CLIMATE CHANGE IMPACTS AND ADAPTATION STRATEGIES OF SMALL SCALE AGRICULTURE PRODUCTION IN MICHEWENI DISTRICT PEMBA, TANZANIA

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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.

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ABSTRACT

This study was conducted in three Shehias within Micheweni district, Pemba to assess the extent of climate change impacts and crop yields. Specifically, the study aimed to identify and assess climate change impacts to small scale farmers, assess the link between precipitation, temperature, sea level rise, crop/fish production, identify and assess climate change adaptation strategies by small-scale farmers in the District. Primary data were obtained through focus group discussions, key informants and households. Household questionnaires and checklists were used to collect both qualitative and quantitative data to obtain information from respondents. In each Shehia, a sample of 30 households was randomly selected from the register for household interviews. Climate data were obtained from Pemba Meteorological Headquater at Chake Chake Airport and the Matangatuani station. Secondary data were extracted from literature review. Data analysis was done using excel (to get descriptive statistics), Statistical Package for Social Sciences (SPSS), correlation analysis and content analysis methods. The trend of climate measured for the last 30 years showed decreasing precipitation and increased temperatures. The highest annual average rainfall was 196.2 mm (1986) and the lowest 72.5 mm (2001) measured at the Matangatuani Meteorological station. Crop failure, low crop production, soil infertility, crop pests / diseases and sea water intrusion were major climate change impacts. Results indicated annual decrease of crop production in the past 10 years, with pests and diseases, uneven distributed low rainfall and extended drought periods. Crop rotation, use of improved seeds and new crop varieties, fertilizer application, irrigation, mixed cropping and adjusting sowing dates were some of adaptation strategies. Sea water rise and intrusion constrained paddy farms production where fish and salt farming contributed to environmental degradation in farming areas. The decrease of crop production resulted mostly from climate variations; hence community should establish short term and drought resistant crops.

DECLARATION

I, **MUSSA SAID BAKARI**, 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.

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DEDICATION

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LIST OF ACRONYMS AND ABBREVIATIONS

CC	Climate Change
CCIAM	Climate Change Impacts, Adaptation and Mitigation
DADO	District Agricultural Development Officer
DHM	Department of Hydrology and Meteorology
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
IGAs	Income Generating Activities
IPCC	Intergovernmental Panel for Climate Change
IUCN	International Union for Conservation of Nature
LDCs	Least Developed Countries
MDGs	Millennium Development Goals
mm	millimeter
NAPA	National Adaptation Plan of Action
RGoZ	Revolutionary Government of Zanzibar
SALM	Sustainable Agricultural and Land Management
SIDS	Small Island Developing States
SPSS	Statistical Package for Social Sciences
TASAF	Tanzania Social Action Fund
TMA	Tanzania Meteorological Agency
Tmax	Maximum temperatures
Tmin	Minimum temperatures
TZS	Tanzanian Shilling
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
USAID	United States Agency for International Development
USD	United States Dollar
WMO	World Meteorological Organization
WRI	World Resources Institute
ZAPA	Zanzibar Adaptation Plan of Action
ZBS	Zanzibar Baseline Survey
ZSGRP	Zanzibar Strategy for Growth and Reduction of Poverty

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Climate change is a global problem; although the associated impacts and adaptation strategies vary across the Globe (New *et al*., 2006, Ehrhat and Twena, 2006). Developing countries are expected to be severely affected by climate change (Kurukulasuriya and Mendelsohn, 2008). These countries are reported to be more vulnerable to climate change impacts because majority of the population depend on rain-fed agriculture for food and livelihoods at large (Morton, 2007; IPCC, 2007a; Boko *et al*., 2007). Climate variability has a direct adverse influence on agricultural production in Africa because nearly 80% of agricultural production in these countries is rainfall and temperature dependent (Thornton, 2011).

Over the past few decades, the continent has experienced increased number of warm days and decreased number of extremely cold days (New *et al*., 2006). Spatial and temporal variability of rainfall and temperature, more intense and wide spread droughts and aggravated floods have been common during the period (Deressa and Hassan, 2009). These changes alter the type of agricultural crops, cropping patterns and lead to emergence of crop diseases (Bosire, 2009). For poor rain-fed agriculture dependent communities, change in rainfall and temperature patterns compound existing vulnerabilities. Heavy dependence on natural climate places livelihoods at risk of climate parameters *in situ* rainfall and temperature as the stability of the trends of these climatic parameters declines, so does the security of their livelihoods (Suryavanshi *et al*., 2012). Limited resources and capacities to respond to stresses (floods, drought and emergence of

crop diseases) caused by instability of these climatic parameters constrain the ability to meet basic needs and move out of poverty.

In recent years, Tanzania has experienced crop failure due to low rainfall and emerging crop diseases in many parts (Mtalo *et al*., 2005). Likewise, in other developing countries the climate change impacts have been unavoidable and can lead to widespread poverty if community have not been prepared to adapt the situation. Currently, this climate is found to be highly variable and unpredictable and the country is prone to extreme weather conditions, including droughts and floods (Agrawala *et al*., 2003).

