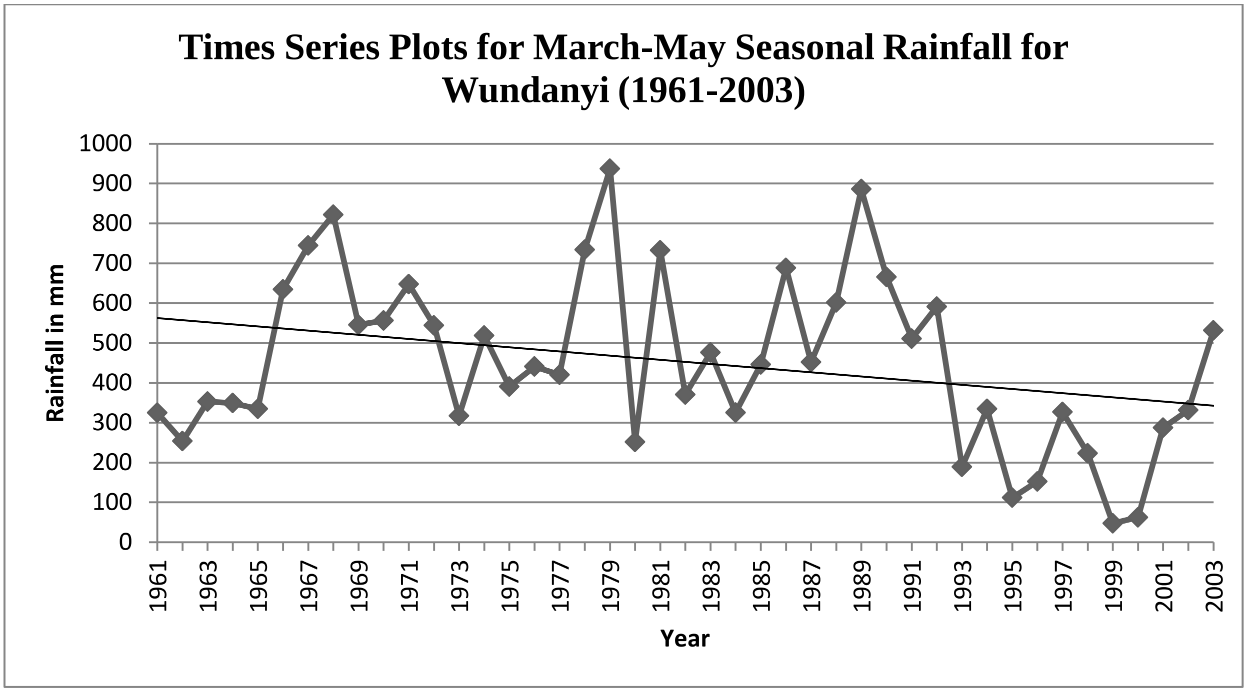


Figure 8: Time series plot for March-May Seasonal Rainfall for Wundanyi (1480 m.a.s.l) – (KMD 2013)

4.2.1.2.3 Rainfall Station in the High Altitude Agro-Ecological Zones of the Taita Hills (MAM Season)

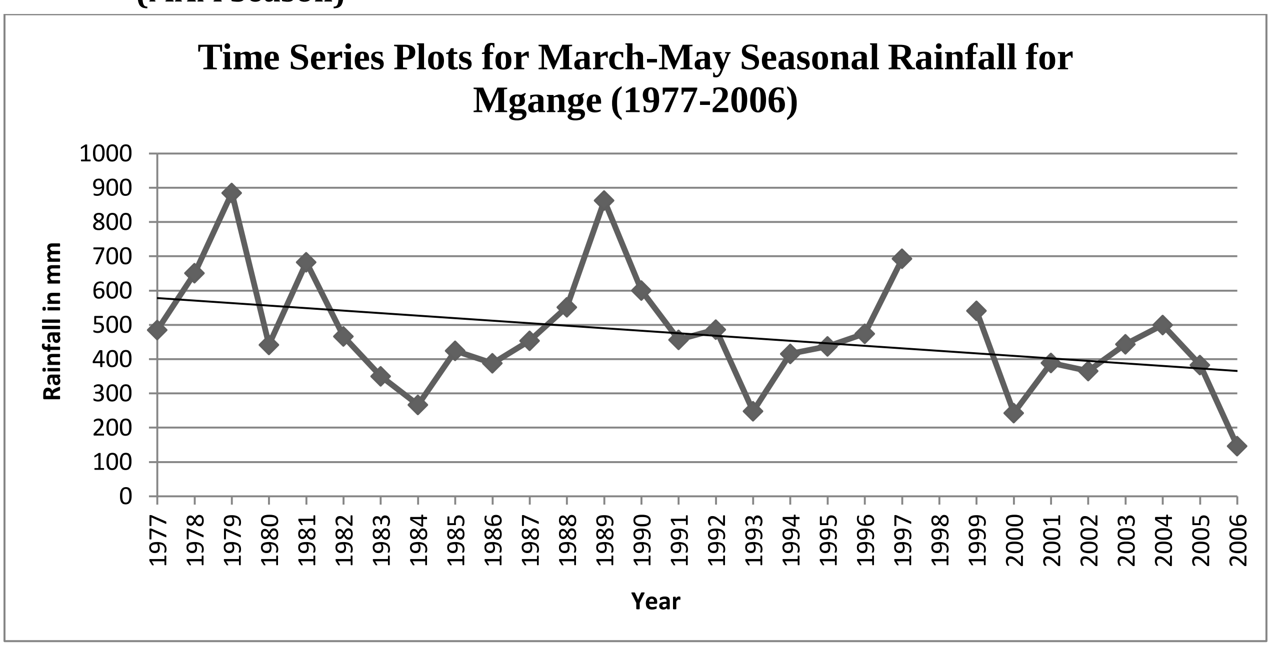


Figure 9: Time series plot for March-May Seasonal Rainfall for Mgange (1605 m.a.s.l) – (KMD, 2013)

4.2.1.3 October to December Seasonal Rainfall

The trend analysis for the October to December (OND) short rainy season depicts a decline in rainfall activity for all the observed rainfall in the low altitude agro-ecological zone (Figure 10) and middle altitude agro-ecological zone (Figure 11). The stations located in the mid altitude agro-ecological zones that is Wundanyi (Figure 11) portray a steep decline in the amount of rainfall received in the OND season in Wundanyi. Only Mgange (Figure 12) depicts an increasing trend in rainfall.

4.2.1.3.1 Rainfall Stations in the Low Altitude Agro-Ecological Zones of the Taita Hills (OND Season)

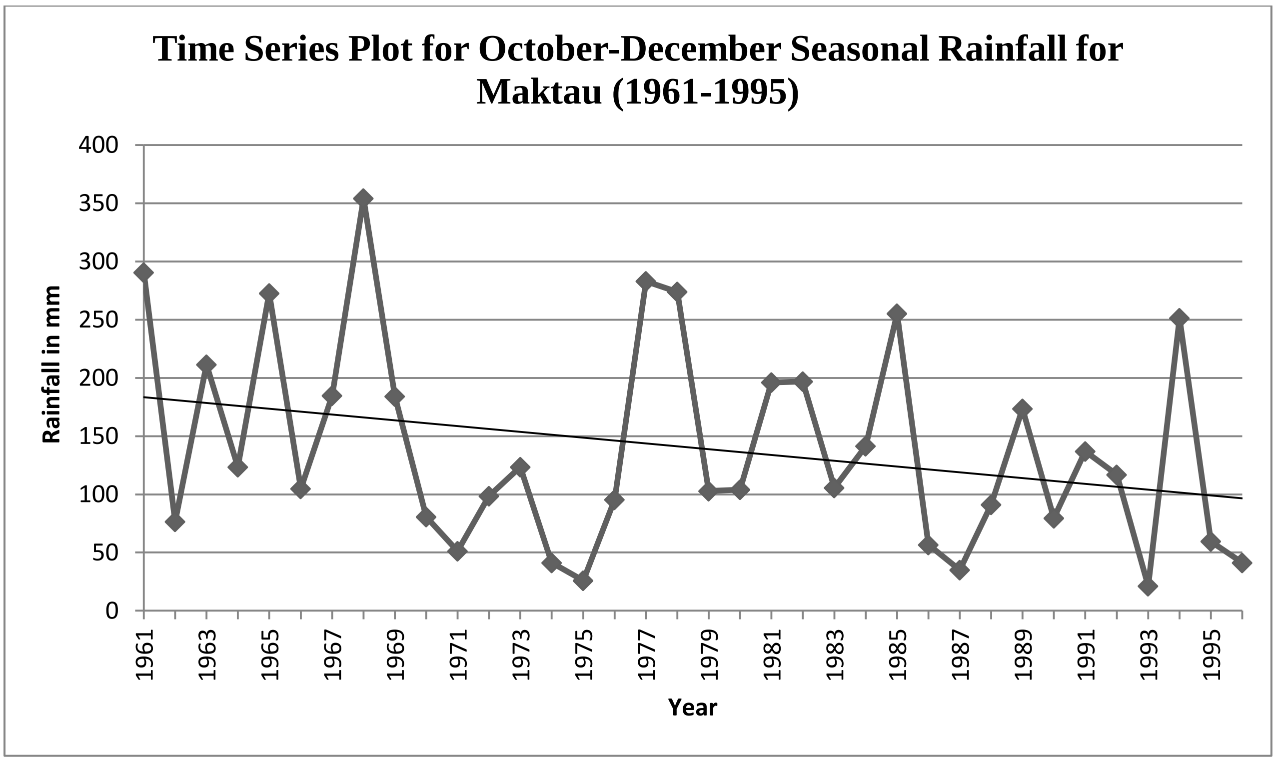


Figure 10: Time series plot for October-December Seasonal Rainfall for Maktau (700 m.a.s.l) - (KMD, 2013)

4.2.1.3.2 Rainfall Stations in the Mid Altitude Agro-Ecological Zone of the Taita Hills (OND Season)

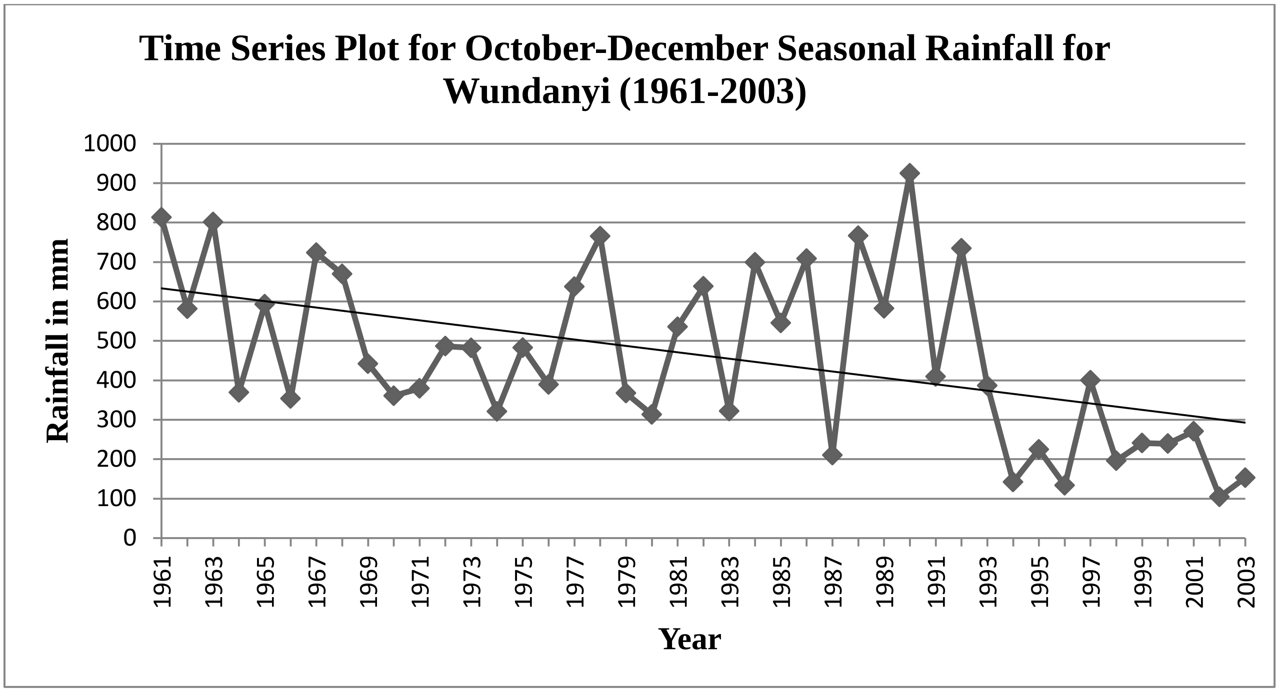


Figure 11: Time series plot for October-December Seasonal Rainfall for Wundanyi (1480 m.a.s.l)

4.2.1.3.3 Rainfall Station in High Altitude Agro-Ecological Zone (OND Season)

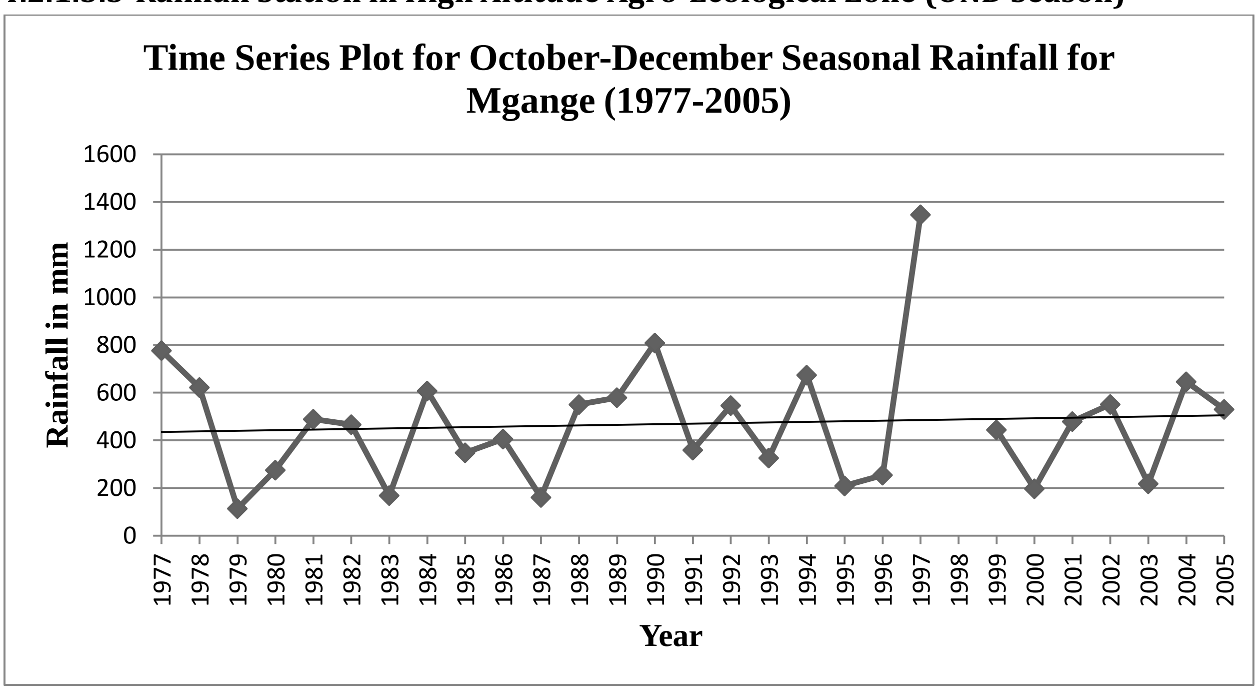


Figure 12: Time series plot for October-December Seasonal Rainfall for Mgange (1605 m.a.s.l)

4.2.1.4 June to September Rainfall Activity

The smallholder farmers' in the Taita Hills perceived the June to September rainfall activity as an extension of the March to May rainy season. The representative stations for the low altitude agro-ecological zones (Figure 13) and the upper altitude agro-ecological zone (Figure 15) depict a decreasing trend in the rainfall activity in the June to September period. On the contrary, the time series analysis shows an increasing trend in rainfall events in the June-August period in stations such as Wundanyi (Figure 14). This followed a poor MAM season for example from 1997- 2003. This impacts on the food security of the households as the temperatures in JJAS season are not optimal for maize cultivation due to the low temperatures during this period. Farmers reported that delays in the onset of the long rainy season had the resultant impact of the cropping season extending into the JJAS season. Consequently, this resulted in the extension of the growing season for the maize crop.

