VULNERABILITY OF RAIN-FED PADDY PRODUCING HOUSEHOLDS TO CLIMATE CHANGE AND VARIABILITY: A CASE OF NORTH 'B' DISTRICT, UNGUJA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN MANAGEMENT OF NATURAL RESOURCES FOR SUSTAINABLE AGRICULTURE OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2013

ABSTRACT

Climate change and variability is one of great challenges facing households in Tanzania. The main objective of this study was to evaluate vulnerability of farm households engaged in rain-fed paddy production to climate change and variability in Zanzibar's North 'B' District. Specifically, the study aimed at determining farm households vulnerability to the effect of climate change and variability; examining the temperature and rainfall trend and to determine factors affecting paddy production. Primary data was collected using pre-structured questionnaires and focus groups discussions. Secondary data for climate were collected from the Tanzania Meteorological Agency office (TMA). The livelihood vulnerability index (LVI) was used to analyse households' vulnerability; the climatic data were analysed using the MAKESENS model and multiple linear regression was used to analyse factors affecting paddy production. Results show that the overall LVI score for both *Shehias* was 0.47 while the LVI-IPCC was 0.080, indicating that households in the study area were most vulnerable with (LVI) while moderately vulnerable under the (LVI-IPCC). With respect to rainfall, results were not statistical significant but with the negative slopes for annual and seasonal precipitation. The average surface maximum and minimum temperatures for January-February were found to be statistically significant ($p<0.005$) with positive slope. Examination of factors influencing paddy production showed that cultivated land size, labour and type of fertilizer used were statistical significant. The study concludes that, decreasing of rainfall and increasing of maximum and minimum temperature are matter of concern and the effect of climate changes appears to take its toll with enormous implications in farm management. This is in terms of inconsistency rainfall patterns. It is recommended that, the government should pay more attention to the other methods like irrigation used by rain fed farm households in adapting the effect of climate change and variability.

DECLARATION

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

Zainab H. Moyo Date

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The above declaration confirmed

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ACKNOWLEDGEMENTS

In the course of undertaking this study, I have received support from many people and organizations to which I wish to register my appreciations. First, I would like to register my sincere appreciation to my supervisors, Professor S. M. Maliondo, Coordinator of Climate Change Impacts Adaptation and Mitigation Programme and Dr. J.K. Urassa of the Development Studies Institute, SUA for their guidance during the proposal development and dissertation write-up. Let me appreciate their tolerance, tireless efforts, vision and willingness to offer constructive criticism and encouragement throughout the whole period of preparation and execution of the research and of write-up this dissertation.

Secondly, I would like to take this opportunity to express my sincere appreciation to Dr. B. Kazuzuru of the faculty of science SUA, Mr. Hamza Zuber Rijal and Mr. Makame Haji of the Department of Environment, Zanzibar for their help in this study.

This work would not have been possible without the financial support offered by the NORAD through the EPINAV project based at SUA, Tanzania, which enabled my field work and financing of other study logistics.

I am highly indebted to the North ‘B’. District officials for granting me permission to conduct my study in their area. I also extend my thanks to the local communities in the villages visited and all those who have contributed information in one way or another for their valuable cooperation, without which this study would have remained a day dream. Special thanks are due to the *Shehas* Mr. Mohammed Bakari of Matetema and Mr. Alhaji

Bakari Juma of Mahonda, who worked with me during the field survey in a spirit of generosity and commitment.

I owe the greatest debt to my adorable husband Dr. Bakari S. Asseid and our children Natasha Kissassi, Nassor Kissassi and Naila Kissassi for their moral support, love, unremitting encouragement, indispensable prayers and tolerance throughout my absence to accomplish this study. They have demonstrated extraordinary courage and made difficult sacrifices. Neither words nor complex mathematical equations can fully articulate their roles in making this work a reality.

Deep thanks are extended to my lovely friends Ms. Amina Hasnu Makame and Mrs Martha Mganilwa for their constant encouragement and personal sacrifice during the difficult times of this study. Lastly, I am very grateful to my sister Asha Ramadhan and my sister in law Ms. Maryam Saad Asseid who made themselves available and provided motherly affection for my kids throughout the research period.

Above all, I thank God from the bottom of my heart, for giving me the courage to invest time in this study. He made it possible for things to happen.

DEDICATION

Special thanks go to my wonderful parents Mr. Hassan Nassor Moyo and Mrs. Salma Moyo whose efforts laid the foundation of my education.

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LIST OF ABBREAVIATIONS AND SYMBOLS

CCIAM	Climate Change Impact, Adaptation and Mitigation Change
DALDO	District Agricultural and Livestock Office
EPINAV	Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value Chains
FEWS	Famine Early Warning System
GDP	Gross Domestic Product
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel for Climate Change
LVI	Livelihood Vulnerability Index
LVI-IPCC	Livelihood Vulnerability Index – Intergovernmental Panel for Climate
MAKESENS	Mann-Kendal test and Sens' methods
MALE	Ministry of Agriculture, Livestock and Environment
NBS	National Bureau of Statistics
OCGS	Office of the Chief Government Statistician
SACCOS	Savings and Credit Cooperative Societies
SADC	Southern Africa Development Counties
SMOLE	Sustainable Management of Lands and Environment
SPSS	Statistical Package for Social Sciences
SSA	Sub-Sahara Africa
SUA	Sokoine University of Agriculture
TMA	Tanzania Metrological Agency
UNEP	United Nations Environmental Programme
URT	United Republic of Tanzania
USAID	United State Agency for International Development

WARDA	West Africa Rice Development Association
WFP	World Food Programme
WWF	World Wild Fund of Nature

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Climate change and variability is rapidly emerging as one of the most serious global problems affecting many sectors and is considered to be one of the most serious threats to sustainable development. Adversely, climate change impacts the environment, health, food security, economies, natural resources and physical infrastructure (World Bank, 2005; Huq *et al*., 2006; IPCC, 2007; McCarthy *et al.*, 2001). Africa is one of the most vulnerable regions to climate change, the isles of Zanzibar included. According to Hulme (1996), Africa is particularly vulnerable to the impacts of climate change and variability because of factors such as, widespread poverty, recurrent droughts, inequitable land distribution and dependence on rain-fed agriculture.

Climate change studies consistently show that many of the world's regions may experience increasing frequency and severity of droughts and floods, increasing inter-annual and inter-seasonal rainfall variability, and warmer temperatures (IPCC, 2007). Developing countries, Tanzania included, are particularly vulnerable to extreme climate events and rainfall variability due to their high dependence on rain-fed agriculture and natural resources for their livelihoods; limited knowledge of climate change; limited resources for adaptation; and weak institutions with limited capacity to mitigate the impacts. In general, the state of preparedness against the adverse impacts of climate change in Tanzania and Africa is generally limited IPCC, (2007).

In Unguja Island, during the last 100 years, there have been seasonal variations of short rains (*Vuli*) and long rains (*Masika*), and an increase in the intensity and extremes in incidence of both droughts and floods with an unknown uncertainty (MALE, 2010). Although climate change has not been systematically monitored in Unguja, extreme conditions have been experienced and recorded recently and winds have reportedly become stronger (Mustelin *et al.*, 2009). Unguja Island has also been experiencing floods in some villages. In addition, villagers have reported that rains have become less reliable (Mustelin *et al.*, 2009). Apparently, all these conditions, changes and seasonal rainfall variations are likely to have affected paddy production, which is a staple food for Zanzibars. Therefore, the study aimed at assessing the vulnerability of rural households involved in paddy production to climate change and its variability.

1.2 Problem Statement and Study Justification

Rice is the staple food for Zanzibaris. The annual rice demand in Zanzibar is estimated to be 100 000 tons, while only 20 000 of the estimated demand is produced in Zanzibar (MALE, 2010). The total land area with a potential for paddy cultivation in Zanzibar is about 16 000ha of which only 8 000ha have been set aside for irrigation. Although there is no direct evidence that climate change is occurring in Unguja, there is increasing frequency of flooding in parts of Stone Town, periodic flooding of rice fields and other low lying areas from sea water especially near the coast (SMOLE, 2010). According to IPCC (2007) there is a potential for more variability for island states which implies a need to address climate change impacts by integrating adaptation responses into development planning measures.

The overall vulnerability of the rain fed farming in Unguja Island is characterized by a combination of climatic constraints as well as non-climate factors which affect households engaged in rice farming. For example, in recent years, rainfall has become increasingly more unreliable, failing in some seasons, and falling out of season in other years (SMOLE, 2010). These rainfall inconsistencies have disrupted land preparation in rain-fed paddy cultivation. As a result paddy production in Unguja has exhibited a declining trend with serious consequences on food security and farmers well-being. Should climate change become more intense as predicted, it is likely that paddy production will decline even further, and farmers livelihoods' will be adversely affected unless some adaptation is developed. For instance, there has been very little harvest from year 2011 cropping season due to decline in rain and hence the livelihoods of farmers who depend on rainfed paddy production were adversely affected.

So far, no study has examined the vulnerability of farmers involved in rainfed paddy production to climate change and variability in Unguja Island. Such a study is essential for developing adaptation strategies to cope with the anticipated climate change and variability. The current study aimed at assessing the vulnerability of farm households involved in rain-fed paddy production in the North 'B' District in Unguja. The study was based on the premise that farming households are the most vulnerable to the effects of climate change and variability hence the possibility that their well-being could be hampered in absence of effective coping or adaptation strategies. Findings from the study are expected to provide information to policy makers on the vulnerability of farm households involved in rainfed rice farming due to climate change and variability. Information generated from the study could be used in the preparation of appropriate adaptation strategies in the face of the anticipated increase in climate change and variability.

1.3 Objectives

1.3.1 Main objective

The main objective of the study was to evaluate vulnerability of farm households' involved in rain-fed paddy production to climate change and variability.

1.3.2 Specific Objectives

i. To determine farm households' vulnerability to the effect of climate change and variability.
ii. To examine the rainfall trend in the study area for the last 30 years.
iii. To determine factors affecting farm household paddy production.

1.3.3 Research Hypotheses

i. Climate change and variability have negatively affected the livelihoods of farmers dependent on rain-fed paddy production in North B, Unguja.
ii. Climate and weather patterns in North B District have changed significantly over the last 30 years.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Key Terms

2.1.1 Climate change

According to IPCC (2007), Climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

2.1.2 Climate variability

Climate variability refers to variations in the mean state and other statistics (such as standard deviations and the occurrence of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events IPCC (2007).

2.1.3 Vulnerability

Vulnerability refer to the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate. Hence, a highly vulnerable system is one that is highly sensitive to modest changes in climate and one for which the ability to adapt is severely constrained (IPCC, 2000).

2.2 Climate Change and Variability Concept

Climate change is a long-term change in the statistical distribution of weather patterns over periods ranging from decades to millions of years (Adger, 1999; Robledo and

Forner, 2005). The changes are the results from accumulations of green house gases that tend to trap radiations that cause warming on the earth (Adger, 1999). It may also result from increased accumulation of chemicals that result in depletion of ozone layer by reacting with the ozone layer and form other compounds (Robledo and Forner, 2005). The most common green house gases are water vapour, carbon dioxide, methane, nitrous oxide and chlorofluorocarbons (Adger, 1999). For many areas, agricultural and other land use activities have upset the natural balance in the carbon cycle, contributing to an alarming increase in carbon release (Batjes, 1996).

Interest has increased in the possible impacts of various agricultural management practices on soil organic matter dynamics. Agricultural and other land use practices have a significant influence on how much carbon can be sequestered and how long it can be stored in the vegetation and soil before it is returned to the atmosphere (Dick *et al.,* 1998). Carbon dioxide (CO_2) emissions from fossil-fuel use, and from other sources, can be offset by removal of CO_2 from the atmosphere via a net increase in the carbon stocks of the biosphere (West and Marland, 2002). The greenhouse gases result from both natural and human causes. Natural causes include continental drift, volcanic eruption, the earth's tilt and ocean currents (Adger, 1999). According to the IPCC (2007), about 90% of the green house gases are caused by human activities. The importance of human causes has been increasing during the past few decades. The main human activities include; industrialization, deforestation and forest degradation (IPCC, 2007).

2.3 Vulnerability to Climate Change and Variability

Historical climate records show worrying trends in climate variables for most parts of Africa. Warming of approximately 0.7 ^{o}C over most of the continent during the 20th century at the rate of about 0.05°C per decade, with slightly greater warming in the June–

November seasons than in December–May; a decrease in rainfall over large portions of the Sahel (the semi-arid region south of the Sahara); and an increase in rainfall in east central Africa have been reported (Hulme *et al*., 2001). Mean temperatures in Africa over the last 30 years showed a pronounced upward trend and were above the long-term average of the past 100 years; and 1988 and 1995 were the warmest years. These rising temperatures have allegedly led to shrinking of Mount Kilimanjaro glaciers by 73% (Mastny, 2000), and those of Mount Kenya and the Mount Rwenzori reported to be gradually receding (UNEP, 2002).

Since 1968 the average rainfall in Africa has been decreasing and with many seasons fluctuating around notably lower means (UNEP, 1999). This has led to shortened rainy seasons in many areas, thereby further aggravating the insufficient water supply available for agricultural production, since many African countries receive less than 500 mm of rainfall and are thus considered dry lands (UNEP, 2006). This impact on mean rainfall is expected to persist as a result of climate change. In recent years, the pattern of rainfall has tended towards the extremes, with increasing severity and frequency of droughts and floods. Many countries, including Botswana, Burkina Faso, Chad, Ethiopia, Kenya, Mauritania and Mozambique, have experienced drought at regular intervals (UNEP, 2006). Floods are also becoming more frequent in Africa despite the generally reduced mean rainfall over most of the continent. The East Africa floods of 1998, the Mozambique floods of 2000 and the more recent floods in West Africa (Ghana, Benin, Togo, Burkina Faso and Nigeria) in 2007 were devastating and led to the loss of much farmland, damage to transport networks, disease outbreaks and loss of human life. The continent already experiences a major deficit in food production in many areas, and potential further declines in soil moisture or inundation of crop lands will be added burdens.