Recent data shows that temperature has increased and precipitation decreased in many areas of the country. The average annual temperature is projected to increase by 2.2°C and rainfall to decrease by 100 mm by year 2100 (URT, 2007; URT, 2003; Agrawal *et al*., 2003; Houghton *et al*., 2001). In this country, where irrigation is very limited and almost the production of all food and cash crops depends on rainfall, changes in climatic parameters is expected to severely have affected crops and cropping pattern. However, little attention has been paid to relate climatic parameters variation with changes in type of crops and emergence of crop diseases.

1.2 Problem Statement and Justification

1.2.1 Problem statement

Micheweni is one of the poorest Districts in Zanzibar where majority of the habitants practice small scale agriculture living at an income of less than USD 150 per capita per year (ZSGRP, 2010; Zanzibar Baseline Survey (ZBS), 2010). The most important economic activity of the community is agriculture followed by fishing and other small enterprises for income generation. In addition to this District being mostly dependent on

agriculture as a major livelihood activity, community efforts have been challenged with various constraints. The challenges include low crop production, minimum fish catch, high temperatures and low rainfall periods, beach erosion, long periods of droughts and sea water rise, encroaching most of paddy farming areas along the coastal belts. While this occurs, the extent and magnitude of the effects is scantly addressed in the literature. In order to ensure their food security, the communities have decided to shift from total dependency on agriculture into other income generating activities such as sea-weed farming, stone and bricks mining, charcoal and small scale enterprises aimed at boosting their income for livelihood development (RGoZ, 2012). Climate change impacts have the potential to undermine and even undo progress made in improving the socio-economic well being of these people from low production rate of agricultural products. The negative impacts associated with climate change are also compounded by many factors, including widespread poverty, human diseases, and high population dynamics, which could be exacerbated by migration of farmers from place to place as a result of salt water intrusion on crop fields. Sea-level rise and unexpected rainfall patterns represent important components of climate change for Micheweni District, with significant implications to deterioration and degradation of natural resources of coastal environments. Subsistence agriculture is dramatically affected by the stress of climate change and farmers will be left extremely impacted without many other options to turn to.

Currently, communities' recognition of climate change is only focused on low crop production, but other changes such as sea water intrusion into crop fields, unpredicted climate patterns, droughts, floods and other climate related impacts are not well felt among the community. Whilst these communities struggle with challenges facing agriculture as a whole, changes in climate are threatening farmers' efforts towards day to day sufficient crop yields resulting into food insecurity. With regard to climate change

impacts and adaptation, farmers in Micheweni have shown little interests and efforts in their farming practices adapting to climate change. This may be due to lack of knowledge and technological capacity of the community. Some studies on climate change already conducted in Zanzibar have lack some important climate change issues. For instance, a study by Hassan, (2010) on local coping strategies for climate change around two marine protected areas has shown these shortfalls. This study, however, has not addressed as many issues regarding the assessment of climate change impacts and adaptation on agricultural production in Micheweni District.

1.2.2 Justification

Environmental change is already affecting small scale farmers' production, and it is threatening their livelihoods in most parts of the globe, particularly in Small Island Developing States (SIDS) including Zanzibar. Micheweni is typical of the victims of this change in climate where extreme variations of weather and rise in sea levels are experienced. The current and the continuing decrease of crop yields among small-scale farmers is likely going to cause a big challenge to livelihood development if timely appropriate actions are not taken against the situation. Literature suggests that higher temperatures and changing precipitation levels caused by climate change will reduce crop yields in many countries (Orindi *et al*., 2006; Stige *et al*., 2006). This is particularly true in low-income countries where adaptive capacity is perceived to be low (IPCC, 2007a).

Adaptation, preparedness and readiness to equip for mitigation measures are very important aspects to overcome climate change. Despite the fact that agriculture is heavily impacted by climate change variability resulting into diminishing crop production (IUCN, 2008), people realization is still very minimal and strategies towards adaptation are not put into consideration. Adapting to climate change involves the need for community

exposure and sensitivity against climate hazards and copes with adverse impacts (IPCC, 2007a; USAID, 2007).

This study focuses on the North eastern part of Pemba island (Micheweni) because this area has been reported to be one of the most vulnerable places in the island in terms of agriculture instability, with high risk and potentially high socio-cultural impacts (RGoZ, 2012).

Results of this study are expected to inform the on-going debate and research on climate change with regard to its impacts, adaptations and possibly as a basis for designing informed adaptation/mitigation strategies. Estimating possible future is essential to climate change impact and adaptation assessment. Therefore, assessing the potential climate change impacts on livelihood through agriculture interventions is urgently needed for the survival of Micheweni communities.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of this study was to assess the extent of climate change impacts on crop yields and adaptation strategies practiced in Micheweni District.

1.3.2 Specific objectives

Specific objectives of the study were:

i. To identify and assess climate change impacts on small scale farmers in Micheweni District.

ii. To assess the link between precipitation, temperature, sea level rise and crop / fish production in the District.

iii. To identify and assess climate change adaptation strategies undertaken by small-scale farmers in Micheweni District.