4.2.1.4.1 Rainfall Stations in Low Agro-Ecological Zones of Taita Hills for JJAS Season

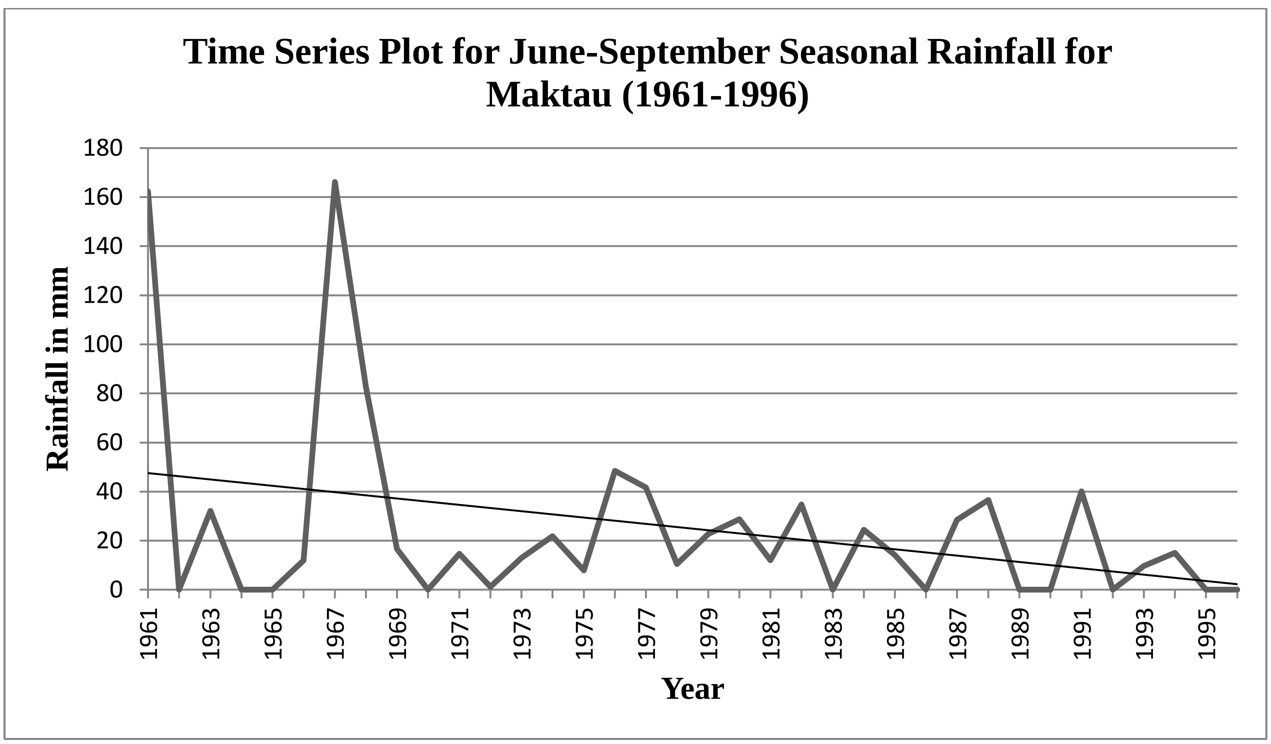


Figure 13: Time series plot for June-September Seasonal Rainfall for Maktau (700m.a.s.l)

4.2.1.4.2 Rainfall Stations in Mid Agro-Ecological Zones of the Taita Hills (JJAS Season)

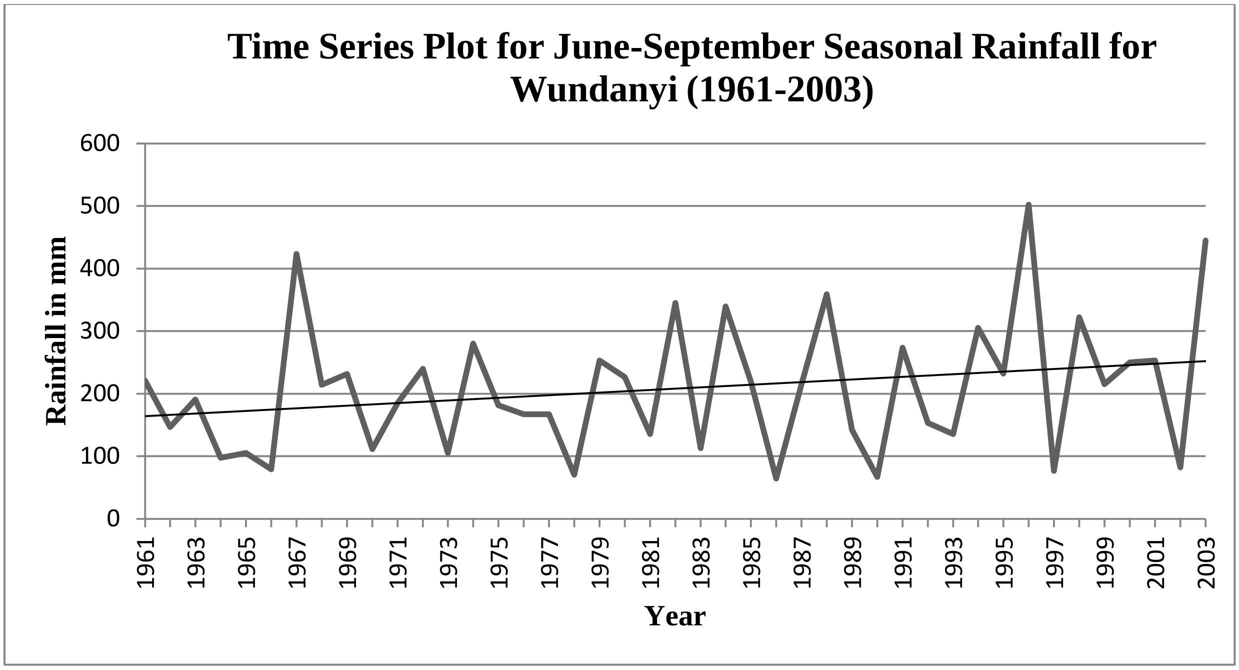


Figure 14: Time series plot for June-September Seasonal Rainfall for Wundanyi (1480 m.a.s.l)

4.2.1.4.3 Rainfall Station in the High Altitude Agro-Ecological Zone (JJAS Season)

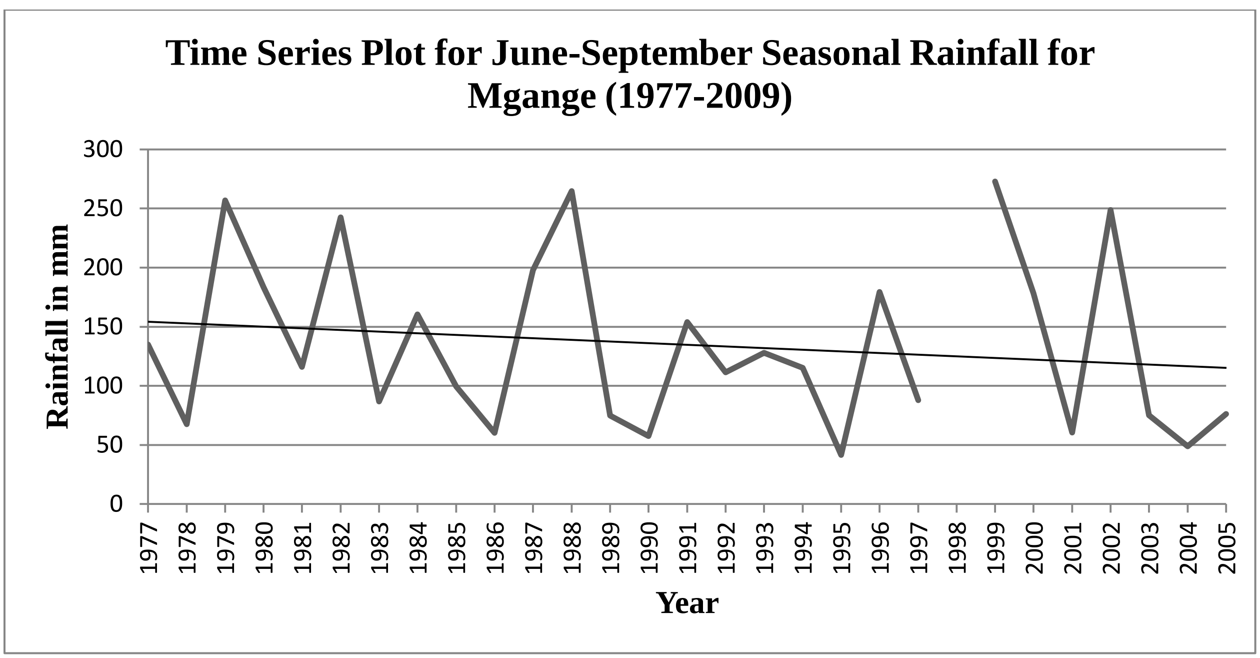


Figure 15: Time series plot for June-September Seasonal Rainfall for Mgange (1605 m.a.s.l)

4.2.2 Temperature

According to the household survey, 42% of respondents noted that temperatures had warmed up in the Taita Hills. The warmest location was noted to be in the lowlands of Mwatate District. In the highlands, the warming of temperatures was exemplified by the kind of food that is currently grown in the area. The respondents noted that in the past, they could not practice mango fruit farming as the trees would not bear fruit but currently, mango farming is one of the economic practices of the households. Additionally, they added that the temperatures experienced during the June – July cold season were warmer than they had been in the past; the respondents noted that during the season in the past, visibility was limited due to the constant presence of fog in the area during the cold season. Temperature data from the KMD weather stations in the higher altitudinal gradients was not available for generation of time series data. The temperature data available was from the Voi weather station which is located in the lowland areas of Taita Taveta County. Due to the presence of the hilly masses and the forests in the highlands, micro-climate of the highland areas could be altered.

4.3 Farm Productivity and Soil Fertility

Farm productivity is perceived to be declining in the Taita Hills. Presently, the use of commercial nitrate-based fertilizer has increased compared to its utilization in the past. The focus group participants noted that in the past, farming could be carried out with the application of fertilizer but currently, without fertilizer application the yield from the farm is minimal. Some of the focus group participants noted that they mix the use of fertilizer with organic farm yard manure. The households sampled also reported that as part of their farm preparation strategies, manure application is included as the last step before the onset of the rainy season.

Farm productivity was also measured in terms of food surplus and food shortages. The households reported that the last food surplus experienced in the area occurred during the 1997 El Nino floods. The food surplus was experienced in the lowland areas of Mwatate but there was crop failure in the highlands as the high amount of rainfall received destroyed crops in the farms located in the upper altitudinal gradients.

Crop production is mainly being carried out for subsistence and the amount left over for storage is not enough to sustain a household of five for more than two months. This means that the households' vulnerability to the impacts of the dry period is enhanced. The District

Development Plan of 1997-2001 explains that the district is a net importer of food. The district receives food aid from the government especially during droughts and the food deficit is occasioned by demographic factors such as increase in population as compared to food production, social variables which include slow adoption of quick maturing and drought resistant crops and poor farming methods. In 2009, the long rains were inadequate leading to crop failure in the lower zones of the district, while little amounts were realized in the hilly masses thus resulting in below average crop yields (Annual Horticultural Report 2009). Manual land preparation remains the dominant method in Mwatate accounting for 78% of all the land prepared.

4.4 Occurrence of Insect Pests and Diseases

Insect pests affecting maize and crucifers are perceived to have increased in the Taita Hills. This was attributed to a decline in rainfall as the population of the insect pests was reported to reduce during the rainy season. The insect pests that were perceived to have increased include the maize stem-borer and thrips. New insect pests which affect their kales and cabbages locally known as *kobe* were also reported by the focus group discussions. The household respondents noted that for a successful farming season, the use of insect pest control management either through traditional knowledge or chemical pesticides to reduce the amount of insect pests on their farms was mandatory.

New crop diseases were also reported during the focus group discussions. The participants reported that past five years (2007 -2012), they had noted that their bean crop had been affected by a disease that causes the crop to dry up just when it is about to flower. The disease results in crop failure and despite having informed their agriculture extension officer the information on the disease they received was inadequate. They were informed that the disease affecting their bean crop is occasioned by an insect pest that has not been identified by the agricultural extension workers. Tomato crops were also reported to have been affected by bacteria wilt which had resulted in some farmers abandoning tomato farming due to the losses incurred.

4.5 Socio Economic Activities Increasing Vulnerability to Impacts of Climate

IPCC (2007), reports that an increase in the global average temperature above the range of 1.5 ^{o}C -2.5^{o}C is likely to cause major alterations in the function and structure of ecosystems. Consequently, households such as those in the Taita Hills that are reliant on natural resource based livelihoods will be impacted negatively. The determinants of adopting climate change adaptation strategies include:

- Years of farming experience
- Household size
- Level of education
- Access to credit facilities
- Access to extension services
- Off farm income activities

It emerged that there are socio-economic factors that increase the vulnerability of households to climate variability and change impacts (Figure 16). The economic mainstay of the Taita Hills is agriculture. The sector employs 95% of the rural Taita population either directly or through agricultural related sectors (Taita Development Plan 2008-2012). However, agriculture has been greatly impacted by climate variability and change as evidenced by failing crop and increased use of fertilizer and farm input in relation to the amount of harvest received. With this in mind the study aimed to establish the socio-economic factors that make the households in the Taita Hills susceptible to the impacts of climate variability and change.