In Zanzibar for instance, the average annual temperature increased by 1.9°C and by 1.1 °C, respectively between 1961 and 2005 (Yanda *et al.*, 2008). There are also changes in rainfall amount and patterns, in addition to shifts in thermal regimes, influencing local seasonal and annual water balances, thereby affecting the distribution and moisture conditions favourable for rain fed production. Zanzibar's economic growth has been stagnant in the last two decades partly due to decline in per capita income and deteriorating per capita food production. These effects have resulted into food insecurity and the state of poverty is widely spreading especially in rural areas. Given this current state of affairs, it is estimated that about 52% of population is considered as being poor, while 32% is living in absolute poverty. Nevertheless, agriculture remains a leading economic sector of the Isles, contributing about 30.8% of the Gross Domestic Product (GDP) in 2008-2009 and about 75% of the foreign exchange earnings. On average, 70 percent of the population depends directly or indirectly in the agriculture sector for their livelihood (OCGS, 2007), and contributes about 30% of the total tax revenue.

The notion of vulnerability to climate change is conceptualized as a function of three factors: exposure, sensitivity, and adaptive capacity (IPCC, 2007). Exposure can be interpreted as the direct danger (the stressor) together with the nature and extent of changes in a region's climate variables (temperature, precipitation, and extreme weather events). Sensitivity describes the human environmental conditions that exacerbate or ameliorate the hazard, or trigger an impact. Exposure and sensitivity are intrinsically linked and mutually influence potential impacts (IPCC, 2007). Adaptive capacity represents the potential to implement adaptation measures in efforts to avert potential impacts. In that context, the ability of communities to adapt to climate change is determined by their level of development, their access to resources or livelihood assets and their scientific and technical capacity.

The impacts of climate variability create challenges for the world's poorest communities as their livelihoods tend to be very sensitive to climate change. These impacts may be related to more intense and frequent extreme events, like hurricanes or floods, and more long-term stresses, such as water scarcity and increased recurrence of drought. Water stress will adversely affect food security and further exacerbate malnutrition and poverty, especially in Sub Saharan Africa (SSA). Instrumental data and climate model simulations indicate an imminent water crisis in large parts of Africa (IPCC, 2007). In SSA, most areas are characterized by low and erratic rainfall, concentrated in one or two short rainy seasons. This results in high risk of droughts, intra- and off-seasonal dry spells, and frequent food insecurity. Intra-seasonal dry spells occur due to inadequate rainfall during the growing period, while off-seasonal dry spells are due to rainfall cessation before crop maturity. Several studies on water assessment and impact of climate change have been undertaken in Africa (Gyau-Boakye and Tumbulto, 2000; Olomoda, 2002; Kabat *et al.*, 2003).

According to IPCC (2007) indicates that extreme events, including floods and droughts, are becoming increasingly frequent and severe. Even countries that previously did not experience frequent severe floods, such as Burkina Faso and Tanzania, have recently reported severe flooding, notably in 2007 and 2011, respectively. In Zanzibar for instance, the implication of floods can be very catastrophic as most of the island is low lying and some areas are below sea level. The digital terrain model of Zanzibar indicates that sea level rise or floods with more than 10m above sea level shall make 25% of Unguja island submerged, and if the water mark increases to 12m above sea level, the island will split into two separate parts at a point in the Jozani and Chwaka Bay National Park which is below sea level (Nieminen, 2006).

2.4 Impact of Climate Change and Variability on Agriculture

According to IPCC (2007), climate variability especially total seasonal precipitation as well as its pattern of variability is affecting agricultural systems especially in developing countries dependent on rain-fed agriculture, where drought is already a limiting factor of production. It is projected that by 2020, yields from rain-fed agriculture could be reduced by up to 50% in some countries (IPCC, 2007). In many African countries it is expected agricultural production, including access to food, will be severely compromised, adversely affecting food security and exacerbate malnutrition. It is further projected that rice production will decrease as temperatures increase in rice-growing areas in Asia (Lobell and Burke, 2008). Climate change may directly affect rice plant growth through changes in air temperature, precipitation, evapo-transpiration, and water temperature. Increased temperature also increases evaporation rates from soil and water bodies as well as evapo-transpiration rate in plants, and increases chances of severe drought as with warmer temperatures crops require more water. Furthermore, increases in temperature may affect crop growth and yield depending on sensitivity of crop growth to temperature changes.

2.5 Climate Change, Vulnerability on Crop Production

The long-term climate variability influences sowing date, crop duration, crop yield, and the management practices adapted in crop production. Short-term weather episodes can also affect yield by inducing changes in temperature, potential evapo-transpiration, and moisture availability. The degree of vulnerability of crops to climate variability depends mainly on the development stage of the crops at the time of weather aberration. This makes climate variability a threat to food production leading to serious social and economic implications (Geng and Cady, 1991; Hossain, 1997).

2.6 Effects of Climate Change on Paddy Production

Many abiotic factors and biotic constraints limit paddy production. Climate change, by inducing variations in the climate patterns, is expected to aggravate these constraints, thereby affecting rice yields. However, the extent of loss of production due to climate change will differ between the five rice production systems recognized in SSA rain-fed upland, rain-fed lowland, irrigated lowland, mangrove swamp and deepwater. Among these, the greatest threat to paddy production due to climate change is anticipated in the rain-fed paddy production systems due to their often total dependence on rainfall as a source of water. However, production of rice near the mangrove areas also faces increased risks of flooding as a result of the coastal erosion, salinity intrusion and storm surges (Field, 1995; Manneh, 2007).

Extreme weather conditions, especially extreme temperatures induced by climate change are perceived to be a greater threat to rice production. Paddy is sensitive to temperature fluctuation but its sensitivity depends on development stage. Panicle is the most sensitive stage to extreme temperatures with very cold or very hot weather leading to high spikelet sterility, reduce tillering, and causing stunting (Futakuchi, 2005) and accelerate the developmental rate of rice, thereby leading to shortened growing cycles. Rain-fed uplands and lowlands are more prone to drought stress than other rice production systems. Crop failure due to drought generally occurs once every five years compared to other crops, and rice is particularly sensitive to drought (Africa Rice Center, 2004).

2.7 Effects of Rainfall on Paddy Production

Rainfall in paddy production is very important. The lower the rain, the lower the paddy productivity. The variability of rain supply in crops can negatively affect crop production. In paddy farms, loss of water at panicle initiation increased the proportion of unfilled grains and decreased 1000-seed weight (Wopereis, 1993; Wopereis *et al.*, 1996). Reduced availability of water at the vegetative stage resulted in reduced morphological and physiological measurements in rice. The affected morphological and physiological features include tiller number, leaf area index, apparent canopy photosynthetic rate, leaf nitrogen, shoot and root biomass, and root length density (Cruz *et al*., 1986).

Varying degrees of water stress at different growth stages can result in a number of plant reactions that can also be variety-specific. In general, water stress during the vegetative stage will delay panicle initiation in rice; mild water stress at reproductive stage will extend panicle development by 10 days and reduce grain number. A severe rain deficit during the same development stage will extend panicle development by 18–28 days, and reduce grain and panicle number (Lilley and Fukai, 1994). A thorough analysis of livelihood activities indicates that agricultural activities are mostly affected through decrease in rainfall which also influences loss in soil moisture (Mongi, *et al*., 2001).

2.8 Climate Change Vulnerability Assessment

Vulnerability assessment describes a diverse set of methods used to systematically integrate and examine interactions between humans and their physical and social surroundings (Hahn *et al.*, 2009). Vulnerability assessments have been used in a variety of contexts including the USAID Famine Early Warning System (FEWS-NET) (USAID, 2007a), the World Food Programme's Vulnerability Analysis and Mapping tool for targeting food aid (World Food Programme, 2007), and a variety of geographic analyses combining data on poverty, health status, biodiversity, and globalization (O'Brien *et al.*, 2004; UNEP, 2004; Chen *et al.*, 2006; Holt, 2007). A common thread is an attempt to quantify multidimensional issues using indicators as proxies. These are often combined into a composite index allowing diverse variables to be integrated (Hahn *et al*., 2009).

The Human Development Index, for example, incorporates life expectancy, health, education, and standard of living indicators for an overall picture of national well-being (UNDP, 2007). Several methods have been used to combine indicators. The gap method (Gillis *et al.,* 1987) was used by Sullivan (2002) to assess ‘‘by how much water provision and use deviates from a predetermined standard for the Water Poverty Index. Hahn *et al.* (2009) suggested that both Human Development Index and the Water Poverty Index are examples of composite indices calculated using weighted averages of individual indicators.

2.9 The Livelihood Vulnerability Index

The Sustainable Livelihoods Approach (SLA) is a useful tool for understanding the socio-economic aspects of vulnerability, especially to climate risks, which is an important step in adaptation processes (IFAD, 2009). The Sustainable Livelihoods Approach, that includes five types of household assets natural, social, financial, physical, and human capital (Chambers and Conway, 1992), is an approach used to design development programming at the community level (United Nations General Assembly, 1997). The approach has proven useful for assessing the ability of households to withstand shocks such as epidemics or civil conflict. Climate change adds complexity to household livelihood security. The Sustainable Livelihoods Approach to a limited extent addresses the issues of sensitivity and adaptive capacity to climate change, but a new approach for vulnerability assessment that integrates climate exposures and accounts for household adaptation practices is needed in order to comprehensively evaluate livelihood risks resulting from climate change (Hahn *et al.,* 2009).

2.10 Trend Analysis

Climatic parameters such as rainfall, temperature, humidity and sunshine hour, may vary with time and space. Scientific studies indicate significant changes in various climatic parameters in various regions of the world. Global warming is mainly caused by the increase in greenhouse gases including CO_2, CH_4 and N_2O in the atmosphere and increased amount of greenhouse gases act as a blanket to trap infrared radiation of solar energy. Stored energy is radiated as heat and makes warmer the cooler parts of the atmosphere as well as land surface (Zaman *et al.*, 2013). Intergovernmental Panel on Climate Change (IPCC) reported in their fourth assessment report that global surface temperature increased by 0.74 ± 0.18 °C during the 100 years ending in 2005 (IPCC, 2007). It was also noted by IPCC (2007) that the rise of mean annual temperature will be 3.3 °C per century. To estimate the trend of these weather events, there are number of models were used. One of them is MAKESENS model.

An Excel template – MAKESENS – is developed for detecting and estimating trends in the time series of annual values of atmospheric and precipitation concentrations. The procedure is based on the non-parametric Mann-Kendall test for the trend and the non-parametric Sen's method for the magnitude of the trend. The Mann-Kendall test is applicable to the detection of a monotonic trend of a time series with no seasonal or other cycle. The Sen's method uses a linear model for the trend (Salmi *et al.*, 2002).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of Study Area

3.1.1 Geographical location

Zanzibar North is divided into two districts, Kaskazini (North) 'A' and Kaskazini (North) 'B'. The current study was conducted in North 'B' District of Unguja in Zanzibar. North 'B' District is located between 05°55′00″S and 039°20′00″E. The district lies in the northern part of Unguja Island. It is bordered by North 'A' and Indian Ocean to the North, and West and Central Districts to the South, and Indian Ocean to the western and eastern border.

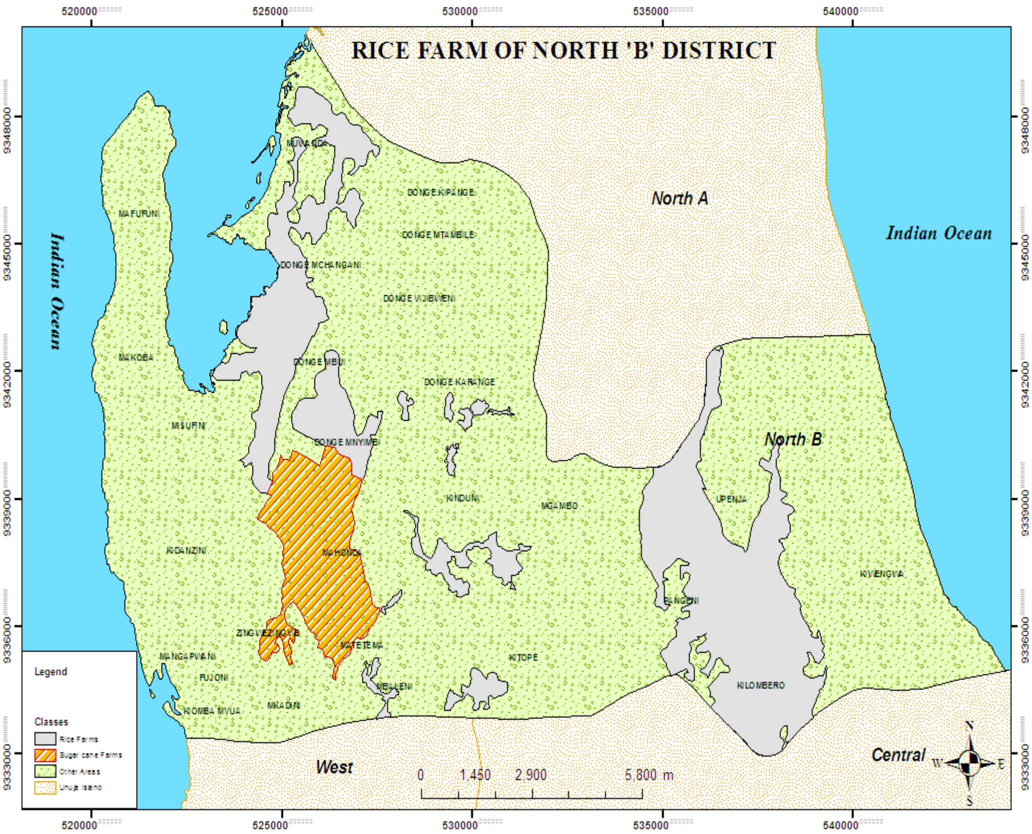


Figure 1: Rice farm of north B district-Unguja

Source: Natural Resource Department- Zanzibar (2012)

3.1.2 Climate and vegetation

The area is characterized by tropical climate and temperatures which dominate the island. The mean maximum temperature is 32°C and while the mean minimum is 19°C with a mean annual temperature of 25.5°C. The rains are bimodal with an estimated rainfall of between 1300 and 1700 mm per year. The long rains fall between March and May (precipitation being between 900 mm and 1 200 mm) while the short rains fall between October and December (precipitation being between 400 mm and 500 mm) and the dry season is between June and September (MALE, 2010).