1.4 Research Questions

The following questions were used to guide the research:

i. What are the major impacts caused by changes of climate in the District?

ii. How are crop and fish production linked to climate change patterns in Micheweni District?

iii. What are the current adaptation strategies of climate change undertaken by small scale farmers?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definitions and Concepts

2.1.1 Climate change

Climate change is defined as **"**the changes in long-term trends in the average climate, such as changes in average temperatures" (Wilson, 2006) or "any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC, 2007b).

The United Nations Framework Convention on Climate Change (UNFCCC) puts more emphasis on the human activities and therefore defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

2.1.2 Climate change adaptation

Climate change adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities (IPCC, 2007a). The definition recognizes that humans can adjust to past (actual) climate change and its impacts, or prepare for projected future (expected) climate change and its impacts. Adaptation can include changes in behaviour, technology, institutions, policies, and other aspects of human systems (IPCC, 2007a). Adger *et al*. (2007) defined adaptation as *"*the ability or potential of a system to respond successfully to climate variability and change, and it includes adjustment in both behaviour and in resources and technology".

2.1.3 National adaptation programmes of action (NAPAs)

NAPA is an initiative which provides a process for LDCs (Least Developed Countries) to identify priority activities that respond to their urgent and immediate needs to adapt to climate change- those for which further delay would increase vulnerability and/or costs at a later stage. Guidelines for the NAPA process assist LDCs to undertake the steps and activities that can ensure effective adaptation based on their different levels of progress with such adaptation that countries are able to select which steps and activities to undertake in order to move forward. NAPA process could be coordinated with national sustainable development objectives, plans, policies and programmes in such a way that coordination and coherence are important elements of the process.

2.2 Climate Change and Variability

Climate change is emerging as one of the most important issues of our time, with the potential to cause profound cascading effects on ecosystems and society. However, these effects are poorly understood and our projections for climate change trends and effects have thus far proven to be inaccurate.

Climate variability refers to changes in patterns, such as precipitation patterns, weather and climate patterns (Wilson, 2006). Denton and Parikh (2003) reported that variability to climate change can accentuate non-climatic stresses such as those related to migration, urbanization, as well as lack of limited food and energy security, poor management of natural resources, loss of traditional coping skills and health risks. These climate change risks will impact progress towards Millennium Development Goals (MDGs) directly and indirectly, but especially those related to poverty reduction, gender equality and environmental sustainability (MDGs 1, 3 and 7 respectively). Inadequate access to food, natural resources, clean water and other resources are mostly contributed by climate

change impacts and variability in various parts of the world including Micheweni District. Likewise, climate change impacts have led to widespread poverty, gender inequality, environmental unsustainability and diseases outbreak among farming communities in the District.

Scott (2014) on climate change implications for employment, argued on future impacts of climate change to slow economic growth and poverty reduction, further erode food security, trigger new poverty traps, the latter particularly in urban areas and emerging hotspots of hunger, women and indigenous peoples being particularly vulnerable. Either, he mentioned on the influence of climate change to both the economy and employment, making it almost impossible to accurately gauge the future with direct impacts on land, fresh water and ocean ecosystems affecting employment dependent on those ecosystems such as agriculture, forestry, fishing and some types of tourism.

2.3 Trend Analysis of Climate Data

Trend of climate in Zanzibar (Unguja and Pemba) is characterized by increasing and decreasing patterns. According to Sanga *et al*. (2013) on small scale farmers' adaptation to climate change effects in Pangani river basin and Pemba, data for temperature and rainfall trends shows an increasing and decreasing rates over time respectively. Another study by Senga *et al*. (2013) on climate parameters variability and its impacts on crop type, cropping pattern and crop diseases also reported a decrease of rainfall and the annual highest maximum and lowest minimum temperature increase over the period of 30 years in the entire area of the Pangani basin and Pemba Island. Sea level rise, on the other hand, was also found to have a slight increase in the same period of years.

2.4 Climate Change Impacts

The impacts of climate change are well documented by Intergovernmental Panel on Climate Change (IPCC) and the World Meteorological Organization (WMO), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP) and the United Nations Educational, Scientific and Cultural Organization UNESCO). As highlighted in the climate change literature, the key impacts of climate change are sea level rise, changes in the intensity, timing and spatial distribution of precipitation, changes in temperature and frequency, intensity and duration of extreme climate events such as droughts, floods, and tropical storms (IPCC, 2007b; USAID, 2009; UNDP, 2009). In Micheweni District, sea water intrusion into the paddy farms, unreliable changes in precipitation and temperature patterns with long periods of drought are thought to be major impacts of climate change on small scale agricultural production. The low crop yield seems to be a result of this situation for many years. The need for community involvement to recognize their roles and responsibilities in addressing climate change impacts will have greater effects towards maximized crop production, hence ensuring food security for livelihood development.