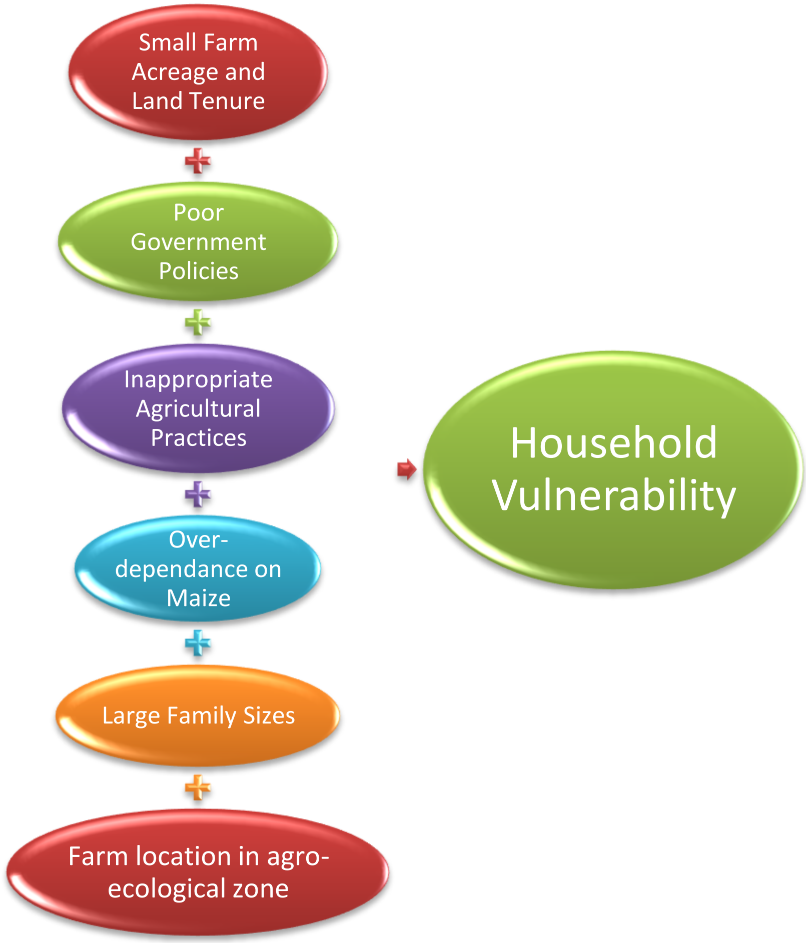


Figure 16: Socio economic variables contributing to the vulnerability to climate change impacts of households in the Taita Hills

4.5.1 Farm Acreage and Land Tenure

Farm acreage plays an important role in the determination of resilience to climate change impacts. This is because large farm acreage allows the farmer to utilize good agricultural practices such as fallowing. For the Taita Hills, it emerged that the households attribute their declining farm productivity to the size of the farm. They noted that they practiced intensive agriculture in both the long rainy season and the short rainy season due to their small land sizes. As a result, the soil was not allowed to fallow between cropping seasons. Most of the households sampled have acreages that are 2 acres or less (Table 6). The Taita Development Plan 2008-2012 states that the average farm sizes in the low agro-ecological zones (Mwatate) are 4.8 hectares (11.86 acres); the mid-agro-ecological zones (Wundanyi) have average farm sizes of 1.3 hectares (3.21 acres) and the average for the highland areas (Mwanda) is 0.4 hectares (0.988 acres).

Table 6: Farm size in acres in the Taita Hills from sampled households in July 2013 (N= 261)

Farm Acreage (Acres)	Mwatate	Josa	Wundanyi	Werugha	Mgange Nyika	Mwanda	Total
0-2	24	23	31	23	22	29	152
2.1-4	9	10	4	12	4	4	43
4.1-6	2	4	3	7	3	5	24
6.1-8	0	1	1	1	0	0	3
8.1-10	0	0	0	0	0	0	0
10.1 and above	0	0	0	1	0	0	1
No farm	8	0	2	1	0	0	11
Not sure	2	2	6	6	5	6	27

The Taita Development Plan for the period 2008-2012 reports that only 40% of the total population in Taita County has permanent land tenure. However from the household survey only 4.7% of the sampled households did not have permanent land tenure. 11.53% of the households did not know the acreage of their farms mainly because the farm had not been subdivided by the patriarch of the family. In such instances, the families practiced communal farming and shared the proceeds from the harvest.

The small farm sizes have been linked to culture and demographic factors which include population increase. The population of Taita Taveta County has been steadily increasing from 1969 to the present. This presents a challenge because culturally, the patriarch of the family subdivides land amongst his sons as part of their inheritance.

4.5.2 Farm Location

The household survey revealed that the households in the Taita Hills perceive the lowland in agro-ecological zone Lower-Mid 4 (LM4) and Lower-Mid 5 (Table 7) to be the most vulnerable to the impacts of climate change. They cited the high temperatures experienced in the area and prolonged dry season which are not conducive for agriculture.

Table 7: Agro-ecological Zones of the Taita Hills (Taita Development Plan 2008-2012)

Agro-ecological Zone	Altitude (M)	Annual mean Rainfall mm p.a.	Annual mean Temperature	Soils	Major Enterprises
LH_2-Wheat/Maize/pyrethrum zone	1370-1680	900-1200	20.1-18.2	Stony sand clay, loams with moderate fertility steep shallow soils	Horticulture, dairy, maize, beans, coffee
UM_3-Marginal coffee zone	1370-1680	900-1200	20.1-18.2	Stony sandy clay loams well drained and quite deep-steep slopes	Horticulture, macadamia, dairy, coffee, maize, beans, irish potatoes, bananas
LM_4-Sunflower/Maize	1220-1520	700-900	20.9-18.8		Sunflower, Pigeon peas, Maize, Cotton, Grams, Cow peas, Beans, Cross breed cattle
LM_4-Marginal Cotton Zone	900-1220	600-800	22.9-20.9		
LM_5-Livestock/Millet Zone	790-980	480-620	23.5-22.4	Dark red sandy clays	Pigeon peas, cow peas, grams, sisal, cassava, mangoes, custard apple.
LH_6-Lower mid, Land ranching zone		No rain fed agriculture	-	Well drained, dark, friable, coarse, loam sand to sandy clay	Ranching (Local/Breeds): National Park
L_5-Lowland Livestock Millet zone	610-790	480-600	24.6-23.5	Well drained dark, friable, coarse, loam sand to sandy clay	Ranching (local breeds): National Park
L_6-Lowland Ranching Zone		No rain fed agriculture	-	Well drained, dark, friable, coarse, loam sand to sandy clay	National Park: Ranching (Local breed)

Moreover, the farms that are located in the high altitude agro-ecological zones which include Lower-Highland (LH) 2 and Upper-Mid (UM) 3 are susceptible to soil erosion. The household survey indicated that during heavy rainfall, crops in the highlands are washed away from the farms. The farms in the high agro-ecological zone have therefore taken up bench terracing as a means of reducing soil erosion by slowing down the movement of water on their farms.

4.5.3 Government Policy

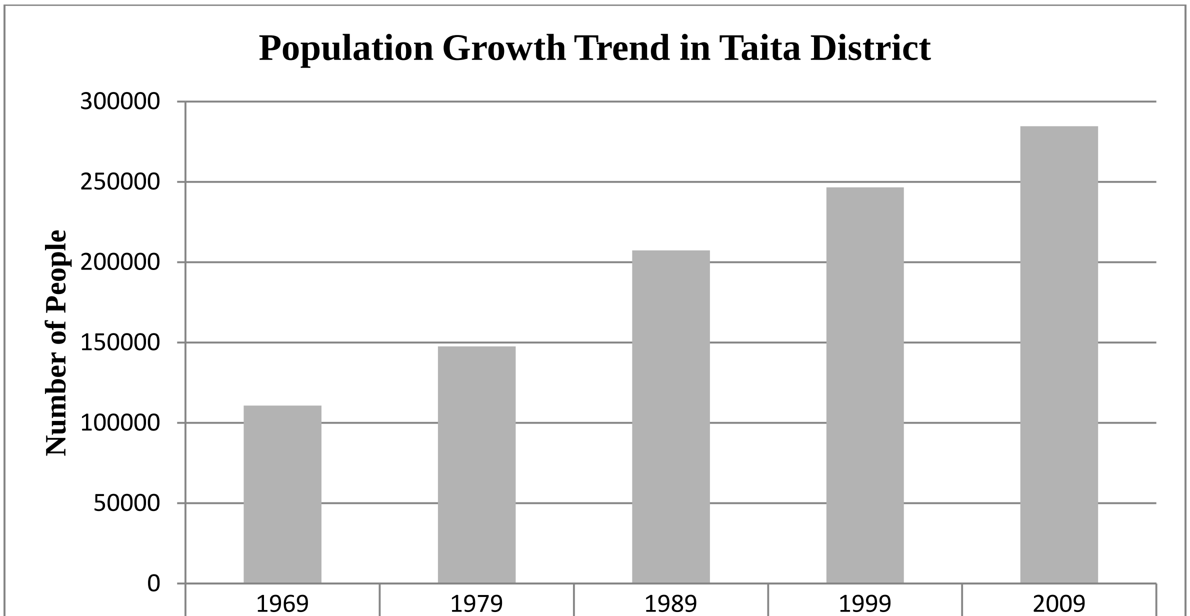
While this study does not serve as a critic of the Kenya government policy, the findings of this study show that whilst the government has introduced a policy on the encouragement of cultivation of the high value traditional crops in the country as a means of coping with the impacts of climate variability in the Arid and Semi Arid lands in Kenya, their production is greatly hampered in the Taita Hills. The sampled households indicated that these crops whilst being suitable for use as food during the dry season, they are being attacked by giant rats and moles which lower their yield significantly. Furthermore, millet, which does well in the lowland areas of Mwatate, is not preferred due to taste preferences; therefore farmers who grow it have no immediate market for their produce. As a result, with the government policies encouraging the growth of the high value traditional crops and the provision of free seed to encourage the implementation of this initiative, smallholder farmers are planting crops that are highly impacted by the pests thus compromising their food security. Consequently, the smallholder farmers' vulnerability to the impacts of climate change is increased.

Furthermore, the focus group participants reported that whereas they are advised to get seed from the local government offices, the seeds are not delivered in time. This then poses a challenge in some of the adaptation strategies undertaken such as dry planting. Moreover, the focus group participants reported that at times the seeds that they are given were reported to be unsuitable for the altitudinal gradients where the farms are located. It emerged that the smallholder farmer has had too many seed varieties given to him to plant in different cropping seasons without adequate information on the best seed within the different rainy seasons.

The focus group discussion participants reported that extension services in the Taita Hills had become demand driven. Consequently, the flow of information from the extension workers to the farmers is inefficient. Furthermore, they do not get advice on time regarding the type of seed to plant and when to plant it, thus increasing their vulnerability to the impacts of climate variability and change. The Food and Crop situation report for Mwatate (2012) states that the ratio of extension officers to the farmers is 1:805, which is not efficient for information dissemination to the farmers.

4.5.4 Family Structure and Dependency Ratio

The Taita Taveta District Deveopment Plan for 2005-2009 states that population in Taita County has been increasing steadily in the past 40 years (Figure 17). In 1999, the total labour force was only 11, 952 which is approximately 4.86% of the total population. This was projected to increase to 132, 669 in 2012 with the majority of the active labourers being women. The age group for the active labour force is between 15 to 35 years (Taita Taveta District Development Plan 2005-2009)



	1969	1979	1989	1999	2009
Population	110742	147597	207273	246671	284657

Figure 17: Depiction of Population Numbers for Taita Taveta County from 1969-2009 (Taita Taveta District Development Plan 2005-2009)

Data from the 2009 census for the Taita County shows that the number of children in the county exceeds the number of middle age and presumably more productive population (Figure 18). This exerts pressure on the productive population as children require more in terms of food, education, health services and nutrition. Consequently, this increases their vulnerability to the impacts of climate change.

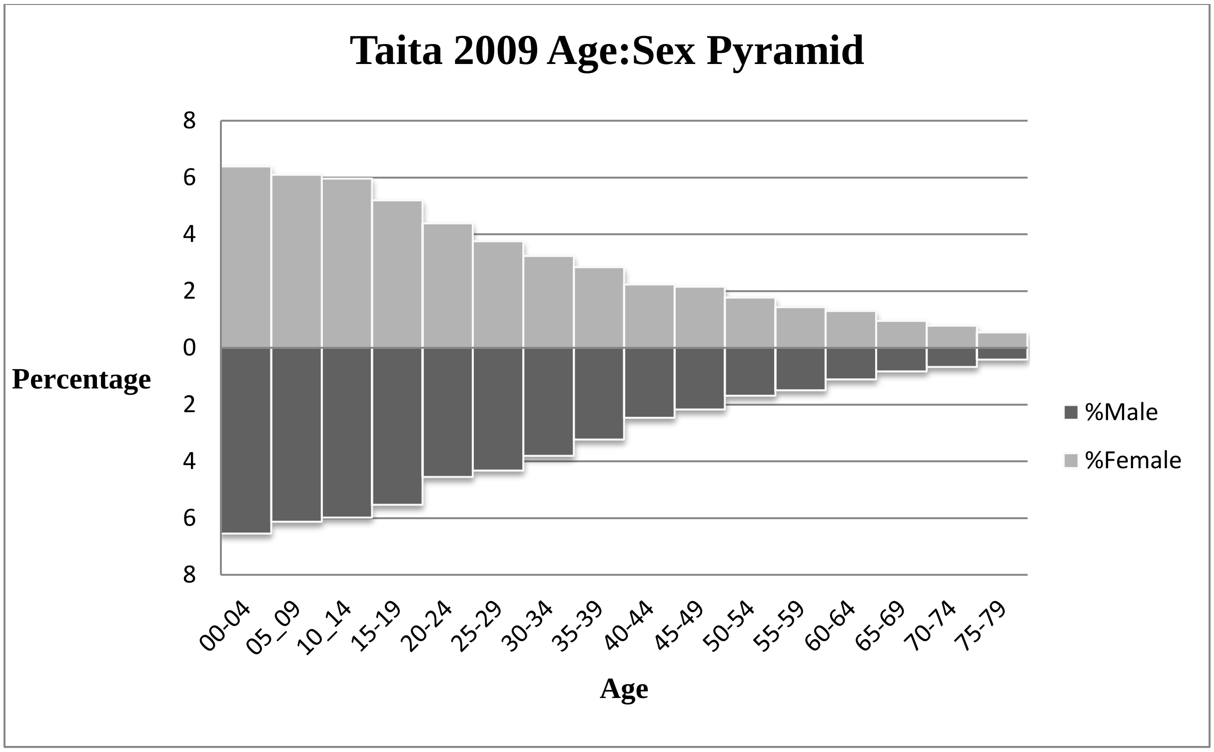


Figure 18: Age: Sex Pyramid of Taita County based on the 2009 Population Census (GoK, 2010)

Age structures that constitute high proportions of children and elderly people are detrimental to the social and economic development process. Therefore, this increases the vulnerability of households to climate variability and change impacts. This is attributed to children and elderly people requiring a lot of general health care, sufficient and nutritious food, clothing and education for the children, yet they are almost unproductive economically. Additionally, high dependency ratio impacts negatively on savings and investments of the household.