3.1.3 Soil and topography

Soils in North B fall into two categories; the deep soil areas and the shallow soil dominated by coral rag. The deep soil areas are dominated by clay and loamy soils, and sand beaches. Most of the paddy fields are found in area with the deep black cotton soils (MALE, 2010). Black soils are very dark in colour and turn extremely hard on drying and sticky and plastic on wetting (Sehgal, 2002). These soils are highly argillaceous (particles smaller than 0.06mm in diameter) with clay content more than 30 per cent. The clay is dominantly montmorillonitic in nature with high coefficient of expansion and contraction within the soil, (Sahu and Antaryami, 2005). The soils have high moisture holding capacity, Sahu and Antaryami (2005) which is very potential for paddy production.

3.1.4 Socio-economic profile

North 'B' district is one among of the highly populated districts in Unguja Island with population of 81 675 (NBS and OCGS, 2013). The district has 31 *Shehias* and 11 456 households engaged in agriculture with most households having less than 0.5ha (MALE, 2010). The district was considered ideal for the study because it is among the most populated districts with large paddy fields and most households engage in rain-fed paddy farming.

The main socio-economic activities of local communities include agriculture, livestock keeping and fishing, and the district has numerous smallholders' paddy fields. The bimodal rain seasons determine the paddy farming season and that of other crops. Other crops grown in the area include: sugar cane, sweet potatoes, cassava, bananas, legumes, fruits and a range of green vegetables. Generally, these crops are grown as a monocrop, but are sometimes intercropped. Common domestic animals in the study area include; cattle, goats and local chicken.

3.2 Methodology

3.2.1 Sampling Procedures and Sample size

The North 'B' District was purposively selected due having many paddy fields where rain-fed paddy farming is practised. Two S*hehias* were purposively selected based on the extent of rain-fed paddy farming. In each selected *Shehia*, two villages were randomly selected. A simple random sampling was used to select 30 households in each village, making a sample size of 120 households. According to Bailey (1998), if a sample is to be subdivided the smallest sub-sample should be at least 30 cases; therefore, the sample size used in the study is considered adequate. Boyd and Westfal (1981) suggested that, a random sample should at least constitute 5% of the total population to be representative of the population but, according to Babbie (1992) 10-30% should be a minimum sample size in a random sample selection.

3.2.2 Research design

A cross-sectional research design was used in this study in which data from respondents was collected at a single point and time. The design is simple and saves time, labour, and financial resources by allowing the researcher to study a large population at once. Apparently, there are other researches designs such as case study and longitudinal, but the cross- section research design was adopted because the researcher was acquainted with the design and has been widely used in similar studies.

3.2.3 Data collection methods

3.2.3.1 Primary data

Both qualitative and quantitative data were collected. The quantitative data was collected using questionnaires (Appendix 1). For qualitative data collection, focus group discussions were held with key informants and individual respondents based on checklists (Appendix 2). Key informants consisted of village leaders and Government officials including *Shehas* of the two *Shehias*, DALDO and the District Commissioner.

(a) Household survey

A household in this case was defined as a group of people who eat from a common pot, sharing the same dwelling and may cultivate the same land (Katani, 1999). A household was chosen as the sampling unit for this study, and the structured questionnaire with both closed and open-ended questions was used to collect household data. The questionnaire was designed to permit acquisition of both quantitative and qualitative information. General descriptions of the respondents were summarized from the structured interview questionnaire (Appendix 1).

Each household interview lasted on an average of 25 minutes. A total of 120 respondents were interviewed in four villages namely Matetema, Cairo, Mahonda and Station ya Zamani in two *Shehias* of Matetema and Mahonda. Interviews were carried out in Swahili which is the mother tongue of the respondents. Generally, the heads of the households were interviewed, and in their absence, the spouse was interviewed instead.

The questions focused on socio-economic issues including variables such as household heads sex, size of household, household income, age, and education level of household head and agricultural production. Also data on main types of crops cultivated in the study area was collected. A pilot study of eight households, two in each village was conducted prior to the questionnaire survey to check reliability and validity of the information. This was essential in order to take into account ambiguity of some of the questionnaire items (Mettrick, 1993).

(b) Focus group discussion

Focus group discussion (FGDs) can provide details on the broad context for local circumstances and practices. Participants in FGDs were generally individuals from a variety of segments of society, including farmers, elders. FGDs were employed to encourage collective response of the link between climate change and variability and the livelihood. The FGDs in this study comprised between 8 to 15 men and women in each group of different age classes (above 40 years) with knowledge and experience on the paddy production and climate change and variability. These focus groups were used to gather information on paddy production, livelihood issues, effects of climate change, hazards and the coping strategies against the effect of climate change and variability between time line (1960s to 2011).

(c) Key Informant interviews

According to Katani (1999) the group meetings can provide details on the broad context for local circumstances and practices, there are frequently particular individuals who for whatever reason have acquired significant knowledge about specific issues. What sets them apart as key informants is that they are recognized by others in their community as being particularly knowledgeable about the area Msalilwa (2012). For the purposes of the study, extension officers, Shehas and community elders in the villages were interviewed.

3.2.3.2 Secondary data

Secondary information was obtained from extension reports. The data on annual paddy yields were obtained from district DALDO office and Ministry of Agriculture and Natural resources reports.

Data on rainfall and temperatures were obtained from TMA office at Kizimbani Station. The rainfall data covered the period between 1981 and 2011, while temperature data was from 1985 to 2011. These data were essential in this study in order to evaluate the effects of paddy production to climate change and variability.

3.3 Data Processing and Analysis

3.3.1 Analysis of socio-economic data

Data from the field survey were coded and summarized and analyzed using the Statistical Package for Social Sciences (SPSS) package to calculate frequencies, means, percentage, cross-tables, ranges and correlation coefficients. The Livelihood Vulnerability Index (LVI) and LVI-IPCC were used to assess components of vulnerability of the households. The components are first broadly categorized under eight (8) different major components which are Socio demographic, livelihood strategies, social network, food, health, water, natural disaster and climate variability, and energy resource. There are several sub-components used as indicators under each component which are elaborated in Appendix II. The livelihood vulnerability (LVI) was calculated using the equation below:

$$LVI_s = \frac{\sum_{i}^{8}{}_{1} w_{Mi} M_{di}}{\sum_{i}^{8}{}_{1} w_{Mi}} \quad \text{.......} \quad (1)$$

Where,

LVI_s is the Livelihood Vulnerability Index for household and equals the weighted average of the eight major components; w_{Mi}, are the weights of each major component, determined by the number of sub-components, $M_{di,}$ that make up each major component were included to ensure that all sub-components contribute equally to the overall LVI (Sullivan *et al.*, 2002).

According to Hahn *et al.* (2009), the LVI is scaled from 0 (least vulnerable) to 0.5 (most vulnerable). On the other hand, the LVI- IPCC was calculated as follows:

$$CF_s = \frac{\sum_{i}^{n}{}_{=1} w_{Mi} M_{si}}{\sum_{i}^{n}{}_{=1} w_{Mi}} \quad \text{.......} \quad (2)$$

Where,

CF_s is the IPCC-defined contributing factor (exposure, sensitivity, or adaptive capacity) for each *Shehia*,

M_{si} are the major components for a *Shehia'* s indexed by i, wMi is the weight of each major component, and n is the number of major components in each contributing factor.

Once exposure, sensitivity, and adaptive capacity were calculated, the three contributing factors were combined using the following equation:

$$LVI\text{-}IPCC = (E_S - A_S) * S_S \quad \text{......} (3)$$

Or

LVI-IPCC =(Exposure – Adaptive capacity)*Sensitivity

Where,

LVI–$IPCC_S$ is the LVI for a *Shehia*$_s$ expressed using the IPCC vulnerability framework, E_s is the calculated exposure score for Shehia s (equivalent to the natural disaster and climate variability and energy resources major components), A_s is the calculated adaptive capacity score for S*hehia* s (weighted average of the socio-demographic, livelihood strategies, and social networks major components), and S is the calculated sensitivity score for Shehia s (weighted average of the heath, food, and water major components). The scale used were the LVI–IPCC from -1 (least vulnerable) to 1 (most vulnerable) (Hahn *et al*., 2009).

3.3.2 Analysis of meteorological data

Trend analysis was used to analyse the time series data on rainfall and temperature. The trend of changes in temperature and rainfall were computed monthly, seasonally, yearly and analyzed using MAKESENS trend model for Kizimbani station using the User's manual of MAKESENS model (Salmi *et al.*, 2002). MAKESENS is a software computer model which was developed using Microsoft Excel 97 and were coded with Microsoft Visual Basic. The MAKESENS trend model comprises two types of statistical tests; Mann-kendal test and Sen's method. First, the presence of monotonic increasing and decreasing trend was tested with the non-parametric Mann-Kendall test and secondly, the slope of linear trend was estimated with the non-parametric Sen's method (Gilbert, 1987).

The Mann-kendal test question (Salmi *et al.*, 2002) is shown below;

$$Z = \begin{cases} \frac{S-1}{\sqrt{VAR(S)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & if\ S < 0 \end{cases}$$ ....(5)

Where,

VAR(S) is the variance of the S statistic and Z_1-*α/2* is obtained from the standard normal distribution. A positive or negative value of *S* indicates an upward or downward trend.

The presence of a statistically significant trend is evaluated using the *Z* value. The statistic *Z* has a normal distribution. A positive value of *Z* indicates an upward trend while a negative value indicates downward trend. To test for either an upward or downward monotonic trend (a two-tailed test) at α level of significance, H_0 is rejected if the absolute value of *Z* is greater than Z_1-*α/2*, where Z_1-*α/2* is obtained from the standard normal cumulative distribution tables. In MAKESENS, the tested significance levels α are 0.001, 0.01, 0.05 and 0.1 (Salmi *et al.*, 2002).

Sens' method

To estimate the true slope of an existing trend (as change per year), the Sen's non-parametric method was used. The Sen's method can be used in cases where the trend can be assumed to be linear as shown in equation below;

$$f(t) = Qt + B$$ ……………………………………………………………...(6)

where Q is the slope and B is a constant (Salmi *et al.*, 2002).

The meteorological data was used in this study in order to recognise if the rain-fed paddy producing household's vulnerability is due to climate change and variability.

3.3.3 Analysis of paddy production

As regards objective two, multiple linear regression analysis was used as follows:

Factors affecting paddy production including production factors

$Y_i = \beta_0 + \beta_1 Age_i + \beta_2 HH_t + \beta_3 Land_i + \beta_4 Labour_i + \beta_5 F_i + \varepsilon_i$ ....(4)

Where,

Yi= Yield

i = 1,2,3,-------n households

β_0 = Constant term (intercept)

β_1-β_5 = coefficients (slope)

Age_i = Age of the head of household

HH_i = number of Household members

$Land_i$= Cultivated land size measured in hectares

$Labour_i$= amount of money spent for labourers

F_i= 1 if a farmer used inorganic fertilizer, and 0 otherwise

ε_i = random error term

3.4 Study Limitations

Lack of reliable annual paddy production data and enough temperature and rainfall data was a serious limitation. These problems made the results to be discouraged especially in effects of paddy production in the study area.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The overall results of this study are presented in this chapter. The discussion is built on the results and analysis assessment of vulnerability of households involved in paddy production, the temperature and rainfall data and trends of a period of 30 years and other result for discussion are included in the factors affecting paddy production.

4.1 Respondents Socio-economic Characteristics

Information on respondents' socio-demographic characteristics, age, marital status, education level, gender and household size are shown in Table 1. These characteristics are considered important because they are assumed to have an influence on vulnerability of the rain-fed paddy producing households. According to Kayunze (2000), large family sizes are an important asset in working together to reduce vulnerability to the effects of climate change. Also Pender and Gebremedhin (2007), point out that, household size is normally seen as equivalent to family labour endowment, despite the lack of a significant impact of family size on crop production, where most of the household members take part in production and/or service provision they contribute significantly to the economy of the household. Conversely, having big families is considered to be one of the causes of poverty in Tanzania (URT, 2002).

The household size in the study area varied from 1 to 13 people with an overall average of 6 members, with about 44% of the households had 4-6 members (Table 1). Household size has an important socio-economic implication on household's ability to improve its livelihoods. However, large household size implies more mouths to feed and share the household budget. On the other hand it implies more availability of labour for farm activities. This implies that the larger the family the higher the probability of adapting to climate change. These results are similar to those of Gbetibouo (2009) who found that, household size enhanced the farmer's adaptive capacity to respond to climate change. However, they contradict findings reported by Apata *et al.* (2009) who found that increase in household size reduces the probability of a farmer in adapting to climate change. Although it is assumed that, the household size represent the labour input to the farm, Mano and Nhemachena (2006) argued that, a large household size is mostly inclined to divert part of its labour force into non-farming activities, (Hassan and Nhemachena, 2008). Furthermore, increase in number of working household members resulted in highest reduction in household food insecurity also Benjamin *et al.* (2012) reported that, a larger family size with higher dependants, had probability to be food insecure.

Table 1: Respondents socio-demographic characteristics (n=120)

Characteristic		Mahonda		Matetema		All *Shehias*	
		Freq	(%)	Freq	(%)	Freq	(%)
Age of respond	18-39	30	(50.8)	35	(57.4)	65	(54.0)
	40-59	25	(42.4)	18	(29.5)	43	(36.0)
	>64	4	(6.8)	8	(13.1)	12	(10.0)
Marital status	Single	13	(22.0)	12	(19.7)	25	(20.8)
	Marriage	46	(78.0)	49	(80.3)	95	(79.2)
Education Level	0 year	18	(30.5)	20	(32.8)	38	(31.6)
	7 years	19	(32.2)	24	(39.3)	43	(35.7)
	11 years	22	(37.3)	16	(26.2)	38	(31.7)
	16 years			1	(1.6)	1	(0.0)
Household Head Gender	Female	13	(22.0)	9	(14.8)	22	(18.4)
	Male	46	(78.0)	52	(85.2)	98	(81.6)
Household Member	1-3	10	(16.9)	9	(14.8)	19	(15.8)
	4-6	26	(44.1)	27	(44.2)	53	(44.2)
	7-9	19	(32.5)	18	(29.5)	37	(31.0)
	10-13	4	(6.5)	7	(11.5)	11	(9.0)

NB: Numbers in brackets indicate percent

The majority (54%) of the respondents were between 18-39 years. About 36% of the respondents were middle-aged (40-59 years old). However, it is noteworthy that the majority (90%) of the respondents were in the working age (18-59 years). This is a very important observation, as this group is better able to cope with climate change adaptation. However, Urassa (2010) observed that households headed by younger people grow on average more crops as compared to those headed by older people. Although the percentage respondents older than 64 years was small (10%), these elders usually have more experience on a wide range of climate change adaptation or copping strategies. According to Basu (2012), older individuals in a society have more experience and have better assess to products than younger ones, and hence a higher probability of adapting.