The impacts of climate change are already being felt across the globe and are resulting in increasing frequency and intensity of extreme weather events (IPCC, 2012). Global average temperature has risen by about 0.74 degrees Celsius in the past 100 years (IPCC, 2007a), and will rise to at least 1.4 degrees Celsius by the end of this century, even if emissions were stopped today, due to the long lasting effect of already emitted green house gases (GHGs). Given that emissions of GHGs will continue to rise if no radical measures are taken in the near future, the world is on a trajectory of 3–4 degrees Celsius rise in average temperatures (World Bank, 2012). This is despite international agreement that a rise of more than 2 degrees Celsius should be avoided, as this may create impacts

that humanity and ecosystems no longer can cope with. The number of climate-related disasters has risen from an annual average of 200 in the early 1990s to more than 350 annually since 2000 (CRED, 2012). At the same time, socio-economic factors in combination with impacts of past disasters are increasingly affecting the vulnerability to cope with and adapt to extreme and non-extreme weather events (IPCC, 2012).

It is estimated that developing countries will bear the majority of the costs of damages related to climate change as a result of increased droughts, floods and strong storms coupled with a rise in sea levels. In addition to an increase in the number of climate-related disasters, higher temperatures and increased vulnerability, together with population growth, will result in increased incidence of food shortages and vector-borne diseases (IPCC, 2012). From a humanitarian standpoint, this will stretch existing resources substantially, particularly considering the increased number of small-scale events that are increasingly undermining people's capacities to cope with and recover from disasters. The most vulnerable people will be the ones hardest hit by these changes in climate.

The IPCC (2007a) notes that "climate change impacts will have a different impact among different regions, generations, age classes, income groups, occupation and gender" around the globe. The impacts of climate change will fall disproportionately upon developing countries and the poor within all countries, and thereby exacerbate inequities in health status and access to adequate food, clean water, and other essential resources.

2.4.1 Climate change impacts in agriculture

According to Aydinalp and Cresser (2008), on the possible negative effects, it was

found that climate change could have influenced agricultural production adversely due to resulting geographical shifts and yield changes in agriculture, reduction in the quantity of water available for irrigation and loss of land through sea level rise and associated salinization.

The yields of different crops and geographic limits may be altered by changes in soil moisture, temperature, precipitation, cloud cover, as well as increases in CO_2 concentrations. Low rainfall and high temperature could reduce soil moisture in many areas, particularly in some tropical and mid-continental regions, reducing the available water for irrigation and impairing crop growth in non-irrigated areas of many regions (Aydinalp and Cresser, 2008).

According to FAO (2007), it was learned that the increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance have implications for future food availability, where the potential impacts on rain fed agriculture *vis-à-vis* irrigated systems are still not well understood. The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts (WRI, 2005). FAO, (2007), estimated the impacts for Africa that 25–42% of species habitats could be lost, affecting both food and non-food crops. Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which include indigenous foods and plant-based medicines (McClean, *et al*., 2005). In developing countries, 11% of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries, about 16 % of agricultural GDP (FAO, 2005).

Changes in ocean circulation patterns, such as the Atlantic conveyer belt, may affect fish populations and the aquatic food web as species seek conditions suitable for their life cycle. Higher ocean acidity (resulting from CO_2 absorption from the atmosphere) could affect the marine environment through deficiency in calcium carbonate, affecting shelled organisms and coral reefs.

2.5 Adaptation Strategies

Adapting to climate change involves the ability of a system to change in a way that makes it better equipped to manage its exposure and sensitivity to climate hazards and cope with adverse impacts (USAID, 2007). It also refers to adjustments in social or economic systems made in response to actual or expected climate effects in order to reduce the vulnerability of society to changes in the climate system (Miller, 2008; Olmos, 2001). Coping strategies, on the other hand, refer to the alternative activities in which households engage in order to secure the daily livelihoods including food or income during drought (Orindi and Murray, 2005).

Decisions on the strategy of adaptation are often made by individuals, groups within society, organizations, and governments on behalf of society (Majule *et al.,* 2013). Some adaptation measures may be taken at individual level. Others like rainwater harvesting and investments, building dams, releasing new cultivars that are more drought resistance require collective actions. These time societies have inherent capacities to adapt to climate change and have developed different adaptation and mitigation strategies to combat climate change. They have developed knowledge, skills, technology, institutional arrangements and strategies that are important foundations for adapting to long-term climate change. Based on the type of economic activities and social networks, societies can access local coping strategies against shocks. These highly differ among households

and communities. Communities have always adapted to climate variations by making preparations based on their resources and knowledge accumulated through experience of past weather pattern. The adaptive measures that households use when faced with climate change could also differ in terms of their ease of implementation, equity effects, lag between implementation and effect, their cost of implications, compatibility with other programs, and agencies implementing measures (Admassie *et al*., 2008).

Farmers in Micheweni district have low education level and they are in the mid to high age class (ZBS, 2010). Their capacity to respond towards world's prevailing climatic changes is very minimal and the ability to adapt in climate change technological transfer from where they are to an advanced level is limited and thus threatening crop production capacity. Among the potential adaptation strategies in agricultural production entails the planting of short term – drought tolerant and early returning crop varieties that are also resistant to pests and diseases. A report by RGoZ (2012) conducted in Zanzibar on adaptation highlights local people being practicing various adaptation measures to minimize the impacts of climate change. It reports the dominant practices found as application of fertilizers, irrigation, exchanging agricultural practice and timing of planting, replanting and construction of walls front to the sea shore.