The family structure in the Taita Hills is unique in that culturally, when a son gets married, he is allowed to move back into the household to enable his mother to train his wife on how to raise a family. This differs significantly from other cultures such as the Kikuyu and Luhya where the son is expected to move out and fend for his family. For the duration that they live with the family, the son's family is dependent on the parents. Furthermore, the focus group participants explained that due to the small farm sizes, sons could not get allocated land to build thus they continued to live in their parents' home while adding to the family labour on the farm. Additionally, the vulnerability of some households was increased due to parents supporting both their children and grandchildren. However, analysis of the data collected from the sampled households show that the number of dependants per household is less than four for most households. The focus group participants explained that culturally, large family sizes were encouraged as sources of labour and they were considered as a sign of blessings from God.

Table 8: Number of Dependants in Sampled Households in the Taita Hills in July 2013 (N=285)

No. of Dependants	Mwatate	Josa	Wundanyi	Werugha	Mgange Nyika	Mwanda	Total
0	6	3	4	3	6	13	35
1	6	5	5	5	7	6	34
2	9	10	10	8	9	7	53
3	9	8	7	14	5	9	52
4	4	7	9	11	9	6	46
5	5	4	4	4	5	5	27
6	5	2	6	4	3	1	21
7	0	1	1	0	2	1	5
8	1	1	0	3	0	1	6
9	1	1	1	0	1	0	4
10	0	1	0	0	1	0	2

4.5.5 Farming Practices

The cropping cycle in the Taita Hills is quite intensive allowing no fallow periods in between cropping seasons. Farm preparation and harvesting often coincide and this leads to soil exhaustion. Figure 19 and 20 show the seasonal calendar for Dembwa that portrays the interlocking cycle of the farming practices in the Taita Hills. The farmers practice repeat cropping with some reporting that they adopt rotational cropping during some of the seasons. The Food and Crop Situation report concurs with this observation (Table 9) which shows the continuous cycle of the cropping seasons in the Taita Hills. This poses several challenges such as insect specialization on crops, decline in soil fertility and soil exhaustion. Additionally, some of the farmers reported that they move to the river basins to farm during the dry season. This is a detrimental practice in that it degrades the river basin causing alteration in the course of the river and reduction in stream flow amounts. Access to water is an important factor in reducing vulnerability to climate change impacts in agro-ecosystems. With the unsustainable use of water upstream by households bordering rivers, the capacity to adapt to climate change impacts will be hindered by lowered stream flow amounts and alteration of stream courses.

Table 9: Seasonal Calendar of Farm Activities for the Taita Hills

Quarter	Activities
First Quarter **January to March**	• Harvesting of previous years short rain crop • Post harvest management of harvested crop • Land preparation in readiness for the long rains
Second Quarter **April-June**	• Completion of land preparation • Planting • Weeding • Pest and disease control • Harvesting of crops planted early in the season
Third Quarter **July- September**	• Planting of maize and beans in the upper zones • Land preparation in the lower zones • Storage and post harvest management of harvested crop • Land preparation for the short rains
Fourth Quarter **October-December**	• Land preparation for the short rains continues/starts • Planting • Weeding • Pest and disease control

(Adapted from Mwatate Food and Crop Situation Analysis 2012)

It emerged that there has been a disruption to the seasonal calendar as some of the adaptation practices involve early planting and irrigation of crops as the smallholder farmers' await the onset of the rainy season. This is discussed in detail in section 4.6.1.1.

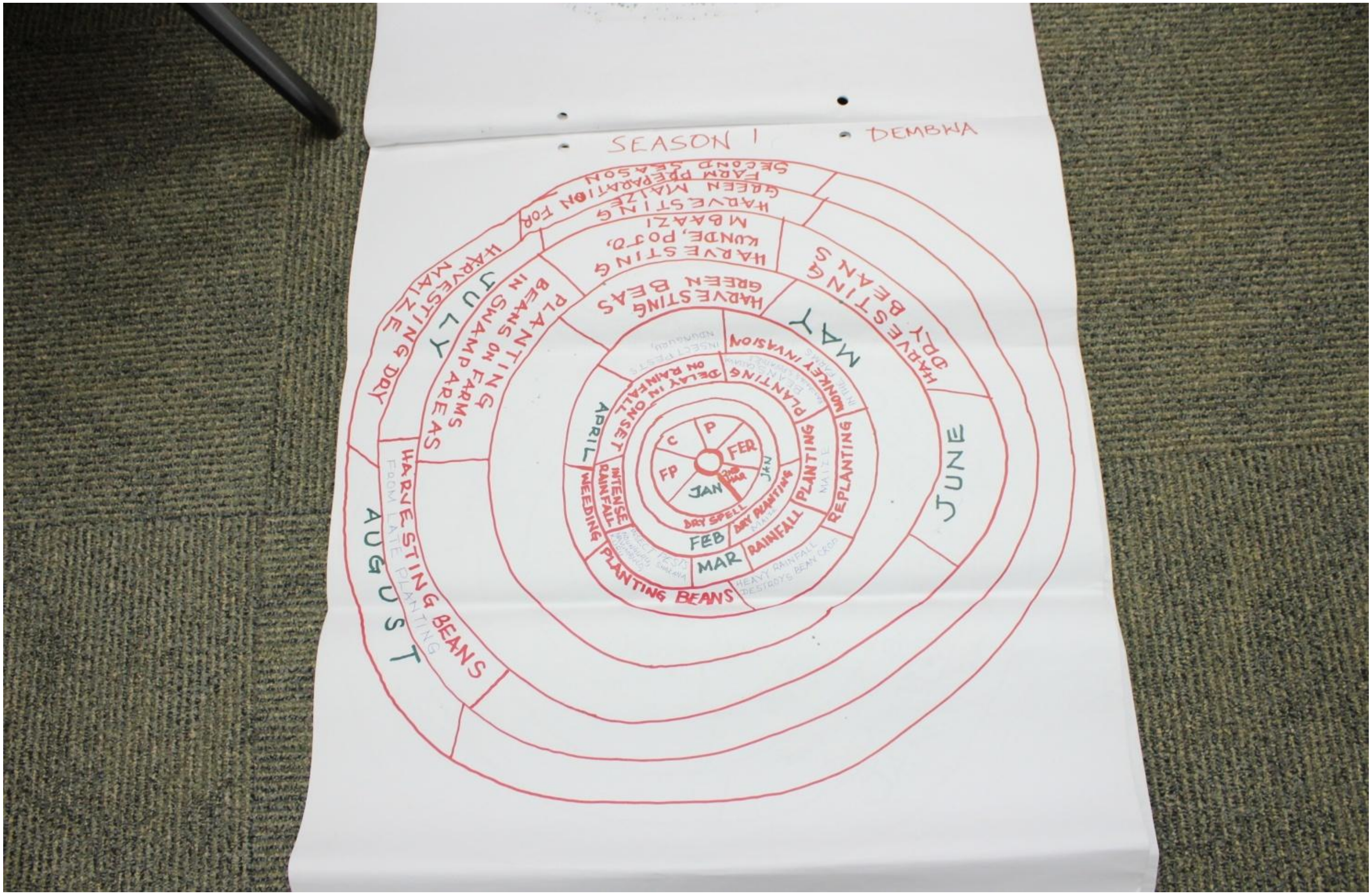


Figure 19: Seasonal Calendar for January-August Farm Activities Developed by Focus Group Participants in Dembwa

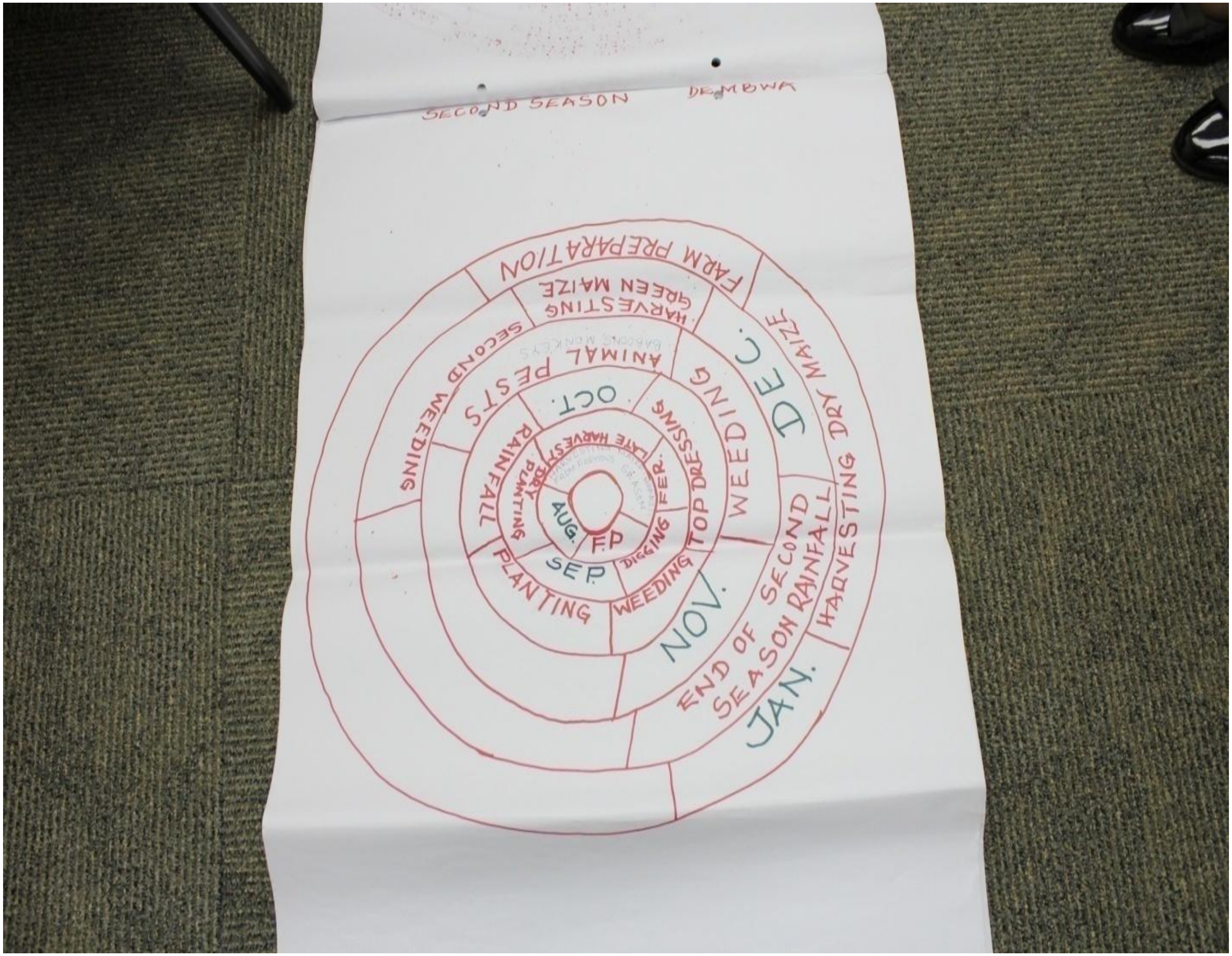


Figure 20: Seasonal Calendars for August to January Farm Activities Developed by Focus Group Participants in Dembwa

4.5.6 Household Food Insecurity and Dependence on Maize Farming

Household food insecurity is also perceived to be high, with 66.42% of the households indicating that in the past 10 years, they have had challenges in feeding their families. The main cause of the household food insecurity was attributed to unreliable rainy season, poor harvest and the consequent lack of enough surplus food to store for the dry season. Additionally, reliance on only one source of income was cited as a contributing factor to household food insecurity. Furthermore, majority of the households in the Taita Hills depend on maize as their staple crop despite the impact of climate variability on the crop. Maize crop requires approximately 800 mm of water with temperatures above 24^{o}C to flourish but approximately 300mm of rainfall is received in the lowlands during the cropping season.

4.5.7 Access to Water

Water is vital for agricultural productivity which the households mainly rely on yet their access to it is limited. The Taita Development Plan for 2008-2012 reveals that the distance to water sources varies during the wet and dry seasons. The Development Plan notes that the wet season, the average distance that households travel to get water is about 1 kilometre whereas during the dry season the distance lengthens to 1.5 kilometres (Figure 21). However the Drought Monitoring report of 2013 notes that the average return distances travelled by the households to access water is 2.03 kilometres for year 2013 while the long term average from year 2006 -2012 is 2.84 kilometres. The longest average return distance travelled during the dry season is in August, which is noted as 3.8 kilometres to the source of water.