In terms of marital status, the majority (79%) of respondents was married, (Table 1). Marital status influences decision making at the household level. Although the majority of respondents were married, women's status may not be important in decision making powers, especially in the poor community as was found under study by Jan and Akhtar (2008).

Regarding household leadership, Table 1 shows that about one fifth (18%) of the households surveyed were females headed. According to Rutasitara (2002), reported that female-headed households are less well-off than male-headed households, and the former are also more vulnerable due to among other reasons possessing limited capital assets. In addition, the World Bank (1996) pointed out that female-headed households in rural areas own less land, less livestock and have, on average, less years of schooling and they tend to have a higher dependency ratio. The findings of the study area, most of female headed had less year of schooling.

In terms of education level, results revealed that 36% of the respondents had primary school education, 32% had secondary education, while 31% had no formal education. Only 1% had higher education (Table 1). Nevertheless, these results show that, the majority (68%) of the respondents had attained primary and secondary education. Education is essential to enable individuals to easily adapt to the environment with adverse condition as in coping with climate change. According to Abdallah (2001), educated people stand a better chance of adopting new technologies in coping with climate change. Educated farmers may also have a better appreciation of the benefits of adapting to climate change (Mudzonga, 2011). These results are in support of the findings by Deressa *et al.* (2009) who reported a positive relationship between education and adaptation to climate change in Ethiopia. In addition, De Jonge (2010) found that farmers who had university education were more likely to respond to climate change than farmers who have primary education.

4.2 The General Results of LVI and LVI-IPCC in Matetema and Mahonda *Shehias*

Eight components were considered in this study, which comprises socio-demographic profile of the household, livelihood strategies and social networks, food security, water management, and health assessment, natural disasters and climate variability, and energy resources (Table 2). Further presents the vulnerability index of the major components and detailed result on minimum, maximum values and LVI sub-component values appear in Appendix 4. The energy resources had higher index (0.78), followed by food (0.55) and socio-demographic profile index (0.42). Intermediate values were recorded for water (0.38) and for natural disaster and climate variability (0.36). The last three components i.e. the livelihood strategies (0.25), health (0.21), and social network (0.20) showed less vulnerability. The overall LVI of 0.47 shows that, the study areas are highly vulnerable, while the overall LVI-IPCC of 0.08 indicated low vulnerability in climate change. These results imply that, the households of study areas are moderately to highly vulnerable to climate change.

Table 2: Vulnerability Index of major component

Major Components	Vulnerability Index
Socio-Demographic Profile	0.42
Livelihood Strategies	0.25
Social Network	0.20
Health	0.21
Food	0.55
Water	0.38
Natural Disaster And Climate Variability	0.36
Energy Resources	0.78
LVI = 0.47	
LVI–IPCC = 0.08	

The LVI is on a scale from 0 (least vulnerable) to 0.5 (most vulnerable).
LVI-IPCC is on scale from -1 (least vulnerable) to 1 (most vulnerable).

4.3 Comparison of LVI between Matetema and Mahonda

4.3.1 Household Demographic Information

Table 3 presents the indexes of sub-components and major components LVI for each *Shehia*. Based on overall Socio-Demographic Profile (SDP) index, Mahonda shows slightly greater vulnerability than Matetema (0.37 *vs* 0.34 respectively). In contrast, the dependency ratio index was higher for Matetema (0.49) than Mahonda (0.42).

The index for female headed households was lower for Mahonda (0.15) and Matetema (0.22). The household heads who had not attended school were less for Matetema (0.05) than for Mahonda (0.29). Not going to school is considered to limit option for livelihood adaptation to climate change. Mhinte (2000), reported that, education increases working efficiency and productivity, making households with more educated heads to benefit in terms of food and income. These results partly explain why household in Matetema were more vulnerable than those in Mahonda as shown in Table 3.

Table 3: Indexed sub-components, major components, and overall LVI for Matetema and Mahonda S*hehias*

Sub components	Matetema	Mahonda	Major Components	Matetema	Mahonda
Dependents ratio	0.49	0.42	Socio-Demographic Profile	0.34	0.37
Percent of female-headed households	0.15	0.22			
Average age of female head of household	0.67	0.55			
Percent of households where head of HH not attended to school	0.05	0.29			
Average Agricultural Livelihood Diversification Index (range: 0.20–1)a	0.13	0.13	Livelihood Strategies	0.10	0.08
Percent of household depends only in agriculture	0.07	0.03			
Percent of households that have not gone to their local government for assistance in the past 12 months	0.93	0.54	Social Network	0.32	0.35
Percent of households where not member of SACCOS/VIKOBA	0.23	0.71			
Percent of households receive support from relative out of Zanzibar	0.02	0.07			
Percent amount (Tsh.) earned from trades year 2011	0.28	0.20			
Percent amount (Tsh.) earned from other sources year 2011	0.13	0.24			
Average distance to health centre	0.60	0.22	Health	0.35	0.12
Percent of households with family member with chronic illness	0.25	0.25			
Percent of households where a family member had to miss work/school in the last 2 weeks due to illness	0.21	0.02			
Average malaria exposure*prevention index	0.33	0.00			
Average number of months households struggle to find food	0.63	0.36	Food	0.34	0.25
Percent of households that do not save paddy harvest last year	0.57	0.56			
Percent of household most get rice from paddy harvest	0.07	0.05			
Percent of households that do not save seeds	0.28	0.20			
Percentage of family get most of its food from its own farm	0.15	0.07			
Average distance taken to water source	0.00	1.00	Water	0.38	0.44
Average number of liters of water stored per household	0.62	0.66			
Percentage of household do not have consistent water supply	0.87	0.14			
Percent of HHs that collect water directly from river, pond and streams	0.03	0.02			
Percent of households reporting water conflicts	0.36	0.37			
Average number of flood, drought, and events in the past 30 years	0.35	0.50	Natural Disaster & Climate Variability	0.38	0.35
Percent of households that did not receive a warning about the pending natural disasters	0.79	0.46			
Percent of households injured during the recent climate disasters	0.02	0.02			
Percent of households reporting death during the recent climate disasters	0.02	0.00			
Percent of HHs reporting land degradation by climate related extremes during past 30 years	0.98	0.95			
Mean standard deviation of daily mean average maximum temperature by month	0.28	0.28			
Mean standard deviation of daily mean average minimum temperature by month	0.14	0.14			
Mean standard deviation of daily precipitation by month	0.49	0.49			
Percent of HHs using only Forest-based energy for cooking purpose	1.00	0.93	Energy Resources	0.77	0.80
Average distance/time to fetch firewood	0.45	0.80			
Percent of HHs reporting that firewood is being scarce now in comparison to 30 years back	0.66	0.54			
Percent of HHs using traditional cooking stoves	0.98	0.93			

Matetema LVI = 0.46; Mahonda LVI = 0.43

4.3.2 Livelihood strategies

According to Table 3, the overall livelihood strategies component in Matetema was more vulnerable than in Mahonda (0.1 *versus* 0.08). More households in Matetema reported that they depended only on agriculture especially paddy production compared to Mahonda. Agriculture dependency was 0.07 for Matetema and 0.03 for Mahonda. However, the average Agricultural Livelihood Diversification Index for both was the same (0.13) indicating less vulnerability for both *Shehias*. Many households who produce primarily for their own consumption had diversified by adding cash crops (e.g., coconuts, spices and vegetables).

From the perspective of managing risk and associated vulnerability of rural households, and in some cases from a desire to increase incomes, farm diversification makes sense as a policy goal (Kimenju and David, 2008). In terms of diversification, households differed significantly in terms of variables related to household assets, markets and institutions. Both household welfare and rural non-farm diversification decisions are mostly driven by household assets including good health, education, and household age composition. Households who live in communities with access to fertilizers, public transport and local produce markets are more likely to engage in crop diversification as livelihood strategies. This is supported by a study of Emmanuel (2011) on rural livelihood diversification and agriculture household welfare in Ghana.

4.3.3 Socio-network

In case of social Network (Table 3) the overall vulnerability was 0.35 and 0.32 for Mahonda and Matetema, respectively, indicating a slight difference between the two *Shehias*. On the contrary, many households in Matetema had not gone to local government for any assistance in the past 12 months (0.93) compared to Mahonda (0.54).

This shows that, households in Matetema were more vulnerable than Mahonda because the later had not been helped by the local government in the last 12 months. Similarly fewer households were members of SACCOS/VICOBA in Matetema (0.23) as compared to Mahonda (0.71).

In case of households who received support from relatives from outside Zanzibar, Mahonda households were slightly better (0.07) than those in Matetema (0.02). This indicates that overall, both *Shehias* differed little with respect to this sub component. Regarding the percentage amount earned from other sources in year 2011, Mahonda households earned more (0.24) than Matetema (0.13). This is because household in Mahonda had other income generating activities such as tailoring and petty trade (Plate 1).

Plate 1: Petty trade and tailoring as other activities aparty of agriculture

According to Hahn *et al.* (2009), socio-network activities like borrowing money and receiving assistance, given as assistance ratio, seeking assistance from government are a measure of the degree to which households rely on family and friends for financial assistance and in-kind help.

However, households that receive money or in-kind assistance but offer little assistance to others tend to be more insecure and vulnerable than those who do. It is clear that, Community bonds and high levels of trust among households are important for decreasing vulnerability to climate change impacts (Thomas *et al.*, 2005); although these social characteristics are more difficult to measure than food security and health indicators.

The financial resources allow the farmers to change their farming practices in response to changes in climate. Most farmers in the areas are cash strapped to employ effective adaptive measures such as buying appropriate crop varieties seed and fertilisers hence the need for access to credit to ease their financial resource constraints. These results are in line with findings by Hassan and Nhemachena (2008) and Fosu-Mensah *et al.* (2010) who found that access to credit was critical in helping farmers to adapt to climate change in Africa.

4.3.4 Access to health services and health assessment

Table 3 shows that Matetema households travelled an average of 1.1km. to a health centre (VI=0.6) while Mahonda households travelled less (0.3 km.) with VI 0.02. Both *Shehias* reported that, the vulnerability index in term of chronic illness was 0.25. Regarding households where a family member missed work or school due to illness, Matetema has greater vulnerability index (0.21) than Mahonda (0.02), suggesting that, Matetema households were more vulnerable than those in Mahonda. Matetema households also reported to be more vulnerable to malaria exposure while Mahonda had no malaria (malaria exposure prevention index: Matetema 0.33, Mahonda 0.00).

The overall health vulnerability score for Matetema (0.35) is higher than that for Mahonda (0.12). This suggests that Matetema is more vulnerable in terms of health.

Furthermore, Matetema households reported a longer average distance in walking to a health centre, with a higher prevalence of chronic illness, malaria exposure and higher percent of people who were so sick in the past 2 weeks that they had to miss work in Matetema compared to the percent in Mahonda.

These findings suggest that diseases like malaria may have a negative impact on household income by limiting the number of healthy working days despite that most of households use mosquito nets (Plate 2). In addition, the distance to health centre facilities in Matetema might be among the reasons why Matetema households had higher health vulnerability index than at Mahonda. Due to long distance to health centre, and hence their vulnerability due to poor health, the capacity of working in their farms were minimal and further affecting paddy production as number of working days were decreased. Mtei and Borghi (2010), reported that the poorest segment of the population receive less health care benefits relative to their need, whereas other population segments receive a greater share of benefit relative to their needs.

Plate 2: A mosquito net which the Matetema and Mahonda households use

4.3.5 Food security

The average number of months Matetema households reported to struggle to find adequate food for their families were on average 5-6 months per year compared to 2-3 months for Mahonda (Table 3). A higher percentage of Matetema (14.8%) households reported to rely solely on their farm for food compared to just 6.7% for Mahonda households. Matetema had a higher overall Food vulnerability scores (0.34) compared to 0.25 for Mahonda. A higher proportion of Mahonda households reported to have seeds for next season (VI=0.20) compared to Matetema (VI=0.28). In addition, Mahonda households reported a lower level of food insecurity than Matetema households (Table 3).

Due to lack of enough rain for paddy cultivation in Mahonda and Matetema, people produce sweet potatoes and cucumber and other vegetables in the paddy fields and this started about five years back according to participants of the focus group discussions. Plate 3a and 3b shows a cucumber and sweet potato field perhaps used as coping strategies for the effect of climate change and variability in study area.

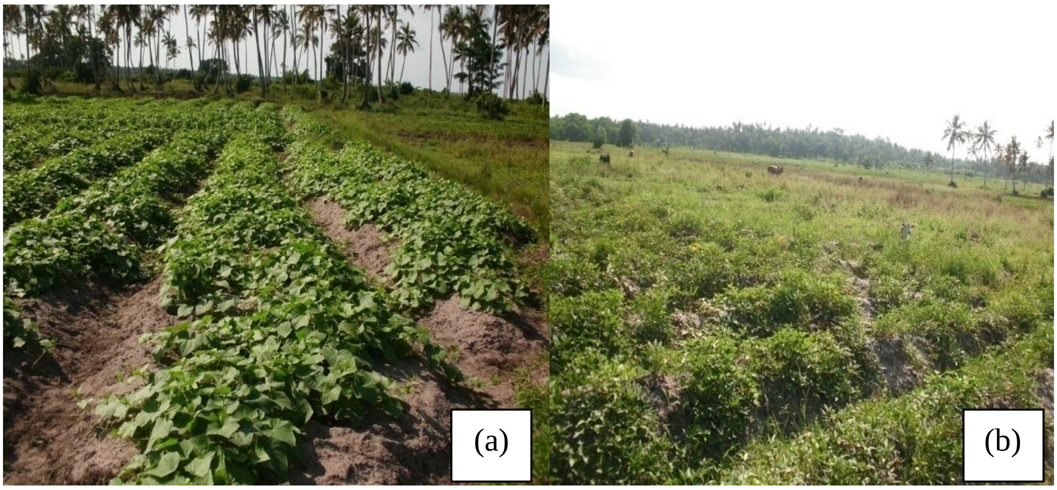


Plate 3: Crop fields as coping strategies due to climate change and variability (a) Cucumber (b) sweet potato

Achieving food security requires that the aggregate availability of physical supplies of food is sufficient, that households have access to those food supplies through their own production, through the markets or through other sources, and that the utilization of those food supplies is appropriate to meet the specific dietary needs of individuals in the households (Benjamin *et al.*, 2012).