Agriculture is a key priority for adaptation, especially in relation to existing climate variability. The study by RGoZ (2012) has reviewed potential adaptation options and costs, drawing on the previous Zanzibar Adaptation Plan of Action (ZAPA) and other literature. There are a very large number of potential options identified, and a key issue will be to prioritize to be taken forward. ZAPA recognised the need to enhance capacity building including awareness raising, institutional strengthening (particularly for extension services), and strengthening the capacity of agricultural research institutes in

the islands. There are obvious early benefits from better information, with short-term and seasonal forecasting, and early warning systems (e.g. for heavy rain, flood risks, and droughts), and these are seen as an early priority. This links to the earlier discussion of better information on agro meteorological services (capacity, equipment and data/monitoring) and enhanced disaster risk management including the communication and dissemination to key stakeholder (farmers).

Recent study by RGoZ (2012) on economics of climate change in Zanzibar have identified promising options that are robust to the possible future changes (in climate extremes and from climate change), particularly those that have wider cross sectoral benefits (e.g. soil and water conservation), those that might provide greater resilience as well as potential opportunities or synergies with low carbon (e.g. conservation agriculture, agroforestry), and those that offer no regret opportunities (e.g. reducing post-harvest losses). Furthermore, the use of rain water harvesting and storage as a low cost approach for water management, particularly for small holder farmers, is a potentially important option. Many of the most promising options fall within a general definition of sustainable agricultural land management (SALM) practices, and these are considered a priority to build resilience, increase production and generate wider benefits for the islands (RGoZ, 2012). So far these opportunities and options have not been implemented in Micheweni District.

2.5.1 Approaches to climate change adaptation

Easterling, (1996) mentioned two main types of adaptation as autonomous and planned adaptation. Autonomous adaptation is the reaction of, for example, a farmer to changing precipitation patterns, in that s/he changes crops or uses different harvest and planting/sowing dates. Planned adaptation measures are conscious policy options or

response strategies, often multi-sectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. For example, deliberate crops selection and distribution strategies across different agro-climatic zones, substitution of new crops for old ones and resource substitution induced by scarcity.

Farm level analyses have shown that large reductions in adverse impacts from climate change are possible when adaptation is fully implemented (Mendelsohn and Dinar 1999). Short-term adjustments are seen as autonomous in the sense that no other sectors (e.g. policy, research etc.) are needed in their development and implementation. Long- term adaptations are major structural changes to overcome adversity such as changes in land-use to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency related techniques. Reilly and Schimmelpfennig (1999) define the following "major classes of adaptation":

(i) Seasonal changes and sowing dates;

(ii) Different variety or species;

(iii) Water supply and irrigation system;

(iv) Other inputs (fertilizer, tillage methods, grain drying, other field operations);

(v) New crop varieties;

(vi) Forest fire management, promotion of agroforestry, adaptive management with suitable species and silvicultural practices.

IPCC (2007a) remarks that "there are societies and groups throughout the world with insufficient capacity to adapt to climate change, for example, women within subsistence. Farming communities are disproportionately burdened with the costs of recovery and coping with drought in many parts of the developing world".

A number of studies conducted recently in Tanzania have recognized that climate change and variability is happening and is coupled with significant impact on agriculture which is the main source of livelihood in rural areas (Agrawala *et al.*, 2003; Majule *et al.*, 2008; Majule, 2008; Kangalawe and Lyimo, 2009; Mary and Majule, 2009). Various climate-related impacts such as floods and droughts regularly have substantial effects on economic performance and livelihood of communities in rural areas that depend on rain-fed agriculture. A study by Ngana (1983) on drought and famine in Dodoma district indicated that the presence of dry spells in critical periods contribute considerably to crop failure and famine. Given the over-dependence on rain-fed agriculture by the majority of people living in rural areas, climate change has been one of the major limiting factors in agriculture production, thus resulting in food insecurity and low-income generation.

According to the report on development and climate change in Tanzania by Agrawala *et al*. (2003), an in-depth sector analysis focuses on the climate change impacts and policy responses on the Mount Kilimanjaro ecosystem indicated that ice cap has retreated on account of natural causes for over 150 years. Due to a decline in precipitation coupled with a local warming trend that has been recorded in the second half of the twentieth century, Kilimanjaro's ice cap is now projected to vanish entirely by as early as 2020.
According to Liwenga *et al*. (2007); Kangalawe and Liwenga (2005); Kangalawe and Lyimo (2013), for example, droughts and floods have been reported to cause failure and damage in crops and livestock leading to chronic food shortages. A study by Rosenzweig *et al*. (2004) on effects of climate change on global food production revealed that changes in rainfall pattern and quantity has led to loses of crops and reduced livestock production. Increasing impacts of climate change and variability in particular drought and floods on agriculture have been associated with various adaptation and coping mechanisms (Gwambene, 2007).