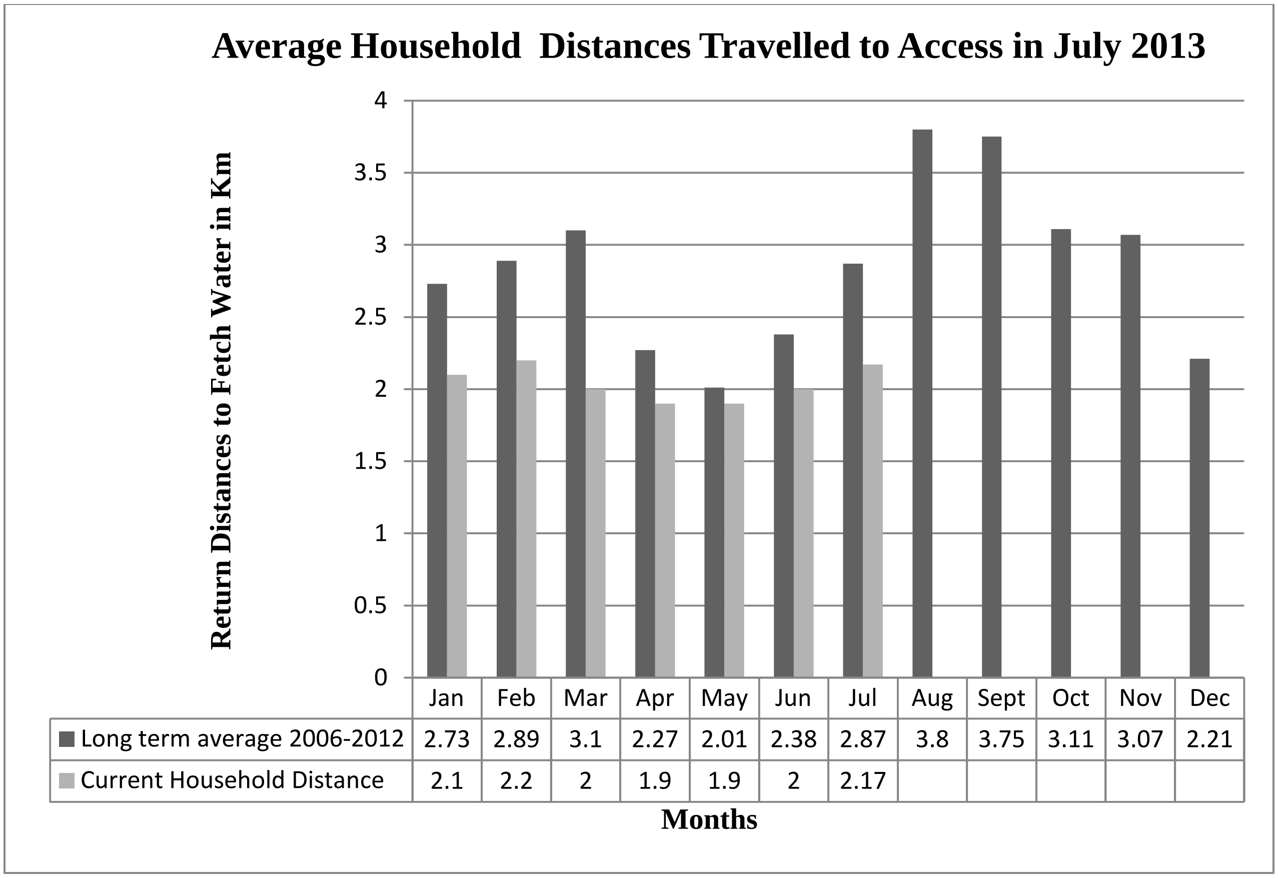
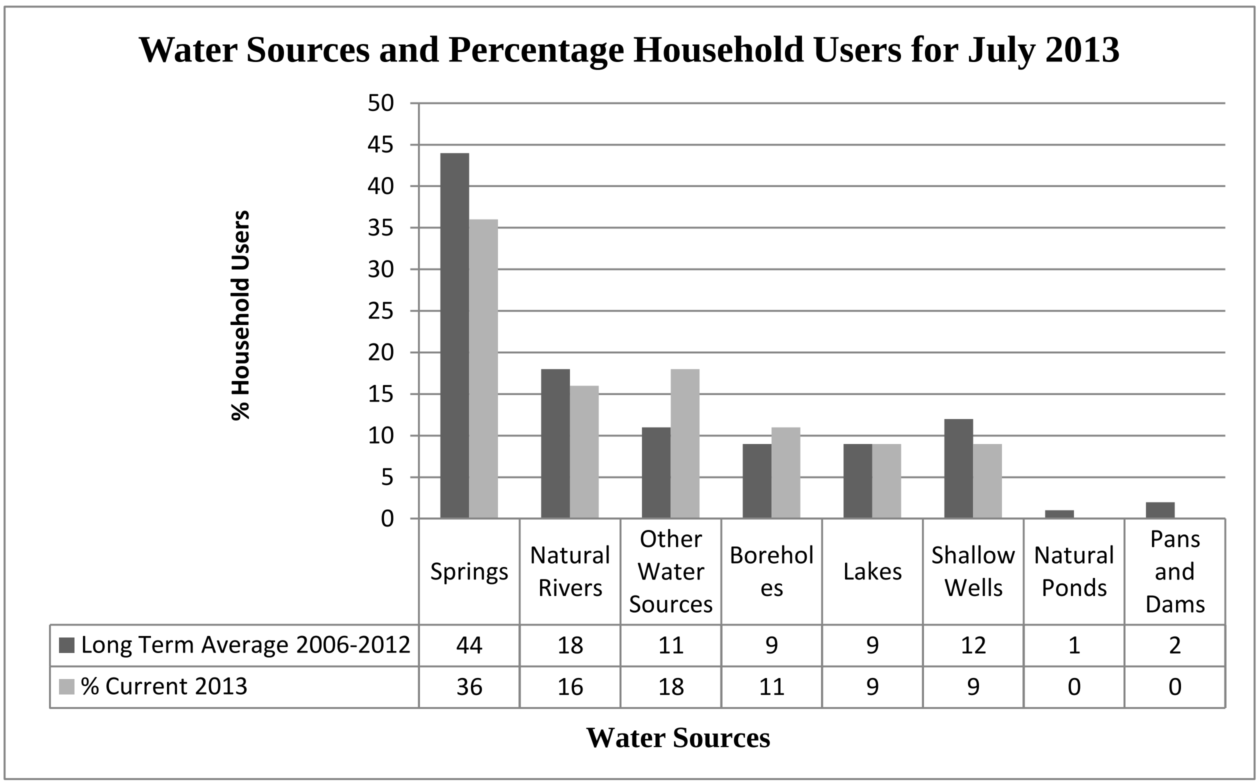


Figure 21: Average Household Distances travelled to Access Water

From the focus group discussions it emerged that for the households with tapped water, the use of the water is regulated by the local administration and the water services board making it illegal to use the water for small scale irrigation. Additionally, it was reported that where the farmers used it for their kitchen gardens, the availability of the water was wanting as the water was rationed. In Mwatate, it was reported that although water pipes had been fixed in the households, the water supply had stopped in 2011.

In the lowland areas of the Taita Hills like, Mwatate, Mwachabo, Kishushe and Kishamba, the lack of water in the area results in human-wildlife conflict. For households that have created water ponds, the wild animals invade their homesteads to access the water and in turn damage their crops as well.

The Taita Hills acts as the water tower for the Taita region. Due to their high altitude, the Taita Hills receive higher rainfall than the lowlands which results in the lowlands experiencing water stress. Taita District has 16% of the households with piped water connections (9% accounting for water that has been piped into dwellings) and there are about 40 boreholes distributed across the district. According to the 2009 housing and population census, 52% of the households derive their water from rain harvesting. River bed degradation has occurred as a result of cultivation on the steep slopes and indiscriminate felling of trees which has resulted in rivers drying up coupled with cultivation of crops on the river banks. Figure 22 depicts the percentage of households that utilize the available water resources. It emerges that the utilization of springs and natural rivers has reduced in the county. The focus group participants stated that their use of spring water and perennial rivers had declined due to the low recharge levels occasioned by declining rainfall.



	Springs	Natural Rivers	Other Water Sources	Boreholes	Lakes	Shallow Wells	Natural Ponds	Pans and Dams
Long Term Average 2006-2012	44	18	11	9	9	12	1	2
% Current 2013	36	16	18	11	9	9	0	0

Figure 22: Percentage of users of water resources in Taita County from 2006-2012 (Taita Taveta County Early Warning System (EWS) Bulletin July 2013)

4.6 Climate Change Adaptation Strategies in the Taita Hills

68.21% of the respondents indicated that they have taken up climate change adaptation strategies to cope with impacts of climate variability and climate change while 30.35% indicated that they had not taken up any adaptation strategies with the remaining 1.42% giving no response to the question on climate change adaptation strategies. The adaptation strategies in use in the Taita

Hills are both reactive and anticipatory. The adaptation strategies that have been identified to be in use in the Taita Hills relate to their perception of climate change such as decline in rainfall amounts, increased temperature, increased occurrence of insect pests and diseases, declining soil fertility and the overall farm productivity. The strategies therefore inform both the current and past adaptation practices that were utilized.

4.6.1 Farm Water Management

Water availability is a critical issue for the households in the Taita Hills especially for the households in the lowland areas of Mwatate, Mwachabo and Kishamba. The impacts of accessibility to water were discussed in Section 4.5.7. The lowland areas of the Taita Hills have been reported to receive below average rainfall amounts which necessitate appropriate water management strategies to be used. Focus group participants reported that there has been a decline in the levels of water in their streams. Piped water is available in some areas of the Taita Hills but the water management company has declared it illegal to use the water for irrigation purposes. Despite this knowledge, 48.41% of the households stated that they have not taken up farm water management as an adaptation strategy. The climate change adaptation strategies put in place by the remaining 51.59% of the respondents with regards to farm water management include; rain water harvesting using tanks which are connected to the gutter of iron roofed houses. This adaptation strategy is however limited to households that have iron roof sheets for their roofs and households with grass thatched houses. However, from the household survey conducted, only 22.22% of the households harvest rain water for irrigation. The water tanks were reported to be for household domestic chores and for watering livestock.

Water harvesting is carried out by the households but mainly for household use. However, 5.16% of the households reported that they have dug boreholes in their farms for irrigation purposes. In areas such as Mwanda, trenches have been dug to control the flow of water and bananas planted in the trenches to utilize the flood water that runs through their farms during the rainy season. It is evident that ground water is under utilized in the Taita Hills. For the low altitude agro-ecological zones, the focus group participants explained that digging of shallow wells increased the levels of human-wildlife conflict, as wild animals would invade their farms during the dry season in search of water.

Indigenous knowledge on farm water management entailed the use of trenches which were dug from the river to the farm. The farmers would agree on where the trenches would pass through the farms and the flow of water would be regulated on a daily basis to ensure equitable distribution of the water among the households. Additionally, trenches were dug at the end of the bench terraces to trap rain water which was utilized to store water for a short time after the cessation of rainfall. The focus group participants reported that the trenches could only store water for a maximum period of two weeks after the cessation of rainfall and as such was not a sustainable means of irrigating their crop.

4.6.1.1 Early planting and irrigation before the onset of the rainy season

Early planting and irrigation/watering of crops before the onset of rainfall occurs in the Taita Hills as an adaptation strategy to the unpredictability of the rainy seasons and the early cessation of rainfall. Land is prepared early and dry planting is carried out. The focus group participants explained in that is done to ensure that the maize crop is past the tasselling stage by the time the rains cease mid season. It was reported that farmers who use this adaptation strategy have a better chance of their maize reaching maturity than those who rely solely on rainfall.

Table 10: Current Farm Water Management Strategies of Sampled Households in July 2013 in the Taita Hills *(N= 252)*

Farm Water Management Strategy	Mwatate	Josa	Wundanyi	Werugha	Mgange Nyika	Mwanda	%
Irrigation	1	12	12	11	11	9	22.22
Water pan/hole	2	1	1	4	4	1	5.16
Water tank	2	0	0	8	8	0	7.14
Terracing and Digging trenches	0	8	13	0	8	7	14.29
Digging Furrows	5	0	0	0	0	0	1.98
Kupanga milulu	0	0	1	0	0	0	0.40
Zai pits	1	0	0	0	0	0	0.40
None	29	8	15	20	20	30	48.41
No response	0	8	0	0	0	0	

4.6.1.2 Zai Pits

Zai pits (Figure 23) are utilized in the lowland areas for water conservation. The pits which measure 75cm by 75cm by 45cm are recommended for nine (9) maize plants or alternatively 60 cm deep by 60 cm diameter for five (5) plants. The top soil is then returned and mixed with manure in 4:1 ratio and mixed with water. In the lowlands of the Taita Hills, the farmers plant five seeds per zai pit. The plants then utilize the water in the pit for growth, thereby ensuring that even in the event of early cessation of rainfall, the plants still have adequate water for germination.

Figure 23: Zai pits at the preparatory stage (Bev Abma 2007)

The zai pits are advantageous in that they trap litter and fine sand during the dry season. The zai pits collect and concentrate water at the plant thereby reducing the risk of water stress in areas that experience erratic rainfall patterns such as Mwatate. The focus group participants noted that the zai pits if well prepared last for up to 2 seasons without the need for additional manure. Furthermore, they noted that the zai pits increased the chances of survival for their maize crop during periods of drought. They however noted that due to the amount of labour required in the preparation of the pits, most farmers did not prepare them well due to the amount of time involved for the supervision and the attendant costs for hiring casual labour for the preparation. This was clearly portrayed when only one farmer stated that he has zai pits on his farm during the household survey.

4.6.2 Soil Conservation Techniques

Soil conservation is important in the Taita Hills due to factors such as slope and lack of vegetative cover which accelerate the rates of soil erosion. The household survey revealed that farms located on the hillsides of the Taita Hills in areas such as Mwanda, Werugha, Wundanyi and Josa, consider bench terracing (Figure 24) as an important soil conservation technique.

Figure 24: Bench terracing on a steep slope in the Taita Hills (Himberg, 2009)

Additionally, napier grass is planted on the terraces to fortify them from breaking apart in the event of heavy rainfall. Traditionally, the bench terraces would be fortified by planting *ngiga* an indigenous shrub that would trap the soil as it moved down hill therefore creating the terraces. Some participants of the focus group discussion explained that they still use this method on their farms for soil conservation. On the other hand, the lowland areas conserve their soil through digging of trenches (Figure 25) to direct the flow of water and conservation tilling referred to as "*kukwangura mchanga"* as it does not entail the turning of the soil.