4.3.6 Water management practices

Table 3 shows that in Mahonda and Matetema, very few households were using natural water sources (2% and 3%, respectively), as most households in both Matetema and Mahonda had access to tap water. Unfortunately, only 13% of households in Matetema reported a consistent water supply, while only 8% of Mahonda households reported daily availability of water, indicating water shortage in both *Shehias*. As copping strategy, Mahonda households stored 155.09 L of water on average compared to 148.5 L in Matetema in plastic containers or drums as shows in (Plate 4).

Plate 4: **Water storage containers of Matetema and Mahonda households**

At the same time, Matetema households reported travelling 0.54km on average to get water compared to 0.5km in Mahonda. The proportion of households who reported of hearing about conflicts over water in their communities was similar for two *Shehias* (37%). The overall result showed that, Mahonda has a slightly higher vulnerability score (0.44) for the water component than Matetema (0.38). This result suggests that although both *Shehias* have access to tap water (Plate 5a), the availability of water is nonetheless not very reliable, and therefore, the use of deep wells is common (Plate 5b). This is a typical response to unreliable tap water supply with people opting for other sources of water including shallow or deep wells as reported by Ishaku *et al.* (2011).

Plate 5: **Source of water in Matetema and Mahonda are (a) taps (b) wells**

4.3.7 Natural disasters and climate variability

Natural Disaster and climate variability as a major component, based on sub components including households members injured/death during the climate disasters; percent of households that did not receive warnings about the pending natural disasters; percent of households reporting land degradation by climate related extremes during past 30 years; mean standard deviation of daily mean average maximum temperature by month; mean standard deviation of daily mean average minimum temperature by month; and mean standard deviation of daily precipitation by month.

The percentage of households that did not receive warnings about the pending natural disasters was higher for Matetema (0.79) than for Mahonda (0.46). In terms of LVI, both Matetema and Mahonda had an index of 0.4, suggesting relatively high vulnerability to climate change impacts. Hahn *et al.* (2009) reported that, early warning systems and community preparedness plans may help communities to prepare for extreme weather events. Seasonal weather forecasts distributed through local farming associations may help farmers to time their plantings and prevent diversion of scarce water resources for irrigation as well as disaster preparedness.

Both *shehias* show a higher vulnerability index, these were 0.98 and 0.95 for Matetema, and Mahonda respectively. This high vulnerability was due to land degradation. According to Mudzonga (2011), if a farmer is exposed to information on climate change then his/her probability of adaptation to climate change increases by about 44%. This implies that more climate change information dissemination through extension services, weather reports and other channels would increase the likelihood of farmers' adaptation to climate change as reported in the study by Deressa *et al.* (2009) and Hassan and Nhemachena (2008) who found information on climate change to significantly influence farmers' adaptation choices.

4.3.8 Energy resource assessment

The overall score of LVI in energy resources component is extremely high in both Matetema (0.77) and Mahonda (0.80). This is due the fact that almost all households rely on forest-based energy for cooking (Plate 6). The average distance for people in Mahonda to fetch firewood was reported to be 2.17 km while Matetema it was 1.35 km, implying that people in Mahonda were more vulnerable in terms of access to firewood than Matetema.

Plate 6: **The firewood for cooking in the study area**

Household percentage reporting that firewood was more scarce than 30 years back, were 98% for Matetema and 54% for Mahonda, implying that on average firewood is more scarce in Matetema. An average of 96.5% of households in both *Shehias* was using traditional cooking stoves. Furthermore, both *Shehias* were using inefficient traditional stoves, hence, putting more pressure on the forest (Plate 7). It is clear from the respondents that forests are being depleted at a higher rate more than they grow. This is partly supported by distance to firewood sources. In the near future, unless alternative measure are taken, all forest will be depleted, creating acute energy crisis, and hence threatening local community livelihood (Kumar, 2010).

Plate 7: **Traditional stoves used in Matetema and Mahonda**

The vast majority of rural people in the third world depend on traditional fuel such as wood, dung and crop residues, often using primitive and inefficient technologies (Masekoameng *et al.,* 2005). Hence, while energy is one of the basic requirements for human life, most of the rural people do not have enough access to efficient and affordable energy sources as reported by the (World Energy Council, 1999); in the challenge of rural energy poverty in developing countries (Green and Erkskine, 1999). The results of the major component are presented collectively in a spider diagram (Fig. 2). The scale of the diagram ranges from 0 (less vulnerable) at the centre of the web and 0.8 (most vulnerable). Energy resources were the most vulnerable.

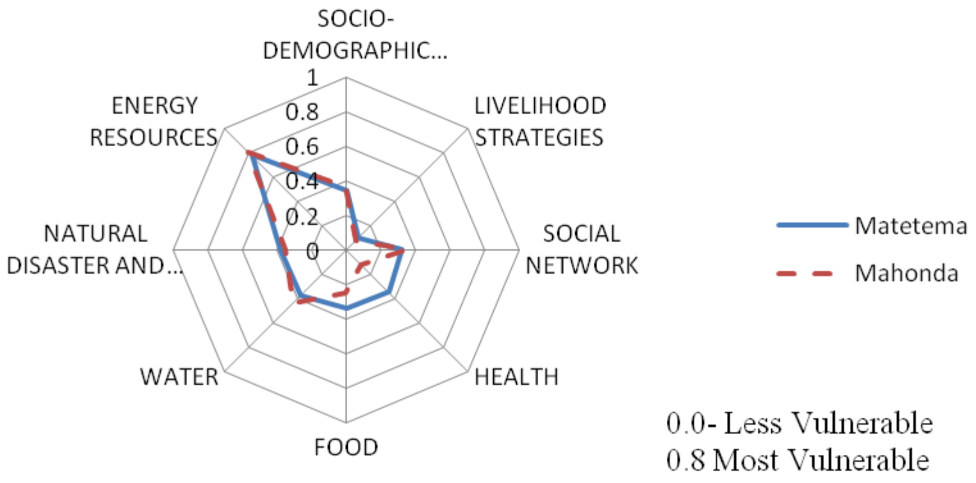


Figure 2: Vulnerability spider diagram of the major components of LVI for Matetema and Mahonda

4.4 LVI-IPCC in Matetema and Mahonda

According to Hahn *et al.* (2009), LVI-IPCC range between -1 to +1. The -1score indicated least vulnerable and +1indicated the most vulnerable. When LVI-IPCC has positive score, it means that a household is more exposed to natural disaster and climate variability than the capacity to adapt or overcome those adverse situations. When score of LVI-IPCC is negative it means a household is less exposed to natural disaster and climate variability.

According to the result presented in Table 4, the LVI–IPCC analysis yielded different results for Matetema (0.080) and Mahonda (0.054). This means that, both *Shehias* score are inclining toward the LVI – IPCC positive scores suggesting some level of vulnerability, and suggest among the three contributing factors to vulnerability, exposure contributes more than others.

Table 4: LVI–IPCC contributing factors for Matetema and Mahonda

IPCC contributing factors to vulnerability	Matetema	Mahonda
Exposure	0.513	0.504
Adaptive	0.286	0.309
Sensitivity	0.354	0.279
LVI-IPCC	0.080	0.054

The study results agree with the general trends in the global model predictions of variable climate in some parts of Africa for example studies by Herrero *et al.* (2010), who reported that Kenya in general would get wetter as a result of climate change and few places would receive less rainfall. The results from the FGDs (Box 1), indicated that there were a number of weather extremes and disasters due to climate change and variability in the study area. Similar results were reported by farmers of Muhonia and Umande in Kenya that the years 1984 and 2009 were characterized by severe drought (Sarah *et al.,* 2012).

Box 1: Key informants opinions on the climatic disasters during the past 40 years

Below are some quotations from respondents in relation to their opinion on climatic disaster:

During 1964 to 1972 "there was drought and hunger " **Mahonda, Station ya Zamani, Matetema and Cairo villages**

During 1972 to 1984 – "there was too much rainfall, and drought" **Mahonda, Station ya Zamani, Matetema and Cairo villages**

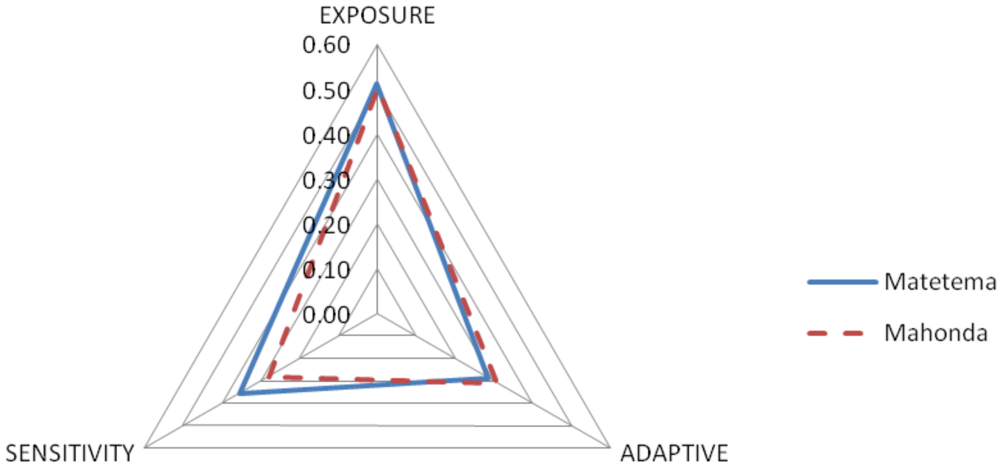
During 1985 to 1990 – "there were floods and cholera" **Mahonda, Station ya Zamani, Matetema and Cairo villages**

During 1990 to 2000 – "there were drought and too much rainfall (*El-Nino*) **Mahonda, Station ya Zamani, Matetema and Cairo villages**

During 2000 to 2010 –"there were earthquake, drought , flood and cyclone" **Mahonda, Station ya Zamani, Matetema and Cairo villages**

During 2010 up to date – "unpredicted rainfall, drought, cyclones "**Mahonda, Station ya Zamani, Matetema and Cairo villages**

Fig. 3 below shows a vulnerability triangle, which plots the contributing factor scores for exposure, adaptive capacity, and sensitivity. The triangle shows that Matetema and Mahonda were similarly exposed to climate change impacts at (0.5).



0 = Low contributing factor
0.6 = High contributing factor

Figure 3: Vulnerability triangle diagram of the contributing factors of the LVI–IPCC for Mahonda and Matetema

Based on account of the current health status as well as food insecurity and water availability, Matetema might be more sensitive to climate change impacts than Mahonda (0.35 *versus* 0.28). However, based on demographics, livelihoods, and social networks, Mahonda showed almost the same adaptive capacity as Matetema, (0.31 and 0.29, respectively).

It was reported that due to the effect of climate change, production of paddy in the study area was declining and communities were adopting short term measures when confronted with unexpected events such as drought (adaptive capacity), including growing crops which are resistant to drought. Some statements from the respondents in relation to their opinion on the copping strategies are presented in Box 2.

Box 2: The copping strategies due to impacts of climate change and variability

Below are some quotations from the respondents in relation to their opinion on copping strategies:

"we have reduced the frequencies of meals from 3 meals to only one meal per day" **Matetema, Mahonda and station ya Zamani villages**

"we have reduced expenditure " **FGD participants Mahonda village**

"we have found early maturing crop varieties as an adoption strategy to climate change and variability for example, for cassava - *kisarawe* and *sepide* which matured in 3 months and for paddy – 88, super B ken, super India, and nerika matured which in 3 months". **FGD participants Cairo village**

" we have started to grow vegetable like cucumber, tomato, water mellow , *zucchini* in 2007" **FGD participants Matetema, Cairo, station ya Zamani and Mahonda villages**

"We have expanded the cassava and banana plantation" **FGD participants Matetema,Cairo, station ya Zamani and Mahonda villages**

"we have diversified into the petty trades" **FGD participants Matetema, Cairo, station ya Zamani and Mahonda villages**

Although the households are vulnerable to climate change and variability, the majority in both communities were aware of climate variability. Manyatsi *et al.* (2010) reported that signs of climate variability included drought, poor rains, and change in rainfall pattern and increase in temperature and most people understand it.

4.5 The Meteorological Data

4.5.1 Trend analysis for surface temperature and rainfall

Data on surface air temperature and precipitation of North B were analyzed using the MAKESENS trend model in Mann-Kendall tests and Sen's method. A significance level of $p < 0.05$ was used for these tests. Any result of $p > 0.05$ is considered not statistically significant.

4.5.2 Results of Trend Analysis for surface temperature

Average annual temperatures were analyzed for the years 1985-2011, which are considered the time series of least amount of uncertainty regarding instrument type and location. Average annual maximum temperatures and minimum temperatures are also analyzed for trends. These data were analyzed seasonally which affect the period of cultivation. The average seasonal minimum and maximum temperature determine the presence of seasonal trends within the cold and hot temperatures. Lansigan *et al*. (2000) reported that, the long-term climate variability influences paddy sowing date, crop duration, crop yield, and the management practices adapted in paddy production. Short-term weather episodes can also affect yield by inducing changes in temperature.

4.5.2.1 Trend Analysis for minimum surface temperature

Raw data for annual surface temperature are shown in Appendix 5. Results of a times series of average minimum temperatures from 1985-2011 analyzed using Mann-Kendall test displayed a significant increasing trend ($Z = 2.17$ at $P\ \alpha\ 0.05$) for period January-February (Fig.4). Sen's estimate was $Q = 0.025$, with both 95% upper and lower boundaries being positive which indicates the presence of a significant linear trend. This means that, the average minimum temperature on dry seasons were increasing at about 0.025^{o}C in study area. This has big implication on paddy production where it is the time for paddy seeds to grow after being planted during October to December (*Vuli* season). Sometime, the seeds failed to grow due to overheating which induces spikelet sterility and therefore reduce paddy production. The study by Sheehy *et al.* (2005), it was revealed that, effect on rice yield depends on possible yield reductions associated with increasing or decreasing temperature. Yield will decrease by 0.6 t ha^{-1} for every 1 °C increase in temperature, but also in a separate study, the simulated yield reduction from a 1ºC rise in mean daily temperature varied from 5-7% for major crops, including paddy (Matthews *et al.*, 1997). Paddy yield losses caused by concurrent increases in temperature are primarily caused by high-temperature-induced spikelet sterility (Matsui *et al.*, 1997).