These mechanisms are based mainly on indigenous knowledge which embodies a wide variety of skills developed outside the formal education system (UNFCCC, 2003). Such coping and adaptation mechanisms include increased exploitation of non-wood forest products and increased wetland cultivation (Majule *et al*., 2008; Majule and Mwalyosi, 2005; Kangalawe *et al*., 2009; Yanda *et al*., 2006; Liwenga, 2003), this indicates clearly how rural people adapt to climate change. Indigenous knowledge arises out of continuous experimentation, innovation and adaptation, blending many knowledge systems to solve local problems (UNFCCC, 2007).

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

2.6 National Adaptation Programme of Actions and Climate Change

National Adaptation Programme of Actions (NAPA) identifies climate change as a global issue posing challenges to the very survival of mankind and sustainable development. The adverse impacts of climate change are now evident almost everywhere. Climate change poses a serious risk to poverty reduction efforts and threatens to undo decades of development efforts. It is widely accepted that the impacts of climate change are, and will continue to be more pronounced in poor countries where these countries have contributed the least to the problem and are the ones least able to cope with the impacts.

According to NAPA (2007), Tanzania's economic base is dependent on the use of natural resources, rain-fed agriculture and biomass for household energy. The economy is highly vulnerable to the adverse impacts of climate change and to extreme weather events. The impacts are already vivid. Through the NAPA preparation process, recent temperature measurements from 21 meteorological stations in the country have shown a steady increase in temperature for the past 30 years which is due to the increasing temperatures where the adverse impacts are now felt in all sectors of the economy threatening human life. Severe and recurrent droughts in the past few years have triggered the recent devastating power crisis. The extreme drop of water levels of Lake Victoria, Lake Tanganyika and Lake Jipe in recent years and the dramatic recession of 7 km of Lake Rukwa in about 50 years, are associated, at least in part, with climate change, and are threatening economic and social activities. NAPA highlighted the eighty per cent of the glacier on Mount Kilimanjaro to have been lost since 1912 and it is projected that the entire glacier will be gone by 2025. The intrusion of sea water into water wells along the coast of Bagamoyo town and the inundation of Maziwe Island in Pangani District, off the Indian Ocean shores, are yet another evidence of the threats of climate change.

According to NAPA (2007), these impacts have already affected not only the local communities but also economic development. In 2005 the Tanzania GDP was targeted to grow by 6.9% but it grew by 6.8%. This was attributed to severe drought that affected most parts of the country, triggering food shortage and power crisis. An economic survey conducted in 2005 showed that the agricultural sector (which is the main economic stay of the country) grew by only 5.2% compared to 5.8% growth in 2004 and this was again attributed to the prolonged drought in 2005/2006. Climate change is thus poised to undermine national efforts to attain the Millennium Development Goals (MDGs) and

places poverty reduction efforts in jeopardy. The loss of human, natural, financial, social and physical capital, caused by the adverse impacts of climate change, especially severe droughts and floods, among many other disasters, are indeed of great concern to Tanzania (NAPA, 2007). The impacts of climate change on sectors such as agriculture, water, health, energy and others have been the driving force for the preparation of the Tanzania National Adaptation Programme of Action (NAPA).

The frequency of extreme weather events such as El Nino floods in 1997/98 and the recent drought are few but important reminders of the deadly effects of climate change to Tanzania. Agriculture being the dominant sector in Tanzanian economy employs over 80 % or two thirds of the population. It accounted for 56 per cent of GDP and about 60 per cent of export earnings in the past three years making a significant contribution to the National GDP compared to other sectors. It is an important economic sector in terms of food production, employment generation, production of raw materials for industries and generation of foreign exchange. According to NAPA (2007), the Gross Domestic Product in real terms grew by 6.8 % in 2005, compared to 6.7 % in 2004, however this was lower than the targeted growth of 6.9% and the drop was attributed to severe drought which affected most parts of the country in the last quarter of last year leading to severe food shortages, food insecurity and hunger.

The overall vision of Tanzania's NAPA identifies immediate and urgent climate change adaptation actions that are robust enough to lead to long-term sustainable development in a changing climate. It will also identify climate change adaptation activities that most effectively reduce the risks that a changing climate poses to sustainable development.

2.7 Sea Level Rise

Rising sea level may have negative impacts on a number of African countries. This can lead to inundation and displacement of wetlands and low-lying coastal zones. The small Islands such as Zanzibar Islands are at high risk of being wiped out in the future. According to IPCC (2007a), "sea-level rise and human development are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas". The IPCC third assessment report estimated that global-mean sea levels had risen 10 to 20 cm during the twentieth century and will rise between 9 and 88 cm (the mid estimate is 48 cm) from 1990 to 2100 (Houghton, *et al.,* 2001). At the regional and local scale, future changes in sea level are more uncertain due to regional climate change effects on sea level and geological processes that are influencing land uplift or subsidence. As an island, Zanzibar will be vulnerable to future sea level rise from climate change. The potential impacts of sea-level rise include flooding and loss of low-lying areas, shoreline (coastal) erosion, salt water intrusion and increased salinity in aquifers and water supplies. The inundation and erosion (flooding and eventually loss of land) may affect human settlements, agricultural land, infrastructure, transport, and water resources within the coastal zone, as well as tourism and provisioning services (fishing, aquaculture and agriculture) (RGoZ, 2012).