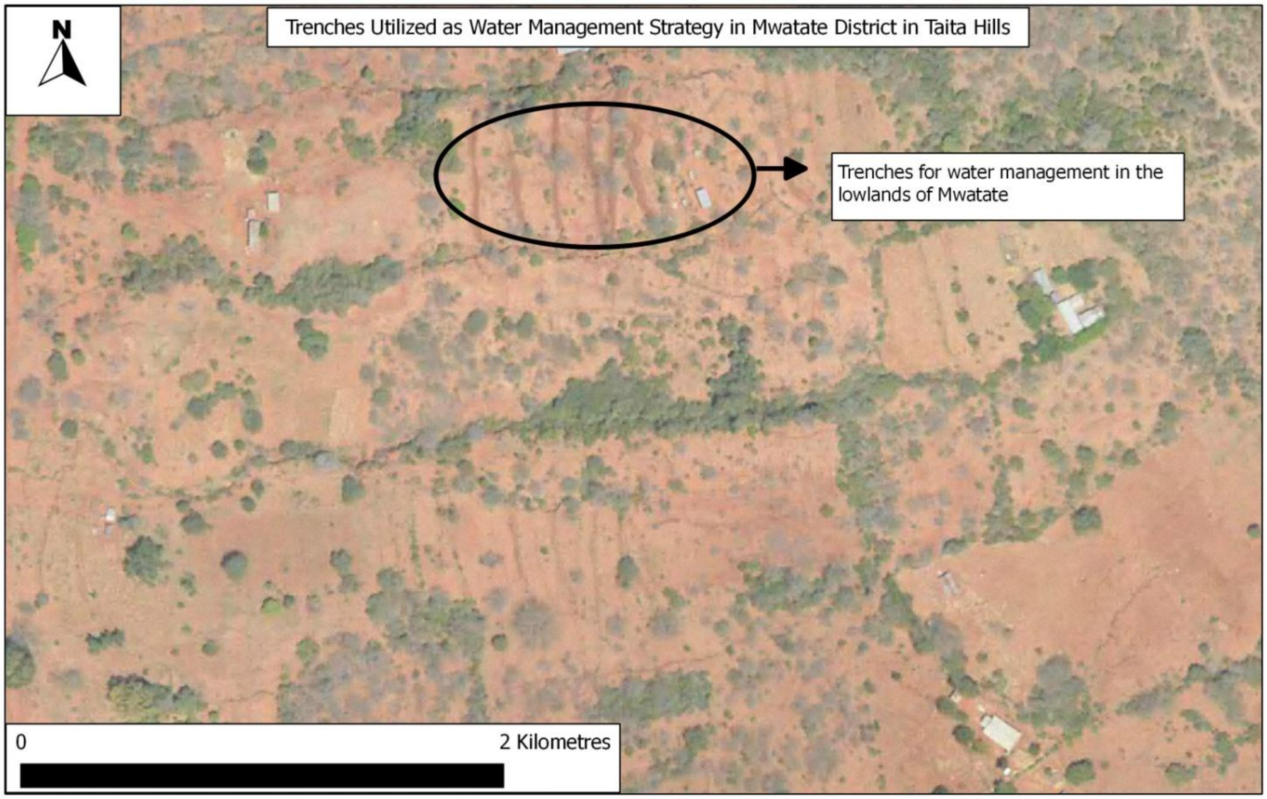


Figure 25: Orthophoto map of Mwatate showing trenches utilized as farm water management and soil conservation strategies (CHIESA 2012)

4.6.2.1 Kupanga Milulu

"Kupanga milulu" is a traditional method that was used to prevent soil erosion and at the same time promote retention of soil moisture. It entails arranging weeds and other dry stalks of plants on the farms to slow down the movement water during the rainy season. It is similar to mulching in that it helps to cover the soil after land preparation thus preventing the loss of soil moisture. It emerged that this method is still being used by farmers who practice early land preparation to help them prevent their soil from drying up as they await the onset of the rainy season. This is particularly useful for adapting to the early cessation of rainfall as the soil water moisture is maintained.

4.6.3 Diversification of Income

The diversification of income activities in the Taita Hills included livestock rearing and fish farming.

4.6.3.1 Livestock Rearing

Cattle rearing carried out through zero grazing has emerged as a strategy of climate variability adaptation to the impacts of climate change in the Taita Hills. This has been occasioned by the successive loss of their maize crop due to prolonged dry seasons and inadequate rainfall amounts. There has been a reported shift from rearing the indigenous zebu cattle to cross bred and pure dairy breeds like jersey and freshian. Zero grazing has been undertaken as an adaptation strategy because of the small farm sizes and decline in natural pastureland. The farmers grow their own napier grass and substitute the fodder with cattle feed and the stalks of dried maize. Cattle rearing was reported to be more profitable than maize cultivation because milk yield was not dependent on rainfall. The benefits that the households derive from cattle keeping are fourfold: milk for domestic consumption, manure production, biogas and security for loans. Furthermore, they stated that, with cattle rearing, they were assured of an income for their families, which they could use to buy maize in case of crop failure.

4.6.3.2 Fish farming

From analysis of aerial photographs of the Taita Hills, it emerged that some households have taken up fish farming (Figure 32) as an adaptation strategy to climate change and as a means of earning supplemental income for the household. The focus group participants explained that some of the fish ponds had been set up by community self-help groups and Nongovernmental Organizations (NGOs) working in the area. Fish farming serves a dual purpose of providing the household with income while at the same time ensuring that there is variation in the household diet through provision of alternative source of protein.

4.6.4 Planting Early Maturing Seed Varieties and Drought Tolerant Crops

In order to adapt to the inconsistent and unpredictable rainy seasons, farmers in the Taita Hills have switched to early maturing seed varieties according to their farm location along the altitudinal gradients. In the lowlands, Dryland Hybrids, Pwani Hybrids which mature in 2-3 months are preferred by the farmers. Additionally, legumes such as pigeon peas and cowpeas and pulses such as green grams are grown because of their ability to withstand water stress. From the focus group discussions it emerged that following the government policy to encourage cultivation of high value traditional crops such as millet, cassava and sweet potatoes, some of the farmers present had received free seed to facilitate the implementation of this policy. However, they reported that delivery of the seed to the farmers was delayed and for the farmers who cultivate the millet to maturity, there was lack of a good market due to the taste preference of the Taita who prefer maize. Furthermore, the tuber crops were affected by giant rats and moles which reduced their yield substantially.

4.6.5 Land Use

The households in the Taita Hills use their knowledge of the seasons and the resultant implications on the use of their land according to altitudinal gradient. 41% of the households stated that they have hired farms in other areas to take advantage of the different climatic variations and availability of land. Households in the highlands have either bought or hired land in the lowlands to take advantage of the ability to plant different crops at the same time of the year. Focus group participants reported that this ensures that despite crop failure in one ecological zone, the chances of total crop losses in both areas is minimized. Moreover, having parcels of land in different agro-ecological zones allows them to diversify the type of crop they plant on their farms. The reasons given for owning or hiring land in different agro-ecological zones included;

- Availability of large land acreage in the lowland areas unlike the smaller land parcels in the highlands
- The characteristic level topography of the lowland areas of Mwachabo and Mwatate allow for intensive cultivation through the use of tractors.
- Inheriting land located in the low attitude agro-ecological zones.
- Avoidance of human-wildlife conflict in areas where wild animals destroy their crops on the farm.

4.7 Climate Change Coping Strategies used for Adaptation to Climate Extremes

The household respondents were asked to identify the climate extremes that they had witnessed in the Taita Hills and the resultant coping strategies that they had taken up. Their responses are summarized in Table 11.

Table 11: Summary of coping strategies utilized during climate extremes in the Taita Hills

Climate Extreme	Coping Strategy Employed
Drought	Planting early maturing maize seed variety
	Planting pigeon peas, cow peas and green grams because of their ability to withstand water stress
	Using zai pits for the cultivation of maize in the lowlands
	Seeking wage labour to gain income for the households
	Irrigation of crops on the farm
	Early planting and irrigation
	Livestock rearing especially zero grazing of animals and chicken rearing
	Taking part in food for work initiatives by NGOs
Floods	Digging trenches and terracing
	Replanting damaged crops in the farm.
Strong Winds	Planting trees

A transect walk of the Taita Hills was carried out to document the existing on-farm climate variability and change adaptation strategies along different altitudinal gradients (Table 12) The climate change adaptation strategies employed in the household correspond with the slope of the land and the perception of amount of rainfall received. Most of the adaptation strategies employed were taught to the households by members of Nongovernmental Organizations (NGOs) such as World Vision which are operational in the area and from agricultural extension officers. Some of the households reported opportunities that have occurred due to climate change, for example, the smallholder farmers' in the lowland areas, explained that they had taken up greenhouse farming due to the prevailing uncertainty in rainy seasons. Other smallholder farmers reported having increased the number of livestock they zero graze while reducing the acreage under crop production. Consequently, they have had the added benefit of starting biogas production on their farms.

Table 12: Cross-sectional table of results of Transect Walk in the Taita Hills

	START					END
	Mwatate	**Kipusi**	**Dembwa**	**Mbengonyi**	**Mghange Dawida**	**Mwanda**
Land Use	**Farmland** **Pasture land**	**Farmland**	**Farmland**	**Farmland**	**Farmland**	**Farmland**
Cropping System	Mixed cropping	Mixed cropping Rotational Cropping	Mixed cropping seasonal rotational cropping	Mixed cropping Seasonal mono cropping Rotational cropping	Mixed cropping	Mixed cropping Seasonal rotational cropping
Crop and Vegetation	Maize, green grams, cow peas, pigeon peas	Maize, cow peas, beans, kales, tomatoes, bananas , sugarcane	Vegetables, maize, beans, sugarcane cassava, pigeon peas, pineapples, bananas	Maize, beans, cassava, sorghum, bananas, avocado, kales, mchicha, millet	Maize, bananas, kales, cassava	Maize, beans, bananas, sweet potatoes, pumpkins, avocadoes, irish potatoes
Soil Conservation Strategy	Conservation tilling, digging trenches	Digging trenches	Bench terraces and trenches	Mulching, terraces stabilized with napier grass, fallowing land	Bench terraces stabilized with napier grass	Terracing, mulching and planting napier grass
Water Management Strategy	Zai pits, digging trenches	Zai pits, water trenches and water pans	Small scale irrigation using pumps; tapped water is available	Rain water harvesting for household and farm use	Rain water harvesting for small scale irrigation	Trenches for water harvesting and planting bananas in the trenches
EBA Strategy	Goat rearing Zai pits Poultry keeping Planting early maturing and drought tolerant crops	Zai pits, cover cropping and digging trenches	Zero grazing, rotational cropping, early dry planting and irrigation	Zero grazing Dry planting and irrigation	Irrigation and zero grazing	Terracing and zero grazing
Problems	Inadequate rainfall Human/wildlife conflict (elephants) High temperatures	Inadequate rainfall	Human-wildlife conflict (monkeys) Moles affecting tuber crops Failing maize crop	Maize stem-borer Human-wildlife conflict (monkeys) Moles attacking banana crop	Insect pests e.g. maize stem-borer and leaf miner on vegetables Moles and giant rats affect tuber crops and bananas	Sudden cessation of rainfall Lack of extension services
Opportunities	Zai pits afford continuous production of maize	Green house farming on some farms	Biogas production Farm yard manure production	Biogas production	Vegetable farming Fish ponds Farm yard manure	Zero grazing Fruit farms

4.8 Indigenous Local knowledge on Climate Change Adaptation

Indigenous local knowledge is an important factor in the Taita Hills for climate change adaptation as it helps households to cope with the impacts of climate change adaptation strategies using methodologies that are easily available to them and do not require professional expertise to utilize and are culturally acceptable. The indigenous knowledge on climate variability and climate change adaptation comprises of traditional weather forecasting using environmental indicators or bio-indicators and food preservation techniques for use during the dry season. Additionally, the households have indigenous knowledge on seed preservation for use in the farms in the successive season. Furthermore the households possess knowledge on traditional farm water management techniques, soil management and traditional agricultural practices that supported them during periods of rainfall inadequacy.

4.8.1 Traditional Weather Forecasting

Indigenous local knowledge on weather forecasting stems from years of observing their environment and noting changes that occurred during the change in seasons. The focus group participants in 6 locations in the Taita Hills indicated that this knowledge was passed on from generation to generation and therefore changes in the environment were noted to detail indicative of prevailing weather conditions. The environmental indicators portrayed the onset or cessation of the rainy season and this was particularly important for the farmers to know when to start their land preparation activities. Table 13 summarizes the environmental indicators identified by the focus group participants and the indicative changes in the season.

In the Taita Hills, the traditional weather forecast is preferred over the modern weather forecast due to:

- The timeliness of the forecast; a farmer can make his own observation and make use of the information when it is needed.
- Consultation with experts is not necessary as the interpretation skills of the indicators are available within the local households.
- The indicators observed in their immediate environment provide more accurate information than forecasts interpolated from data of the weather stations based far away and on different agro-ecological zones.

Table 13: Environmental Indicators for Traditional Weather Forecasting

Indicator	Local name	Scientific Name	English Name	Observation	
				Dry Season	**Wet/Rainy Season**
Plant Indicators	*Mlungu*	*Erythrina abyssinica*	Flame Tree *[Red -hot pocker tree,Lucky bean tree)*	Shed its leaves during the dry season	Acquired new leaves at the onset of the rainy season
	mvumbu	*Ficus thonningii*	Strangler fig	Shed its leaves during the dry season	Acquired new foliage at the onset of the rainy season
	Pambare	*commiphora sp*	Commiphora	Yellowing of leaves signified reduction in rainfall	Acquisition of new foliage indicated the onset of the rainy season
	Kilulu	*Ficus sp*	Fig	Shedding of the leaves at the onset of the dry season	Acquisition of red leaves at the onset of the rainy season
Animal/Bird Behaviour	Ng'ombe (ndama)		Calf/ cow		Livestock continuously sniffing the air and jumping about.
	mashanda	*Centropus s.superciliosus*)	White –Browed Coucal	Its cry was not heard during the dry season	Hearing the cry of the white browed coucal indicated the onset of the rainy season
Local Environmental Occurrences	*Ukungu*		Fog		Fog moving from the valley to the highlands
	Theluji		Snow		Spotting of snow on Mt. Kilimanjaro
	Mwezi		Moon	The tips of the crescent were pointing to the right or to the left, the side on which they faced would have a potentially dry season ahead	The pointed tips of the crescent moon were facing upwards, this indicated a potentially wet season ahead (it also indicated good omen for the community),
	Upinde wa mvua		Rainbow	Rainbow appearing during the rainy season indicated the cessation of rainfall	-
Indicator insects and amphibians	*Vitona maji*	*Cercopoidea*	Spittle bugs		Presence of spittle bugs which drip a liquid substance when attached to the surface of leaves of trees
	Chura		Frogs		At the onset of the rainy season frogs croaked in the marshy areas
	Siafu		Ants		Ants coming up to the surface of the ground and infested houses at the onset of the rainy season
	Vipepeo		Butterflies		Butterfly migration into the area indicated onset of rainy season
	Nyuki		Bees	Bees moved away from the area at onset of dry season	Bees moving to the area indicated the onset of the rainy season.

4.8.2 Seed and Food Preservation

Seed and food preservation is an important coping strategy in the Taita Hills. Traditional practices on seed preservation entailed hanging of the harvested maize cobs above the fireplace to dry. The soot from the fireplace would coat the maize and the heat would dry it slowly thus preventing insect pest attacks on the maize. Additionally, beans were preserved by mixing them with ashes and storing them in an air tight container. This would then be used as food during the dry season when farm productivity was hindered or reduced and it would also serve as seed for the succeeding season. In this way the household ensured that it had food and seed for the next season thus reducing their vulnerability to climatic variability. Harvested vegetables were boiled for a short while and then sun dried and stored in an airtight container. This ensured that the household had food when the rainy season failed. These methods of seed and food preservation are still in use in the Taita Hills.

4.8.3 Insect Pest Control

The focus group participants explained that traditional methods such as sprinkling of ash on affected crops were used for insect pest management. Additionally, filling the holes made by the maize stem-borer with soil was used as a technique for the control of the stem-borer pest. Insect pest management ensures that they have good yield at the end of the season, sufficient for storage, sale and household use. Ash was also used as a post harvest storage technique for bean seeds and peas.