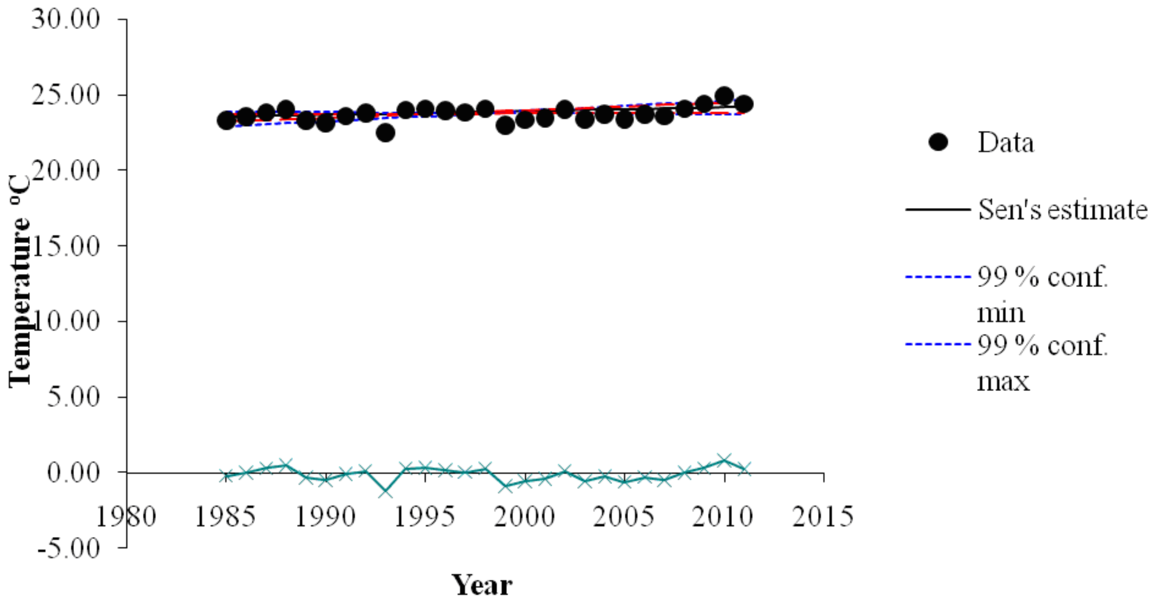


Figure 4: Mann-Kendall and Sen's Estimate Results for average JAN-FEB Minimum Temperature Trend Analysis (1985-2011).

4.5.2.2 Average Maximum temperature trend analysis for January - February

The maximum average temperature during January-February 1985 -2011 (Fig.5) exhibited a significant and positive trend (The Mann-Kendall test: was $Z = 2.24$ at $P > 0.05$). However, Sen's estimate produced a slope of almost no trend with $Q = 0.054$.

According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, it was shown that global surface temperature increased by 0.74 ± 0.18 °C during the 100 years ending in 2005 (IPCC 2007). It was also noted by IPCC (2007) that the rise of mean annual temperature will be 3.3 °C per century. It is evident from the data from Kizimbani station that Unguja North B temperature increased significantly at the rate of 0.054 (Fig. 5).

In paddy production, also extreme maximum temperature is also of particular importance during flowering which usually lasts two to three weeks. Exposure to high temperature for a few hours can greatly reduce pollen viability and, therefore, cause yield loss. Spikelet sterility is greatly increased at temperatures higher than 35 °C (Matsui *et al.*, 1997). Similarly, Masahumi *et al.* (2012), suggested that, in paddy, seed abortion occurs when plants are subjected to temperatures above 35°C but, when the average temperature exceeds 26–27°C at 20 days after ear emergence, grain filling and grain quality are decreased, and there are more immature grains and therefore, production decreases. This means that the paddy production for the North B district was not affected by maximum temperature which was below 35^{o}C but in prolonged temperature as shown in Fig. 3.

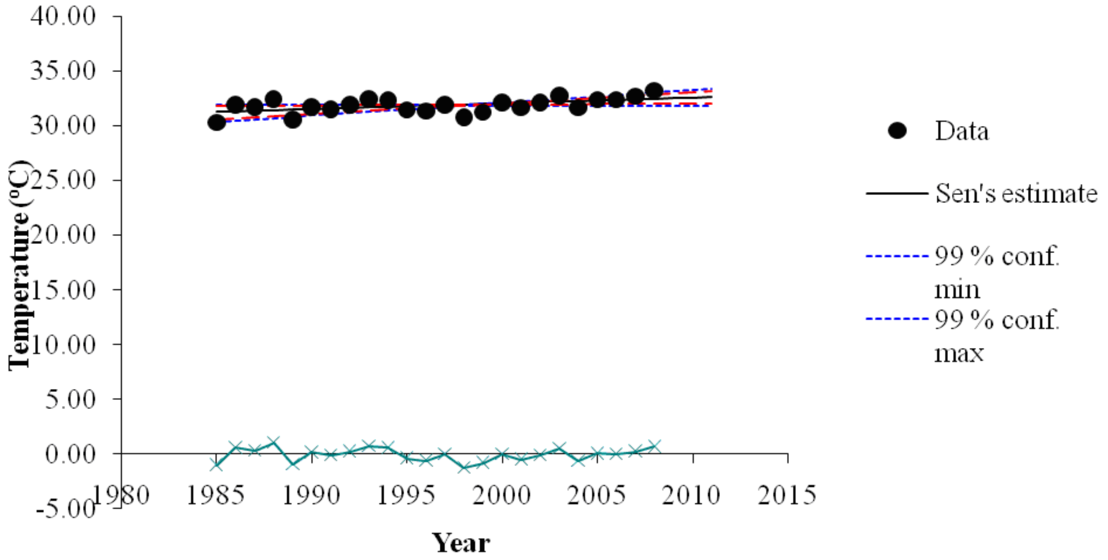


Figure 5: Mann-Kendall and Sen's Estimate Results for Average Jan-Feb Maximum Temperature Trend Analysis (1985-2011).

Table 5: Summary of Trend Analysis for average temperature (1985-2011)

Temperature Parameter (1985-2011)	Mann-Kendall test (*Z*)	Significance level	Sen's slope estimate (*Q*)
Annual Max Average Temp.	1.71	0.1+	1.74E-02
Jan-Feb Max Average temp.	2.24	0.05*	5.39E-02
Jun-Jul-Aug-Sep Average temp.	1.81	0.1+	2.50E-02
Jan-Feb Min Average temp.	2.17	0.05*	2.50E-02
Annual Min average Temp	1.40	>0.1	1.25E-02

Note:
*** if trend at $\alpha = 0.001$ level of significance
** if trend at $\alpha = 0.01$ level of significance
* if trend at $\alpha = 0.05$ level of significance
+ if trend at $\alpha = 0.1$ level of significance

4.6 Trend Analysis for Average Rainfall

Rainfall measurements taken at Kizimbani station were analyzed for the time series covering 1981-2011. The overall result indicates no statistical significance trend in annual and seasonal rainfall (Table 6). This means that, due to decrease of rainfall in the study area, the paddy production decreased in the same time. This result is the same as that of described during the FGDs in Box 1 that, there is drought and unpredicted rainfall which in turn low production. The observations concur with those by Mary and Majule (2009), who revealed that trend analysis of rainfall data indicated that annual rainfall has decreased.

Table 6: Summary of Trend Analysis for Rainfall (1981-2011)

Rainfall Parameter (1985-2011)	Mann-Kendall test (*Z*)	Significance level	Sen's slope estimate (*Q*)
Annual Average rainfall	-1.46	>0.1	-1.09E+01
Jan-Feb Average rainfall.	0.41	>0.1	2.50E-01
Mar-Apr-May Average rainfall.	-0.31	>0.1	-3.58E-01
Jun-Jul-Aug-Sep Average rainfall.	-0.58	>0.1	-1.99E-01
Oct-Nov-Dec Average rainfall	-1.53	>0.1	-2.28E+00

Note:
*** if trend at α= 0.001 level of significance
** if trend at α = 0.01 level of significance
* if trend at α = 0.05 level of significance
+ if trend at α= 0.1 level of significance
If the cell is blank, the significance level is greater than 0.1.

4.6.1 Seasonal rain trends analysis

For this study, seasons were defined as the 'hot season' *Kiangaz*i (January-February), 'long rains' *Masika* (March -April-May), 'cold season' *Pupwe* (June-July - August - September) and 'short rains' *Vuli* (October-November- December).

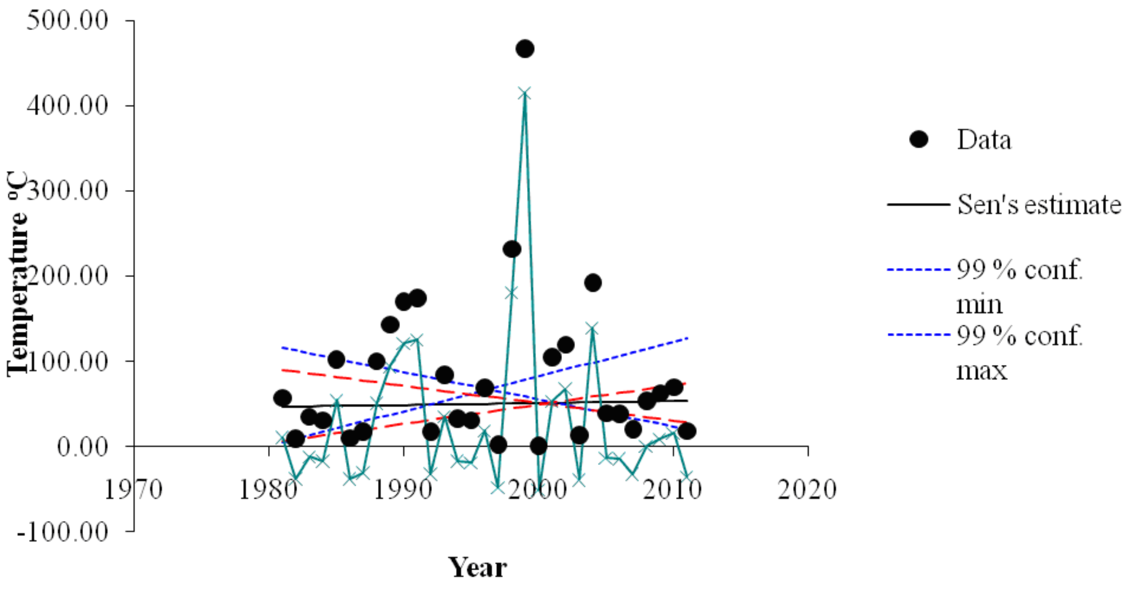


Figure 6: Mann-Kendall and Sen's Estimate Results for Average January-February Rainfall Trend Analysis (1981- 2011).

4.7 Factors Affecting Paddy Production

Factors affecting paddy production in Unguja North 'B' were analysed using the multiple linear regression model. The variables used as predictors were age of respondents; size of households, type of fertilizer used, amount of money spent for labourers and cultivated land size. The amount of money spent in labour correlated with the type of fertilizer used by a farmer. This scenario led to non-inclusion of those variables two in the same model. The model results are given in Table 7 without inclusion of type of fertilizer. The model results shows that the model is highly significant (p=0.000) with independent variables predicting more than 85 % of the total variation in paddy production.

Table 7: Multiple Linear Regression model of Paddy Yield

Variables	Unstandardized coefficient			
	B	Std error	T	Sign.
Constant	4.088	0.231	17.685	0.000
Age of head HH	-0.001	0.004	-0.301	0.764NS
HH members	0.033	0.018	1.836	0.069NS
Cultivated land size	0.996	0.157	6.341	0.000*
Labour	0.000	0.000	3.340	0.001*

F = 171.357 P = 0.000*
R^2 = 0.856 Adjusted R^2 = 0.851
NS= Non significant, *= Significant at p<0.05.

4.7.1 Cultivated land size

The result in Table 7 indicates that land size positively influence paddy yields (P= 0.000). This is typical of what one would expect that, the bigger the land size the higher yield, and the smaller land size the low the yield. These results also comply with what participants of the focus group discussions said that in 1960s up to 1970s the cultivated land for the communities were relatively larger than now where the majority of it is occupied leading to only 0.25ha to 0.5ha per farmer which lowers the production. This result is also supported by Maji *et al.* (2012) for rice farmers of Nigeria, that the bigger the farm size, the higher the yield and the higher the per capita income. Hans *et al.* (2006) comply that improved land access could increase total crop production.

4.7.2 Amount spent on Labour

According to result in Table 7, labour which a key management input in production factors strongly and positively affected yield production (P=0.001). It is expected that the more labour available, the higher yield, and other things remaining constant. This means that, more labour during farm activities like preparation, planting, weeding, fertilization, sowing, applying pesticides, and more labour during harvesting, the yield higher expected. On the other hand, it could lead to an increase in household expenditure and consequently, put the farmers in a more vulnerable position (Maji *et al.*, 2012). The study of Amaza *et al.* (2006), reveals that hired labour are the major factors that are associated with changes in the output of food crops. This result also complies with result of North B district.

4.7.3 Types of fertilizer used

Fertility is also an important factor in paddy production for high yield. The result from study indicate that soil fertility highly and positively influence paddy yields (P=0.004) (Table 8), it appears that the higher the use of inorganic fertilizer the more yield a farmer would get. Fertilizer is an essential input in agriculture, also fertilizer application are crucial for any national effort aiming at improving agricultural productivity. In china, Sam and Ji-yum (2004) revealed that, increase in yield was once modern agriculture was introduced, including use of fertilizer. Rice yield increased 89kg/yr compare to 40kg/50yr. it means using of inorganic fertilizer in china enable to increase yield. According to Amaza *et al.* (2006), support that fertilizer is the major factors that are associated with changes in the output of crops production.