Climate change has wide-ranging effects on natural ecosystems and socio-economic sectors worldwide (Bates *et al.,* 2008). Small Islands States have been shown to be more vulnerable from projected impacts of climate change, sea-level rise and beach erosion in particular. Thus, sea level rise can be among the most challenging climate change issues since it threatens the destruction of key coastal infrastructure and costal livelihoods. The rise in the sea level may not only cause damage to existing infrastructure in Zanzibar but also result in floods, rendering many areas uninhabitable and unsuitable for food

production. Furthermore, it could increase the rate of coastal erosion that will have a grave effect to the economy and generally the safety of the people of small islands. Adverse effects of climate change in coastal environment including rising of sea level, may pose the great threats for small islands states like Zanzibar and low-lying areas (Hassan, 2010). Initiatives in Zanzibar at individual levels and groups by community and government have been undertaken to reduce the effects and extent of sea water intrusion in farms through tree planting and dikes construction but still more efforts need to be overemphasized.

2.8 Projections of Future Sea Level Rise and other Coastal Effects

As a small and low lying island, a critical issue for Zanzibar is the rise in sea level from climate change. Rising temperatures, associated with ocean expansion and ice melt will lead to sea level rise. The IPCC (2013) projected global average increases of between 0.3 meters and 1.0 meters of sea level rise over the next century. These projections need to be compared against other factors, notably natural land up lift or subsistence, as these are important in the relative sea level rise. Investigating these other factors is therefore a priority. Nonetheless, there is a strong projected trend of increasing sea level which will have potential effects for many areas of the islands, especially when combined with the changing wind and wave regime (RGoZ, 2014).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location and climate

Zanzibar comprises of two-sister Islands Unguja and Pemba and numerous small islands and islets. Pemba is located in the Indian ocean about 60 km East of Tanzania mainland and lies between longitude 39^{o} and 40^{o} East and between latitude $4^{o}50'$ and $6^{o}30'$South, covering 920 km^2. Micheweni District is located at the North-Eastern part of Pemba Island comprising of 27 administrative Shehias. This study was conducted in Micheweni Constituency which is comprised of three Shehias / villages: Mjini wingwi, Majenzi and Micheweni (Fig.1).

Temperature ranges between $21^{o}C$ at the coolest and $34^{o}C$ at the warmest. Traditionally, two rain seasons occur in the area: long rains between March and May and short rains between November and December. The mean annual rainfall is about 1860 mm; the long rains averaging 363 mm per month and short rains at an average of 175 mm per month.