4.8.4 Farm Water Management and Soil Conservation Techniques

Farms that border rivers would dig boreholes on their farms usually near the river bed to ensure water percolation onto the farm. In the case of large streams with adequate flow, the furrow, mukoa, mkuwa are led direct from the stream to the fields. If necessary a small dam able to hold about 80 to 100 cubic metres of water are used to check and divert sufficient water flow to the farm. Small springs were also exploited through the use of collecting basins known as *ndiwa.* These basins had a capacity of approximately 70 cubic metres and were built into a slope at the bend of the stream. The outer side had a built up wall and an outlet pipe made of a hollowed out log directed the water through the farms (Plate 1)

Plate 1: Traditional Bamboo Water Piping (Himberg 2009)

The households explained that indigenous soil conservation techniques, involved planting *ngiga* an indigenous shrub that would prevent soil erosion and cause the formation of terraces with time. Additionally, practices used by the households in the Taita Hills in adapting to climate variability and change include manure application, bench terracing, loosening of soil an creation of bunds or drainage channels. They reported that the mounds are an adaptation strategy to help reduce the effects of prolonged dry season on their tuber crops. Matured roots and tuber crops are also left in the mounds until it becomes favourable to harvest as a way of adapting to either drought or flood. Manure is also used by many households in adapting to the effects of climate change and variability. Manure was found to be mainly in the form of cow dung that had been cured in the sun and dried maize stalks and farm refuse that had been decomposed. The use of manure by smallholder farmers is perceived to be effective and less costly in terms of improving soil fertility as a result of erosion emanating from floods and other extreme weather events. Some farmers also reported mixing the manure with synthetic fertilizer to enhance soil fertility.

4.9 Ecosystem-based Adaptation Strategies in the Taita Hills

Climate variability and change strategies in use in the Taita Hills were identified as conforming to EBA practices by comparing them to the basic principles of EBA. From the definition of Ecosystem Based Adaptation it emerges that the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. For a climate change adaptation strategy to qualify as an EBA strategy, it must satisfy the following conditions: ensure the sustainable management of water resources to provide water storage and flood regulation services, establish diverse agricultural systems that utilize indigenous knowledge of specific crop and livestock varieties, maintain genetic diversity of crop and livestock while conserving the diverse agricultural landscapes to ensure food provision in changing local climatic conditions, utilize available science and local knowledge and ensure knowledge generation and sharing, and, promote the resilience of ecosystems using nature based solutions to provide benefits to people especially the vulnerable groups.

EBA encourages the use of local and external knowledge about ecosystems to identify climate change adaptation strategies, while creating an environment for effective local adaptation and ecosystem management (Vignola *et al.* (2009); Mercer *et al.* (2012). The priorities for EBA include natural resource conservation to enhance effective adaptation so as to build the resilience of a community and reduce the vulnerability to climate change (Girot *et al.* 2012; Perez *et al.* 2010). Stemming from the finding of the climate change adaptation strategies in place, Figure 26 depicts the identified EBA strategies in use in the Taita Hills.

These are climate variability and change adaptation strategies that have been established and effectively managed to ensure the continued delivery of ecosystem services to ensure effective adaptation processes that reduce vulnerability to the impacts of climate change.

- Irrigation
- Zero Grazing
- Bench Terracing
- Fish farming
- Conservation tilling
- Cultivation on two different farms located in the highland and lowland areas, to take advantage of the different rainfall and temperature conditions.

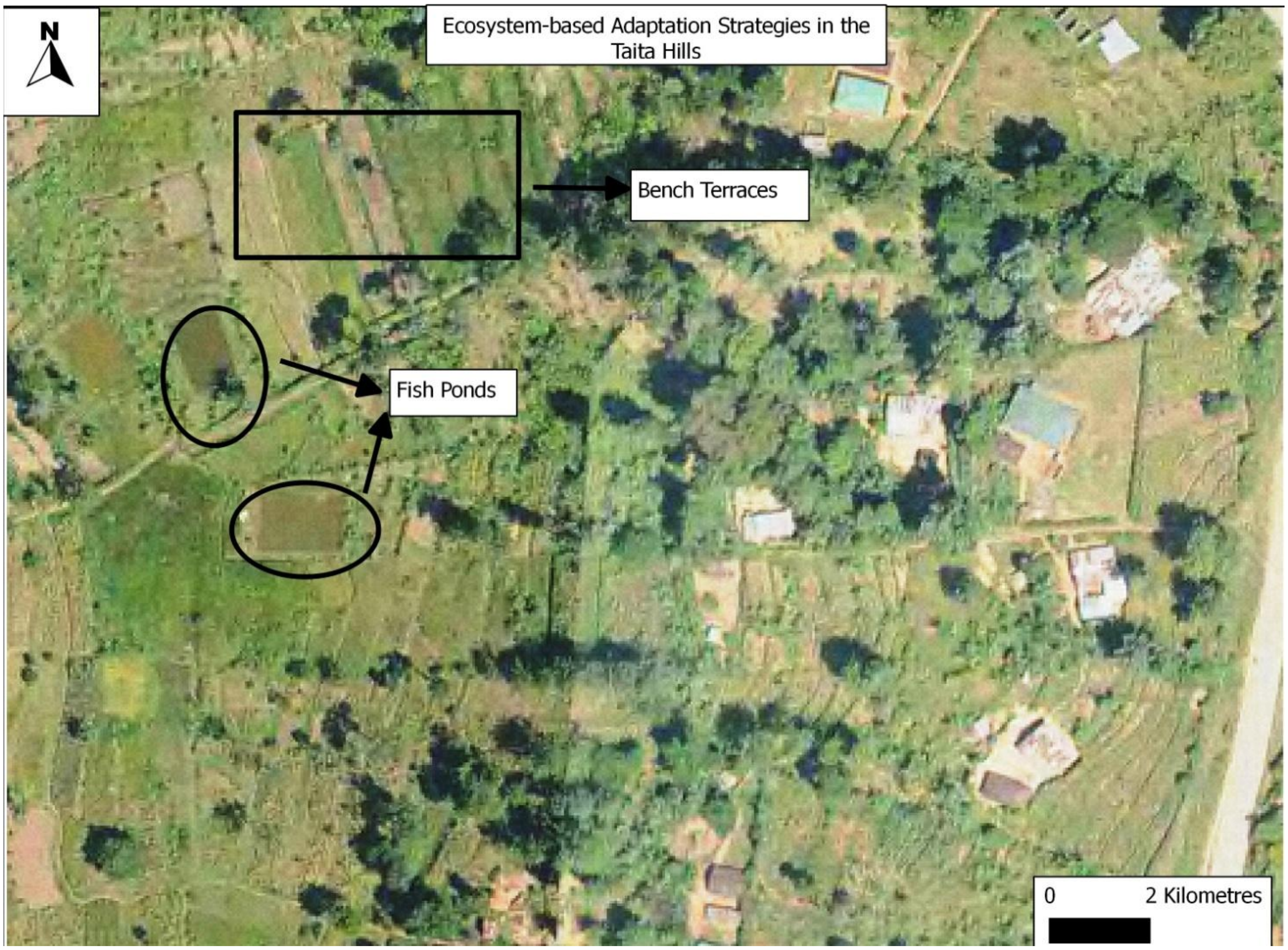


Figure 26: Orthophotomap depicting Ecosystem based Adaptation Strategies in use in Wundanyi in the Taita Hills (CHIESA 2012)

4.9.1 Integration of Indigenous Knowledge and Ecosystem-based Adaptation for Climate Change Adaptation

The integration of indigenous knowledge into climate change adaptation strategies (Figure 27) is an important step in the creation of suitable climate change adaptation strategies for rural households. For example, the households in the Taita Hills possess the knowledge on the environmental indicators that are used in forecasting changes in the weather. However, from the sampled households this knowledge is not used sufficiently in the adaptation to the impacts of climate variability and change. The potential for integration of indigenous knowledge and EBA is possible because indigenous knowledge is based on the environment and protecting its integrity so as to ensure continued productivity of the agricultural ecosystems. The focus group participants explained that there were taboos and restrictions concerning the felling of the indigenous trees that were used for weather forecasting. This helped to preserve their forests and their rivers which flowed from the highlands. Moreover, traditional land use was regulated by the elders and farming on the hillsides was forbidden with large scale cattle rearing allowed in the lowland areas only.

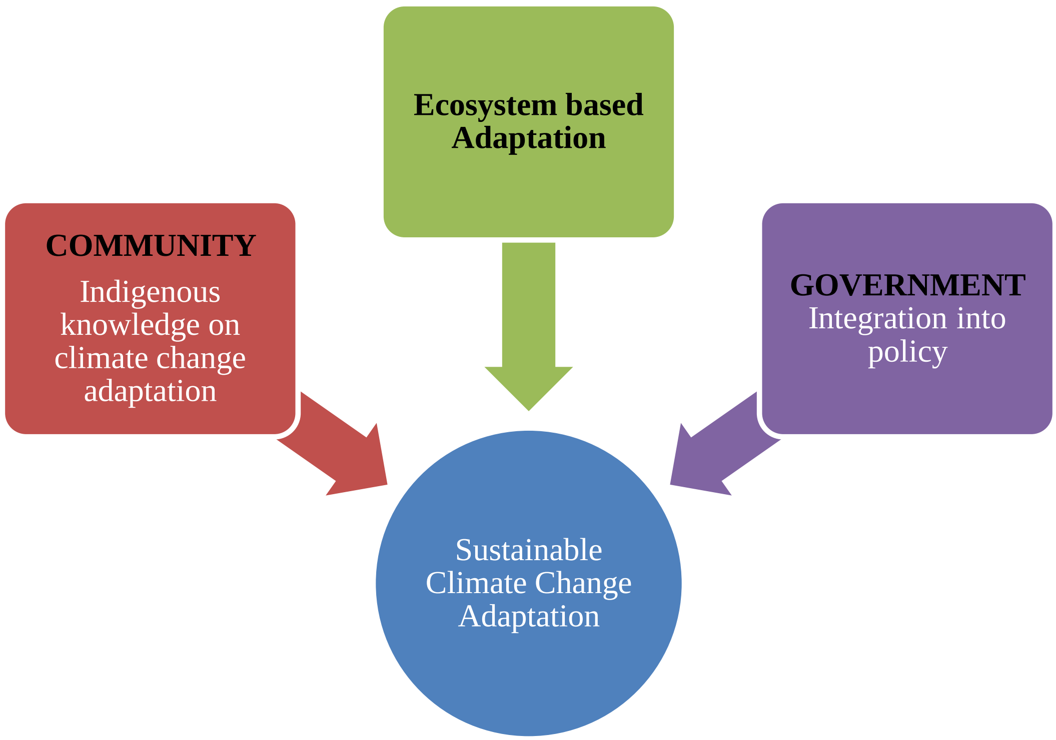


Figure 27: Sustainable Integration of Ecosystem based Adaptation Strategies with Local Indigenous Knowledge

Indigenous knowledge to climate change adaptation is vital for reduction of vulnerability to the impacts of climate change by promoting farm level adaptation. The households in the Taita Hills possess indigenous knowledge on adaptation and use it to cope with the impacts of climatic variability and change. IK when integrated with EBA offers the opportunity for the formulation of culturally acceptable and sustainable climate change adaptation strategies. The potential for integration is evident as majority of the indigenous climate change adaptation strategies tie in with the principles of EBA. Furthermore, EBA encourages the integration of the community and their knowledge on their ecosystem in the formulation of ecosystem based adaptation strategies

4.9.2 Challenges for Integration of EBA and IK

The main challenge to integration of IK to EBA is the lack of documentation of the indigenous knowledge of the Taita community. The information collected on traditional weather forecasting was mainly from the age group of 40 years and above. The younger age groups were not conversant with the environmental indicators used for weather forecasting. Additionally, in the households, head of household who were below 40 years of age stated that they were not aware of any methods that were utilized traditionally to cope with climate extremes or climatic variability in the Taita Hills.

Other challenges of integrating indigenous knowledge and ecosystem based adaptation include:

- Indigenous knowledge on weather forecasting is not utilized to inform the coping strategies undertaken for climate variability and change.
- There is lack of adequate scientific data for validating the responses of the observed environmental indicators.
- Community discrimination of people who hold onto the traditional indigenous systems. They are considered as heretic and backward.
- Traditional knowledge has not been incorporated into policy documents to make it acceptable to the wider community in the Taita Hills.
- Lack of intergenerational transfer of traditional knowledge. The youth are not interested in learning the indigenous ways of weather forecasting and farm practices for climate variability adaptation.

CHAPTER 5
Summary, Conclusion and Recommendations

5.0 Summary

In Africa the most vulnerable sectors to climate change are agriculture, water resources, ecosystems and biodiversity. Failure to take adequate measures to adapt to the negative impacts of climate change in sub-Saharan Africa has the lead the region to become vulnerable to the impacts of climate change (FAO, 2009).

This research project studied the potential for integrating EBA with IK for climate change adaptation. The objectives included finding out climate change perception and climate change adaptation strategies in use in the Taita Hills and making a recommendation of the sustainable adaptation practices.

The paper established that the farmers in the Taita Hills are aware of the changing climatic conditions in their ecosystem which has necessitated the initiation of adaptation strategies at the household level. Consequently, they have taken up climate change adaptation strategies such as changing their seed varieties, early planting and irrigation, manure application and livestock rearing. However, some of the adaptation strategies undertaken are not sustainable. These include farming in wetland areas which degrades the river bed causing alterations in stream flow. Additionally, whereas some of the farm water management intervention strategies are useful (irrigation) some do not last for the period of a climatic event such as a prolonged dry period. For example, it was reported that the trenches which are dug to collect water during the rainy season only retain the water for a period of two weeks after rainfall cessation. Consequently, these waters cannot be adequately used for irrigation. Further to this, socio-economic factors such as failure to diversify household income (reliance on farming only) small land sizes, high rates of dependence, lack of extension services increase the households' vulnerability to the impacts of climate change.

5.1 Climate Change Perception and Adaptation

The households in the Taita Hills have perceived a change in their climate over the past 30 years. The change reported has been gradual and adaptation strategies have been taken up based on the perceived changes. Most of the climate change adaptation strategies undertaken relate to agriculture which is also their main economic activity. The strategies undertaken for climate change adaptation comprise of both reactive and anticipatory practices. For instance, due to the early cessation of rainfall and insufficient amounts of rainfall, farmers are planting early maturing seed varieties that are suited for their altitudinal zones. In the lowlands, farmers utilize the Dryland Hybrid which is tolerant to water stress and matures in 2 to 3 months. On the other hand, some farmers seek for alternative sources of income such as wage labour in the event of a drought in order to buffer the household from the impacts of a failed season.

The farmers in the Taita Hills have taken up adaptation strategies that relate to their observation of their climatic conditions at different altitudinal zones. In the lowlands of Mwatate, crops which are tolerant to water stress and early maturing maize seed varieties are planted, whereas in the highlands, zero grazing has been undertaken as an alternate to pure crop farming. Additionally, farmers in the Taita Hills hire or own land in two altitudinal zones as a means of adaptation. The fields are then cultivated based on the expected weather conditions at the different altitudinal zones.