Table 8: Multiple Linear Regressions for Paddy Yield

Variables	Unstandardized coefficient			
	B	Std error	t	Sign.
Constant	3.542	0.285	12.446	0.000
Age of head HH	-0.001	0.004	-0.160	0.873NS
HH members	0.027	0.018	1.483	0.141NS
Cultivated land size	1.718	0.098	17.598	0.000*
Type of fertilizer	0.466	0.157	2.973	0.004*

F = 167 P = 0.000^{*}
R^2 = 0.854 Adjusted R^2 = 0.849

4.8 The Link between Weather, Paddy Production and Vulnerability

Study shows that, an increasing in temperature trend and inconsistent in rainfall, during the months of January and February, which are historically dry season. During January and February it is frustrate preparation for paddy production. Similarly, Mongi *et al.*, (2010) indicate that the overall rainfall amount was found to decline while distribution was varying both in time and space at semi arid area in Tanzania. Also inter-seasonal dry spells between January and February appeared to increase both in duration and frequency. Temperature has shown an increasing trend. Since paddy is staple food in the study area, any factors leading to decreasing in paddy production cause vulnerability to households. Mongi *et al.* (2010) implies that on rain fed agriculture are possible shrinking of the growing season, increasing moisture and heat stress to common food and eventually low production, income and food insecurity. Therefore is strong evidence demonstrating the vulnerability of rain fed agriculture to negative impacts of climate change and variability in the study area.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study reported have assessed farm households' vulnerability to the effect of climate change and variability and examined rainfall and temperature trend of last 30 years and assed the factors affecting farm household paddy production.

Overall, livelihood vulnerability index indicated that households vulnerability was attributed mainly by, food insecurity and limited access to cooking energy. However, when a comparison is made on the vulnerability between Matetema and Mahonda households, Matetema households appears to be slightly more vulnerable than Mahonda. When the climate change factor is brought into the equation, vulnerability of all households appears to be moderate for Matetema and Mahonda. These suggesting that the effects of climate change are not obvious at the moment.

It is further concluded that, the decreasing annual rainfall and increasing of annual temperature are a matter of concern especially on paddy.

5.2 Recommendations

It can be concluded that, most households in North B, especial in Matetema and Mahonda are moderately vulnerable to the effect of climate change and variability and it is therefore recommended that:

i. The rain fed dependent farming households should be more sensitized about climate change and variability, their effects, solutions and appropriate adaptation measures. This could be achieved by organizing seminars on climate change and variability regularly.

ii. The government should pay more attention to the other methods like using water harvesting.

iii. Communities in the study area should be educated on using other energy sources including biogas in order to minimize the use of wood as source of energy.

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APPENDICES

Appendix 1: Questionnaire for Vulnerability of Rain-Fed Paddy Producing Households to Climate Change and Variability: A Case of North 'B' District, Unguja

A: General Information:

Date of Interview..............................

Name of the village.................................

Shehia ....

Name of Respondent ....

Farming area1…………… Shehia1……………….District1……………………………

Farming area2…………… Shehia2……………….District2……………………………

B. Characteristics of Respondent

1. What is your age?...........................
2. Gender of respondent

   1.Female

   2.Male
3. What is your marital status?

   1.Single

   2.Married

   3.Divorced

   4.Widowed/widower

   5.Separate
4. What Education level you have achieved?

   1. No formal education
   2. Adult education
   3. Primary education
   4. Secondary education
   5. Higher education

A. Social Demographic

5. What is the head's gender of your family? 1. Female 2. Male

6. How many dependants are in this household?

7. How many family members are in this household?

8. What is the age structure of your household members?

	Age	Male	Female
S/N			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

B. Livelihood Strategies

9. Have you given any support to neighbour in past one year?

   1.Yes 2.No

10. If yes, what kind of support?..

    1.Food 2.Cash 3. Clothes 4. Other

11. Have you received any kind of support from neighbour in the past one year?

    1.Yes 2. No

12. If yes, what kind of support?...

    1.Food 2.Cash 3. Clothes 4. Other

13. Have you approach any government's official for assistance during the past year?

    1. Yes 2.No

14. If yes, for what purpose?..

15. Are you a member of any CBO/NGO?

    1. Yes 2.No

16. If yes, why did you join to any CBO/NGO?

    ....

17. Are you a member of a SACCOS group?

    1.Yes 2. No

18. Have you ever received a support from relatives outside of Zanzibar?

1. Yes 2. No

C. Health

19. How long does it take to reach nearest health centre from your house?

1. <1km 2. 1km 3. 2km 4. Above 2km

20. Is anybody in your family chronically ill?

1. Yes 2. No

21. Has anyone in your family been so sick in the past one month that they had to miss work or school?

1. Yes 2. No

22. Has anyone in your family had malaria in past 3months?

1. Yes 2. No

23. Do you have mosquito net?

1. Yes 2. No

D. Food and Nutrition

24. Where does your family get most of its food?

1. Own farm 2. Market 3. Others

25. The foods you are producing take you how long?

1. Less than 3 month 2. 3months 3. 4months 4.5months 5.6months

26. Does your family have adequate food the whole year?

1. Yes 2. No

27. Are there times during the year that you do not have enough food?

1. Yes 2. No

28. If yes how many months in a year do you get trouble of enough food?

1. 3months 2. 4months 3. 5months 4. 6months

29. Where most is get your rice?

1. Paddy harvest 2. Shop/market 3. Others

30. Did you save some paddy you harvested in the previous year?

1. Yes 2. No

31. Do you keep your own seeds for next season?

1. Yes 2. No

E. Natural Disaster and Climate Variability

37. Productivity

Types of crops	**Land/ha**	**Production**	**Production/ton/ha**

38. What climate related disasters and extremes have affected your land?.....................
39. How have these affected the land? ....
40. How many times has this area been affected by a flood/drought in ten years?
    1. Non 2. Once 3. Twice 4. Three times
41. Did you receive a warning about the flood/drought before it happened?
    1. Yes 2. No
42. Was anyone in your family injured in the flood/drought?
    1. Yes 2.No
43. Did anyone in your family die during the flood/drought ?
    1. Yes 2.No
44. What type of fertilizer do you use?

1. Organic 2.Inorganic 3. Non of above ☐

E. Energy Resources

45. What is the major source of energy for cooking/heating purpose in your household?
    1. Firewood 2. Charcoal 3. Gas 4. Electricity 5. Solar ☐
46. How long does it take to fetch firewood for your family?
    1.0.5 km 2. 1km 3. 1.5km 4. 2km 5. More than 2km ☐
47. What is the situation of availability of firewood in comparison to 30 years back?
    1. More than before 2. Less than before 3. Same as before: ☐

48. What kind of Cooking stove (observation).
    1. Traditional 2. Improved

F. Water

49. Where do you collect your water from?
    1. Tap 2. River 3. Pond 3. Well
50. How long (in km) does it take to get your water source?
    1. <1km 2. 1-1.5km 3. >1.5km
51. Is this water available every day?
    1:Yes 2:No
52. What containers do you usually store water in? (Observation)?
53. How many containers?..
54. How many litres are they in each container?..
55. During the past year, have you seen any conflicts over water in your community?
    1:Yes 2:No

D. Financial Assets

1. Assets

56. How much land do you have?.....................
57. Besides farming, what other activities does your family do associated with agriculture?
    1. Fishing 2. Animal keeping/ Poultry keeping 3. Shop 4.civil servant 5. Others

2. Finance

58. How much did you earn from trade last year?...........................
59. What are your other sources of cash income ?..................
60. How much did you earn from those sources last year?........................
61. Do you take credit service from any CBO/Financial Institutions or other organizations?
    1.Yes 2, No

E. Physical Assets

62. Do you have electricity in your house?
    1.Yes 2.No

63. How much time does it take to reach nearest bus station?

1. 0.5km 2. 1km 3. 1.5km 4. 2km 5. 2.5km 6.more than 2.5km

64. Do you have cell phone?

1.Yes 2.No

65. What is the condition of your road?

1.Tarmac 2.Earth road

A. Agronomy

66. What the amount of fertilizer did you use last year?..................................

67. How many labourers/farmers did you use in a year?..............................

68. How much amount of pestcides did you used in last year?.......................

69. What size of your cultivated land (ha) in year?...

70. What the subsidy did you get last season?

1. tractor 2. Fertilizer 3. Seeds 4. Herbicides/pesticides

Thank You for your cooperation!!

Appendix 2: Checklist for key informants for Agriculture Offices

1. Name of Officer……………………………….
2. Designation/Title……………………………..
3. What is the effect of climate change and variability on the production of rain-fed rice in the Government?
4. When did the effect of climate change and variability start in North B district?
5. What is the trend of climate change and variability for past 30 years?
6. What is the average rainfall and temperature in every year?
7. Do you think the climate change and variability has a significant contribution to vulnerability and resilience to rain-fed rice farming to livelihoods?
8. What kind of assistance do you provide to the households in help them in managing their paddy field in North B district?
9. What are the main problems facing the government due to climate variability?
10. How these problems affect the sector of Agriculture?
11. How does climate change and variability affect rain-fed rice farming?
12. What adaptation strategies are applied to deal climate change and variability effects?
13. How effective are these strategies?
14. Are there laws and by-laws concerning land conservation?
15. What are these laws and by-laws?
16. Are these laws and by laws being implemented?
17. What are the problems facing the implementation of laws and by laws?
18. What are the challenges facing the livelihoods involves on rain-fed rice farming in North B district? …………..
19. How much sacks of rice (100kg) per acre does the government get from the North B district?

Appendix 3: Checklist for Focus Group Discussion

1) What are the livelihood resourses from the village?

2) What crops available and used in the village?

3) What are the previous and current climatic hazard faced by the village?

4) What are the impacts of the previously mentioned climatic hazard on the livelihood resourses?

5) What are the impacts of the previosly mentioned climatic hazard on crops?

6) What are the coping strategiesfor those impacts?

8) Which social groups do you think are vulnerable to the climatic change and variability?

9) Why do you think the above mentioned social groups are more vulnerable to climate change and variability?

10) What organization/institutions were available in your area to assist you during climatic hazards occurring?

Appendix 4: Livelihood Vulnerability Index sub-component values

Major Components	Sub components	Units	Minimum values	Maximum values	Indexsd	VI
Socio-Demographic Profile	Dependents ratio	Ratio	0	1	0.45	
	Percent of female-headed households	Percent	0	100	0.18	
	Average age of female head of household	Average	39	65	0.60	
	Percent of households where head of HH not attended to school	Percent	0	100	0.44	0.42
Livelihood Strategies	Average Agricultural Livelihood Diversification Index (range: 0.20–1)a	Average	0.2	1	0.13	
	Percent of household dependents only in agriculture	Percent	0	100	0.38	0.25
Social Network	Percent of households that have not gone to their local government for assistance in the past 12 months	Percent	0	100	0.26	
	Percent of households where not member of SACCOS/VIKOBA	Percent	0	100	0.26	
	Percent of households receive support from relative out of Zanzibar	Percent	0	100	0.04	
	Percent amount (Tsh.) earned from trades year 2011	Percent	0	100	0.24	
	Percent amount (Tsh.) earned from other sources year 2011	Percent	0	100	0.18	0.20
Health	Average distance to health centre	Kilometer	0.5	2	0.47	
	Percent of households with family member with chronic illness	Percent	0	100	0.25	
	Percent of households where a family member had to miss work or school in the last 2 weeks due to illness	Percent	0	100	0.12	
	Average malaria exposure*prevention index	Average	0	6	0.02	0.21
Food	Average number of months households struggle to find food	Average	2	6	0.61	
	Percent of households that do not save paddy harvest last year	Percent	0	100	0.49	
	Percent of households most get rice from paddy harvest	Percent	0	100	0.06	
	Percent of households that do not save seeds	Percent	0	100	0.76	
	Percentage of family get most of its food from its own farm	Percent	0	100	0.85	0.55
Water	Average distance taken to water source	Kilometer	0.5	1.5	0.02	
	Average number of liters of water stored per household	Liter	50	210	0.64	
	Percentage of households do not have consistent water supply	Percent	0	100	0.87	
	Percent of HHs that collect water directly from river, pond and streams	Percent	0	100	0.03	
	Percent of households reporting water conflicts	Percent	0	100	0.37	0.38
Natural Disaster And Climate Variability	Average number of flood, drought, and events in the past 30 years	Count	0	3	0.27	
	Percent of households that did not receive a warning about the Pending natural disasters	Percent	0	100	0.67	
	Percent of households injured during the recent climate disasters	Percent	0	100	0.02	
	Percent of households reporting death during the recent climate disasters	Percent	0	100	0.01	
	Percent of HHs reporting land degradation by climate related extremes during past 30 years	Percent	0	100	0.97	
	Mean standard deviation of daily mean average maximum temperature by month	Celsius	1.03	2.83	0.28	
	Mean standard deviation of daily mean average minimum temperature by month	Celsius	1.37	3.55	0.14	
	Mean standard deviation of daily precipitation by month	Millimetre	66.87	213.86	0.49	0.36
Energy Resources	Percent of HHs using only Forest-based energy for cooking purpose	Percent	0	100	0.95	
	Average distance to fetch firewood	Kilometre	0.5	2.5	0.63	
	Percent of HHs reporting that firewood is being scarce now in comparison to 30 years back	Percent	0	100	0.60	
LVI = 0.47 LVI–IPCC = 0.08	Percent of HHs using traditional cooking stoves	Percent	0	100	0.96	0.78

The LVI is on a scale from 0 (least vulnerable) to 0.5 (most vulnerable).
LVI-IPCC is on scale from -1 (least vulnerable) to 1 (most vulnerable).

Appendix 5: Monthly Rainfall (in millimeters) of Kizimbani Zanzibar

Monthly Rainfall (in millimeters) of Kizimbani Zanzibar														Seasonal Rain			
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JF**	**MAM**	**JJAS**	**OND**	**ANN**
1981	114	0.5	195.6	238.8	155.6	21.2	15.5	80.1	69.6	174.9	117.7	571.4	57.5	196.7	46.6	288.0	1755.3
1982	18.7	0	99.6	381.5	437.3	166	165.1	55.4	44.7	388	325.1	114.7	9.4	306.1	107.8	275.9	2196
1983	26	44.1	142.5	237.1	457.8	69.8	71.2	13.9	43.5	76.6	73.2	122.2	35.1	279.1	49.6	90.7	1377.9
1984	60.9	0.5	171.6	749.3	238.6	128	80	23.9	63.6	250	448.5	116.9	30.7	386.5	74.0	271.8	2332.2
1985	68.8	135	337.1	289.7	403.8	4.4	99.7	22.6	88.6	117.4	238.8	170.3	102.0	343.5	53.8	175.5	1976.3
1986	20.7	0	255.4	541.3	386.2	36.9	17.5	64.9	81.9	87.7	323.5	240.2	10.4	394.3	50.3	217.1	2056.2
1987	24.8	10.6	114.6	204.2	393.1	0.9	45.0	112.8	23.3	120.7	171.7	49.5	17.7	237.3	45.5	114.0	1271.2
1988	154	45.9	90.0	340	104.3	225	44.8	78.7	68.2	77.2	253.4	274.9	99.9	178.1	104.2	201.8	1756.2
1989	285	1.1	152.1	338.3	291.8	74.2	51.8	98.9	58.3	213.8	97.9	155.3	143.2	260.7	70.8	155.7	1818.7
1990	134	207	272.4	269.2	194	86.6	37.1	18.9	69.4	139.8	188.7	103.9	170.3	245.2	53.0	144.1	1720.6
1991	175	TR	182.7	81.2	417.6	46.6	105.9	39.8	59.5	62.7	162	110.6	174.6	227.2	63.0	111.8	1443.2
1992	31.6	3.2	100.1	621.7	492.9	74.6	126	25.8	105.6	31.1	115.7	384.4	17.4	404.9	83.0	177.1	2112.7
1993	167	1.9	114.0	333.3	295.6	49.0	40.8	51.0	54.7	164.5	155.0	325.5	84.6	247.6	48.9	215.0	1752.6
1994	0.0	66.5	233.3	719.6	367.3	28.6	104.1	42.1	52.0	119.6	310.0	226.0	33.3	440.1	56.7	218.5	2269.1
1995	30.9	31.0	288.4	304.4	398.9	4.6	30.4	121.1	69.5	78.6	93.4	76.6	31.0	330.6	56.4	82.9	1527.8
1996	47	90.7	166.8	429.9	422.1	3.9	42.7	22.7	17.7	153.9	141.6	0.3	68.9	339.6	21.8	98.6	1539.3
1997	0.6	4.9	344.7	391.3	155.5	138.0	22.9	14.4	36.7	578	260.8	215.8	2.8	297.2	52.9	351.5	2163.2
1998	367	96.3	144.4	529.1	148.7	172.0	65.7	22.7	74.6	136.9	208	56.3	231.8	274.1	83.8	133.7	2022.2
1999	141	793	247.9	415.5	288.2	192.0	89.8	118.0	67.0	29.0	231.6	296.3	466.8	317.2	116.8	185.6	2909.2
2000	1.0	0.7	167.8	342.9	95.7	301.0	128.8	85.4	19.1	7.3	127.7	446.7	0.9	202.1	133.6	193.9	1724.2
2001	119.0	92.1	132.4	233.5	308.6	77.0	19.2	20.7	19.5	44.8	102.5	67.6	105.4	224.8	34.1	71.6	1236.5
2002	161.0	77.9	272.5	572.9	165.9	44.0	73.6	171.9	149.7	166.9	251.7	283.2	119.7	337.1	109.8	233.9	2391.6
2003	2.1	24.7	71.1	58.8	240.7	69.2	148.7	57.2	95.1	159.4	149.9	75.5	13.4	123.5	92.6	128.3	1152.4
2004	105.0	280	245.4	411.2	49.0	89.5	45.2	35.7	38.1	156.1	335.9	192.9	192.1	235.2	52.1	228.3	1983.2
2005	77.6	1.3	181.9	578.4	378.2	36.9	17.7	61.5	43.9	72.2	186.3	19.6	39.5	379.5	40.0	92.7	1655.5
2006	65.7	12.1	135.1	486.2	162.8	170	38.6	30.7	33.3	112.4	246	226.2	38.9	261.4	68.0	194.9	1718.6
2007	32.4	9.2	229.4	313.7	402.3	78.3	22.3	82.4	24.6	136.7	112	67.2	20.8	315.1	51.9	105.3	1510.5
2008	72.5	34.8	200.8	526.6	93.3	64.8	47.9	41.3	43.0	110.5	144.6	61.3	53.7	273.6	49.3	105.5	1441.4
2009	35.4	89.7	175.4	244.5	143.1	80	30.9	27	5.8	137.8	56.6	229.4	62.6	187.7	35.9	141.3	1255.6
2010	49.4	89.8	129.5	376.9	298.0	54.0	2.9	55.5	54.6	8.5	187.1	49.3	69.6	268.1	41.8	81.6	1355.5
2011	35.9	0.6	286.5	549.9	339.5	47.1	33.6	42.0	177.8	141.9	390.9	139.4	18.3	392.0	75.1	224.1	2185.1
TOTAL	2624	2245	5881	12111	8726	2634	1865	1739	1853	4255	6207.8	5469					

Appendix 6: Mean monthly Maximum temperature (C) at Kizimbani Zanzibar

Mean monthly Maximum temperature (C) at Kizimbani Zanzibar																	
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JF**	**MAM**	**JJAS**	**OND**	**ANN**
1985	31.3	29.3	30.6	30	28.4	28.8	28	28.3	28.6	29	29.6	30.3	30.30	29.67	28.43	29.63	29.51
1986	31.5	32.3	31.8	31.6	29.0	28.5	28.2	28	29.4	30.5	30.5	31.5	31.90	30.80	28.53	30.83	30.51
1987	31.2	32.2	32.6	31.5	29.4	28.6	28.8	28.2	29.3	30.2	31	31.9	31.70	31.17	28.73	31.03	30.66
1988	32.2	32.7	33.4	30.5	30.0	28.5	28.5	28.5	28.9	30.1	30.4	30.8	32.45	31.30	28.60	30.43	30.70
1989	29.6	31.5	31.7	29.7	27.5	28.1	28.1	27.4	28.6	29.3	30.5	31.4	30.55	29.63	28.05	30.40	29.66
1990	31.4	32.0	31.4	30.7	30.0	28.7	28.2	28.2	29.2	29.8	30.4	30.8	31.70	30.70	28.58	30.33	30.33
1991	31.5	31.5	31.9	31.3	28.8	28.8	27.8	28.1	28.6	32	31.0	30.7	31.50	30.67	28.33	31.23	30.43
1995	31.2	32.6	31.6	30.2	28.9	29	28.9	28.5	29	30.1	31.7	32.3	31.90	30.23	28.85	31.37	30.59
1996	32.8	32.1	31.8	29.8	28.8	28.9	28.2	28.2	29.4	29.4	30.2	32.0	32.45	30.13	28.68	30.53	30.45
1997	32.7	32.0	30.9	30.2	29.2	28.1	28.3	29.5	29.7	29.2	30.1	30.9	32.35	30.10	28.90	30.07	30.35
1998	30.7	32.2	32.2	31.0	30.4	28.9	28.3	29.1	28.8	29.5	30.1	31.1	31.45	31.20	28.78	30.23	30.41
1999	31.0	31.6	31.3	29.4	28.8	28.1	27.6	27.7	28.8	29.5	30.1	30	31.30	29.83	28.05	29.87	29.76
2000	31.5	32.3	31.2	30.2	29.5	27.3	27.8	28.2	29.0	30.6	31.1	30.7	31.90	30.30	28.08	30.80	30.27
2001	30.4	31.1	31.9	31.2	30.0	29.2	27.7	28.1	28.7	29.9	30.5	31.6	30.75	31.03	28.43	30.67	30.22
2002	30.9	31.6	31.1	28.9	29.6	28.7	28	27.6	27.9	29.1	30.0	30.8	31.25	29.87	28.05	29.97	29.78
2003	31.5	32.7	32.8	32.5	30.4	28.7	27.8	28.3	28.7	29.6	30.6	31.6	32.10	31.90	28.38	30.60	30.74
2004	31.0	32.3	31.7	30.3	29.5	28.5	28.1	28.5	29.2	30.0	30.6	30.6	31.65	30.50	28.58	30.40	30.28
2005	31.7	32.5	31.1	30.3	29.0	28.1	29.9	27.9	29.1	29.8	31.2	31.5	32.10	30.13	28.75	30.83	30.45
2006	32.1	33.4	31.4	29.5	29.2	27.8	29.1	28.4	29.3	30.0	29.9	30.8	32.75	30.03	28.65	30.23	30.42
2007	31.7	31.6	32.5	30.6	29.2	28.9	28.6	29	30.3	29.8	30.6	31.4	31.65	30.77	29.20	30.60	30.55
2008	31.7	33.1	31.8	28.9	29.0	28	27.9	28.5	29.1	30.8	30.7	31.8	32.40	29.90	28.38	31.10	30.44
2009	32.8	32.0	31.7	30.7	29.7	29.1	28.3	29.1	30.6	31.3	31.6	31.8	32.40	30.70	29.28	31.57	30.99
2010	32.7	32.7	32.0	31.1	30.3	29.3	28.6	29.2	29.6	31.1	30.3	32.7	32.70	31.13	29.18	31.37	31.09
2011	32.7	33.7	32.3	30.7	29.1	28.9	29.0	29.0	29.3	29.6	30.3	31.2	33.20	30.70	29.05	30.37	30.83

Appendix 7: Mean monthly Minimum temperature (^oC) at Kizimbani Zanzibar

Mean monthly Minimum temperature (^oC) at Kizimbani Zanzibar																	
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JF**	**MAM**	**JJA**	**SOND**	**ANN**
1985	23.5	23.1	22.8	23.1	22.4	21.1	20.1	19.8	19.6	10.6	21.9	23.2	23.30	22.77	20.33	18.83	20.93
1986	23.5	23.6	23.5	23.4	22.6	21.3	20.9	20	19.8	21.1	22.3	23.4	23.55	23.17	20.73	21.65	22.12
1987	24.0	23.7	23.9	23.9	23.1	21.5	20.8	20.9	20.4	21.5	22.5	23.4	23.85	23.63	21.07	21.95	22.47
1988	24.4	23.7	24.1	23.7	22.7	21.7	20.5	20.5	20.5	21.0	22.5	23.1	24.05	23.50	20.90	21.78	22.37
1989	23.5	23.1	23.3	23.0	22.2	21.0	20.5	19.9	20.0	21.0	22.1	24.0	23.30	22.83	20.47	21.78	21.97
1990	23.0	23.3	23.0	23.6	23.0	20.7	20.2	20.3	19.5	21.3	22.5	23.3	23.15	23.20	20.40	21.65	21.98
1991	23.6	23.6	23.2	23.8	22.8	21.4	21.1	19.7	19.1	21.2	21.8	23.3	23.60	23.27	20.73	21.35	22.05
1992	23.5	24.1	23.4	23.2	22.3	21.4	23.0	19.2	19.6	20.4	22.3	23.5	23.80	22.97	21.20	21.45	22.16
1993	21.4	23.6	23.1	23.1	22.7	21.5	20.3	19.6	19.3	20.7	22.0	23.2	22.50	22.97	20.47	21.30	21.71
1994	24.3	23.7	23.8	23.0	22.3	21.3	20.8	20.2	20.3	21.6	22.4	23.1	24.00	23.03	20.77	21.85	22.23
1995	24.3	23.9	23.8	23.8	22.6	21.1	20.9	20.3	19.9	21.0	22.8	22.4	24.10	23.40	20.77	21.53	22.23
1996	24.0	23.9	23.7	23.2	22.6	21.4	19.8	18.6	19.3	20.2	21.4	23.8	23.95	23.17	19.93	21.18	21.83
1997	24.2	23.5	23.6	23.4	22.5	21.5	20.8	19.9	20	21.7	23.4	23.9	23.85	23.17	20.73	22.25	22.37
1998	23.4	24.8	24.2	24.0	22.8	22.0	21.0	20.3	20.4	20.0	21.5	23.1	24.10	23.67	21.10	21.25	22.29
1999	23.7	22.3	23.4	22.9	22.2	21.0	20.2	19.5	20.1	19.9	21.7	22.4	23.00	22.83	20.23	21.03	21.61
2000	23.7	23.0	23.0	22.7	22.3	21.0	20.2	19.8	19.4	20.0	22.5	23.3	23.35	22.67	20.33	21.30	21.74
2001	23.7	23.3	23.3	23.5	23.8	23.2	20.5	19.9	19.6	20.9	22.1	23.9	23.50	23.53	21.20	21.63	22.31
2002	24.2	23.9	23.8	23.2	22.4	21.1	20.4	20.1	19.9	21.0	22.2	23.1	24.05	23.13	20.53	21.55	22.11
2003	23.3	23.5	23.8	23.4	22.7	21.9	20.7	19.7	20.1	20.7	22.0	23.5	23.40	23.30	20.77	21.58	22.11
2004	24.0	23.5	23.5	23.3	22.5	20.7	19.9	18.3	19.8	21.3	22.2	23.2	23.75	23.10	19.63	21.63	21.85
2005	23.4	23.4	23.0	23.6	22.4	21.3	19.0	19.0	19.3	19.9	21.6	23.5	23.40	23.00	19.77	21.08	21.62
2006	23.9	23.6	23.4	22.7	21.9	21	19.9	20.1	19.9	21.0	22.3	23.0	23.75	22.67	20.33	21.55	21.89
2007	23.7	23.5	23.1	22.7	22.4	20.6	19.9	19.7	18.9	24.6	22.7	23.7	23.60	22.73	20.07	22.48	22.13
2008	24.1	24.1	23.7	23.3	22.1	20.8	20.1	20.2	20.1	22.7	23.5	23.8	24.10	23.03	20.37	22.53	22.38
2009	24.3	24.5	24.4	24	23.1	22.1	20.6	20.1	20.5	22.7	23.2	24.0	24.40	23.83	20.93	22.60	22.79
2010	25	24.9	24.7	23.7	23.4	22.1	20.5	19.6	19.4	20.7	22.8	23.6	24.95	23.93	20.73	21.63	22.53
2011	24.3	24.5	24.1	23.7	23	21.7	19.7	19.7	20.7	21.8	23	24.1	24.40	23.60	20.37	22.40	22.53