The government policy on encouraging the cultivation of high value traditional crops such as millet and arrow roots needs to be informed by research and farmers' experiences. As noted earlier, the farmers reported that the tuber crops are failing due to attacks by giant rats and moles whereas the millet lacks sufficient market due to taste preference for maize by the households in the Taita Hills. Policy decisions on climate change adaptation strategies should be informed by an understanding of farmers' perception of climate change and their adaptation strategies and decision making process. It requires the engagement of multiple stakeholders, community based organizations, researchers, and the farmers to successfully initiate ecosystem based adaptation strategies.

5.1.1 Socio Economic Factors Influencing Vulnerability

The socio-economic factors that increase vulnerability to climate change in the Taita Hills include; dependence on maize farming, farm acreage, family size, overreliance on farming as a livelihood activity and low levels of education.

The farmers reported that insufficient access to inputs, lack of knowledge about other adaptation options and no access to water were the main climate change adaptation constraints. Other barriers included lack of credit and lack of information about climate change, high cost of adaptation and insecure property rights.

5.1.2 Indigenous Knowledge on Climate Change Adaptation and Integration with EBA

Mapara (2009) defines traditional weather forecasting as a part of indigenous knowledge systems for a community which have survived for a very long time. Both traditional and conventional weather forecasting are important factors in agricultural production and adaptation to climate variability and change. The household possess knowledge on weather forecasting through the use of bio-indicators in their local environment and methods of adapting to climate variability. However, a disconnect exists between the application of the indigenous knowledge in climate change adaptation. The information possessed is only used for land preparation activities.

5.2 Conclusion

This study was designed to capture the climate change impacts on different agro-ecological zones in the Taita Hills and the resultant climate change adaptation strategies initiated by the households. Farmers in the Taita Hills are concerned with the impacts of climate variability and change on their livelihoods and are taking up climate change adaptation strategies. However, some of the adaptation strategies being implemented are not sustainable and will eventually increase their vulnerability to climate change impacts.

Importantly, the farmer possesses local indigenous knowledge on weather forecasting and climate change adaptation and should be encouraged to utilize it in the adaptation process. This study therefore strongly supports that the there is potential for integration of the smallholder farmers' indigenous local knowledge with Ecosystem based adaptation strategies for sustainable climate change adaptation. Policy making on climate change adaptation strategies should therefore strive to incorporate indigenous local knowledge to ensure the implementation of holistic and culturally acceptable adaptation practices. Nyong (2007) stated that the implications for policy-making is to exercise great caution before joining the quest for adaptation solutions until a better understanding of local and regional climate change scenarios, as well as local adaptive strategies and capacities, is obtained. Focus on economic development that allows flexibility for adjusting to various climate change vulnerability scenarios is likely to be most successful.

5.3 Recommendations

The determinants of climate change adaptation include presence of social safety nets, extension services and credit and climate information to support adoption of adaptation strategies. The recommendations discussed below are targeted to the smallholder farmers in the Taita Hills, the Government and the scientific community.

5.3.1 Recommendations to the Smallholder Farmer

i. Diversification of Livelihoods

The adaptive capacity of the households in the Taita Hills may be limited due to their low levels of education, the family size and age structure which has more dependants than the economically productive age group. Given the variability of the climate conditions in the Taita Hills and the climate change projections for East Africa it is important for the households to diversify their sources of income in order to buffer the households against impacts of climate variability and change and to ensure their resilience against the impacts of climate change.

ii. Sustainable Farm Water Management Strategies

Households have dug trenches but they only store water for a short period of time after the cessation of the rains usually 2-3 weeks after. Lining the trenches with polythene sheeting will extend the duration in which the water lasts in the trenches. Additionally, the water can be directed to a pond to use if for irrigation purposes during the dry season. Farming in the wetland areas should be stopped as this is not a sustainable climate change adaptation strategy. Instead farmers should utilize drip irrigation which utilizes only a small amount of water for productive agriculture

5.3.2 Recommendations to the Government

i. Inclusion of Community in Decision Making

The ability of the smallholder farmers to adapt to the impacts of climate change is constrained by factors such as, increasing scarcity in key resources, limited access to information (weather forecast, climate change, market, pest and disease outbreak information); limited education, skills and access to financial resources and markets required to diversify their livelihood activities; and social and gender inequalities and marginalization, which reduce the voice and adaptive capacity of the most vulnerable. To enhance the adaptive capacity of these communities will require community-based and community-led interventions, but will also require tailored support from all stakeholders. This means that the government should also incorporate the local and indigenous knowledge of the community in decision making. In so doing, smallholder farmers will be more accepting of the initiated climate change adaptation strategies.

ii. Implementation of proven policies

Additionally, the government should implement policies that have been proven through research and collaboration to prevent the implementation of strategies that will increase the vulnerability of communities to the impacts of climate change.

iii. Improved Agricultural Extension Services

The government and local administration should ensure that the smallholder farmer has adequate access to extension services. This can be achieved through the initiation of farmer field schools where the farmers are educated on appropriate farming techniques that reduce vulnerability to climate change impacts. This will also help reduce the time that it takes for an extension agent takes to move from one farm to another. Moreover, the smallholder will be able to get timely information with regard to seed varieties and weather forecasts for forthcoming cropping seasons, thereby enabling him to plan his farm activities in advance.

5.3.3 Recommendations to the Scientific Community and Academia

The accessibility of traditional weather forecast by the households in the Taita Hills Scientific weather forecast can be processed and disseminated from the meteorological departments but may not be accessible or useful to the rural people. The households rely on weather forecasting indicators derived from their local environment to make decisions in their daily lives especially in guiding their farming practices

Further research on the areas detailed below should be considered:

1. How traditional knowledge on weather forecasting can be integrated into climate change adaptation. Observations on the timing of the weather indicators and the attendant changes of the weather and climatic conditions.
2. The viability of the uptake of high value traditional crops in the Taita Hills as an adaptation strategy
3. Traditional farm water management for climate change adaptation in the Taita Hills.

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ANNEX 1

SEMI-STRUCTURED QUESTIONNAIRE FOR FOCUS GROUP DISCUSSION

1. Has the village change in the past 20 years? If yes how has it changed and what are the reasons for these changes?

2. Has the village experienced any changes
    a. In terms of climate conditions (if yes, please explain and give more details)

    b. In terms of economic activities and livelihoods (if yes, please explain and give more details)

    c. In terms of land use (if yes, please explain and give more details)

3. Have the changes been gradual or sudden?
    a. Are the changes positive, negative, or neutral

4. Has the community taken up any activities to cope with the changes? If so, what kinds of actions have been taken and what kind of tools/methods have been used? If they have not been used, what is the reason for that?
5. Have you experienced any change in climatic condition or weather patterns in your village within the past 40 years? If yes what kind of changes?

6. How have the changes in climatic conditions or weather patterns affected you?
    a. In terms of agriculture (if yes, please explain and give more details)

    b. In terms of land use (if yes, please explain and give more details)

    c. In terms of economic activities and livelihoods (if yes, please explain and give more details)

7. Which challenged and opportunities have these changes brought?

8. What have you done to cope with these changes?

9. Have you utilized any opportunities that have arisen from the changes in climate? If yes, please explain in detail.

10. Which types of households are affected by the climatic conditions and weather patterns and how? Who in particular was affected? Where are these households located in the village?

11. Which parts of the village are the most affected ones? Why are these areas more vulnerable than the others?

12. Does the village have any savings in cash or in kind to be used in terms of disaster or extreme climate conditions?

13. Has the government launched any activities to help the affected households? If yes, please explain.

14. What are the main economic activities carried out in your village? Are there any other economic activities available? What economic activities are you carrying out?

15. Has the profitability of any economic activities or livelihoods changed due to the impacts of climatic conditions?

16. In the past 20 years, have there been any new economic activities introduced in your village? If yes, what kind of activities and by whom?

17. In the past 20 years, have some economic activities disappeared from your village? If yes, what kind of activities? Why have these activities disappeared?
18. Do the community members support each other during bad and good times? If yes, please explain.
19. Have the households in your village taken any actions to deal with the impacts of climatic conditions or weather patterns on farming? If yes, what kind of actions?

20. How did the households learn about these actions? Were these actions taught at schools or by extension agents?

21. Are there any options to cope with the experienced impacts that could have been taken up but were not? Why?

ANNEX 2

We are researchers with the CHIESA Project under the Climate Change Adaptation Component, as part of our objectives; we are studying climate change adaptation strategies in the Taita Hills, Kenya. The information collected will be treated with confidence and used for research and academic purposes only.

Climate Change Adaptation Strategies in the Taita Hills

<u>Semi Structured Questionnaire</u>

Name of District.. Date of interview..

Name of Town.. Name of Interviewer.......................................

Farm Location ………………………………………………. (Please give brief description of location visited (hillside, lowland, hilltop etc).

A. Socio-Demographic characteristics

Gender of respondent		
Age of respondent		
Occupation		
Main sources of income		
Head of household (indicate male/female/child headed)		
Ethnic group		
Highest level of education	a. Primary b. Secondary	d. Tertiary e. Other(Specialties)

	c. University f. No formal education
Duration of residence in Taita Hills	

B. Dependants in Household

Gender	**Age**	**Level of Education**

C. Household Economic Characteristics

1. What are you doing today that helps to provide food and income for the household?
   Paid employment ____ (permanent employment ____ Temporary employment ____)

   Farming ______________

   Business _________________ Other (please specify) _________________

2. Is what you are doing now to help provide food and income for the household the same thing that you did in the past 10 years?

3. If not, what did you do to provide income and food for your household in the past 10 years?

4. What was the main reason for the change in the means of provision of food and income for your household?

5. What roles do other members in your household play in providing food and income for the household (role of each family member in regards to their livelihood)

Household member	Gender	Livelihood role

Household Health Characteristics

6. What are the major health problems that some of your family members have faced during the past 10 years?

7. Please specify the members who were affected and the health problem that affected them (*take note of problems that are nutrition related*)

8. In your view, what were the reasons for these problems and what did you do to solve the problems? (*ask this question for each of the nutrition related health problems and try to understand the underlying causes and how the family addressed the problem and its related causes)*

9. What measures have you taken to prevent such problems from recurring?

10. What resources would you need to prevent such problems from recurring?

Household Food Consumption and Food Security

11. What type of food is eaten in the household during the dry season?

12. Can you rank these foods according to their frequency of consumption (*give 10 marks to the most frequently consumed food and then mark the remaining foods on a scale of between 1 and 9)*

13. How does the household diet change during the other seasons (rainy) and why?

14. During the last 10 years, did you face any problems related to feeding your family well? If yes, please describe in detail.

15. In your view, what were the reasons for these problems and what did you do to resolve them? (*try and find out the underlying causes)*

16. What measures have you taken to prevent such problems from recurring?

17. What resources would you need to become more successful at preventing such problems?

Climate Change Perception

18. How long have you lived in the Taita Hills region?

19. During that time, have you observed any changes with regards to the weather and climate in the area?

20. If yes, please elaborate on the type of changes you have observed with regards to the weather and climate of the Taita Hills area?

21. What do you understand by climate change?

22. Which areas do you consider to be most vulnerable to the impacts of climate change? Please give reasons

23. How do you feel the following climate related factors have changed in the period in which you have lived in the Taita Hills?

i. Rainfall (*inclusive of onset and cessation of rainy seasons)*
ii. Rainfall consistency *(intensity)*
iii. Temperature (*average, minimum and maximum*)
iv. Length of the growing season for your staple crop
v. Accuracy of weather forecasts
vi. The presence and accuracy of indicators used in traditional weather forecasting
vii. Farm productivity
viii. Incidences of crop insect pests and diseases
ix. Incidences of livestock diseases
x. Availability of fodder for livestock
xi. The type of livestock that is owned by farmers in the area
xii. Incidences of food shortages
xiii. Incidences of food surplus
xiv. Incidences of drought

24. What types of climate extremes have you witnessed in this area in the time that you have lived here? (*drought, floods, strong winds, heavy thunderstorms with lightning and hale)*

25. What did you do to cope with these extreme climate events?

Land Tenure and Farming Practices

26. What is the approximate acreage of your farm?

27. Does your household have permanent land tenure or have you rented or leased your farmland?

28. Do you have or have you hired any pieces of land elsewhere to practice farming? If yes, in which area?

29. Is there a reason why you chose this area?

30. What is the main type of crop that you grow on your farm?

31. Do you mainly grow it for domestic consumption only or do you get enough yield for sales? (*please give estimates of sales*)

32. What are the other types of crops that you grow? Do you get enough yield for sale?(*please give estimates of sales*)

33. If you do not have a main type of crop that you grow, what determines the type of crop grown on your farm?

34. Do you think the main type of crop that you grow has been impacted by climate variability and change

35. If yes, please explain

36. Do you own any livestock, if yes please specify the type of livestock owned.

37. If you keep cattle, what is the main reason behind your rearing of livestock?

38. Between your livestock rearing and maize cultivation, which one do you deem to be more profitable to you?

39. Please explain the reason behind your answer

Climate Change Adaptation Strategies

40. Have you taken up any ways of coping with the changes in weather and climatic variability on your farm? If yes, what activities do you carry out?

41. Do you have any traditional knowledge on traditional or indigenous methods of coping with climate variability and change? If yes, please provide details.

42. Are there any traditional or indigenous coping strategies that are used for: If yes, please explain

    i. Water management strategies on the farms
    ii. Soil conservation
    iii. Agriculture or farming practices
    iv. Land preparation
    v. Seed selection
    vi. Seed preservation upon harvest
    vii. Insect pest control and management

43. What methods of coping with climate change have you taken with regards to

i. Water management strategies on the farm
ii. Soil conservation
iii. Agriculture or farming practices
iv. Land preparation
v. Seed selection for planting
vi. Seed preservation upon harvesting
vii. Insect pest control and management

44. Do you have any of the following practices on your farm?

i. Terracing
ii. Conservation Tilling
iii. Water harvesting for irrigation
iv. Fish farming
v. Specify another on-farm agricultural climate change adaptation strategy

45. What has informed your decision to take up the coping strategies that you are currently using?

ANNEX 3
Transect Walk Observation Guide

OBSERVATION GUIDE FOR TAITA HILLS, TRANSECT WALK

NAME OF OBSERVER: ______________________________ DATE: _________________

LOCATION_________________________

	Start				**End**
Soil					
Land use (*e.g. farmland, grazing land)*					
Cropping system (e.g. *rotational, mixed cropping)*					
Crop and vegetation (e.g. maize, cabbages)					
Soil conservation strategy					
Water management strategy (e.g. *rainwater harvesting, irrigation)*					
Other ecosystem based adaptation strategy					
Problems					
Opportunities					