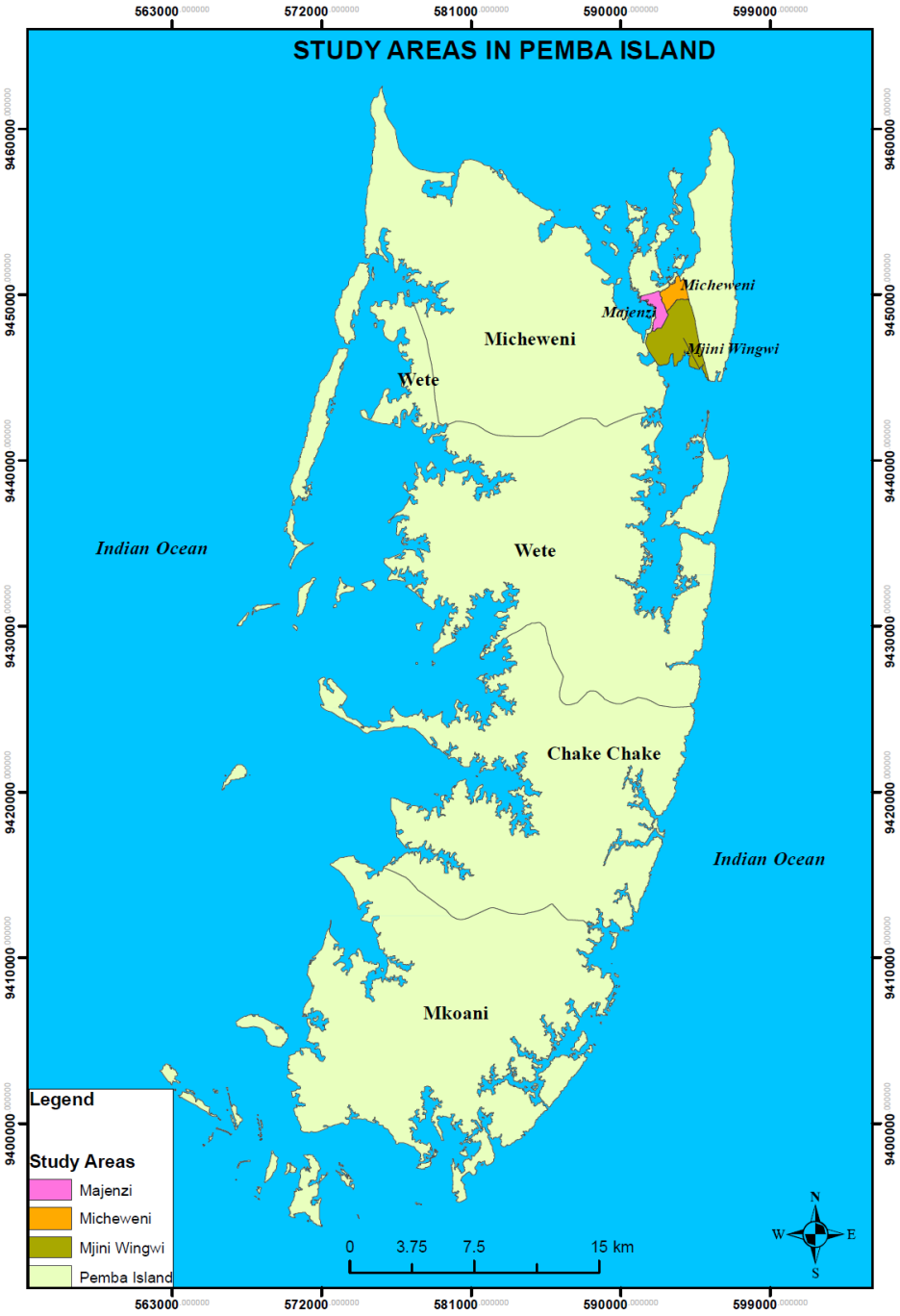

Figure 1: Map of Pemba showing study areas in Micheweni District

3.1.2 Population

According to the 2012 Census report, Micheweni District has a population of 103 816 inhabitants with the average household size of 5.3, women making up 51%) of the population (URT, 2013). The study area population is 13 088 inhabitants, women making 49.5% of the population (URT, 2013), (Table 1).

3.1.3 Culture

The culture of Micheweni people is almost the same to that of all parts of Zanzibar. Being Muslims, they wear pleasant dresses which identify and differentiate them from other foreign cultures. They live cooperatively in their daily life and this is easily recognized during traditional, wedding and funeral ceremonies. *Khanga* and head scarf (kilemba) are the most conspicuous, enjoyable and appreciated dress for women and dishdasha (*Kanzu*) with sewn caps for men. In all occasions, it is very rare to see a naked head of a mature woman. Apart from being sent to school for basic education, *Madras* and Islamic education is a necessity for children. Dances and drama are normal performances during weddings, public, religious holidays and political ceremonies. The long-time hospitality of the people is still recognized and valued. Men mostly appear to be household heads performing large parts of the daily work particularly farming and fishing activities while women engage on paddy farming, house chores handicrafts and children caring.

3.1.4 Economic activities

According to ZBS (2010) report, Micheweni people depend mostly on subsistence agriculture as the major income generating activity for their livelihoods. Other economic activities of the District include fishing, livestock and poultry farming, sea-weed farming, small business enterprises and lime making. Most of the land is coral rag supporting the growth of shallow-rooted cereal crops such as millet, sorghum, maize, finger millet, cassava, bananas among others. Tree planting for household consumption and sale, stone and brick mining are other socio-economic activities of the population. Paddy farming, which is highly affected by sea water intrusion is also a common practice in lowlands. Information from DADO office shows that for 2013, Micheweni comprised of 2317 farmers practicing subsistence farming in various areas.

3.1.5 Fishing

Fishing which is mainly practiced by men is the second income generating activity of Micheweni people after agriculture. Fish constitutes the most important source of protein in Zanzibar, and fisheries are an important economic sector on the island as well as sustaining many livelihoods. The impacts of climate change on fisheries potentially include shifts in species, food chain effects, diseases, and increased ocean acidity. Fish production is so far fluctuating at times, showing increasing and decreasing rate at monthly and annual basis. Harvesting of fish is permissible to almost all species at maturity although this differs from species to species. The only restricted fish types to harvest are the known endangered and threatened species including dolphins (*Pomboo)*, turtles (*Kasa*) etc. According to Hassan (2010), the fisheries activities were found to be affected by severe wind change to the extent that fishermen have to shift from normal fishing grounds instead to deep sea though they face acute gear problems.

3.2 Justification of the Study Area

Micheweni is the poorest District in Zanzibar with most of the population living at a minimum income of less than 1 US$ per day per household (ZBS, 2010). Due to its poor economic condition, the District has been identified as the only Millennium village /District in Zanzibar among other villages in Tanzania. Most of economic donations are regularly year after year directed towards this District to combat their livelihood problems believed to be caused by climate variations. Apart from supporting different types of staple and cash crops, the Eastern part of Micheweni where this study was conducted does not support the growing of Zanzibar's main cash crop (cloves); the highly dependent Zanzibar crop for foreign exchange earnings, economic growth and community livelihoods.

3.3 Research Design

The study used cross sectional design. Creasey (2006) and Miller (2006) recommended the use of this design because of its high degree of accuracy and precision in social science research. A cross-sectional research design allows the researcher to effectively describe change over time and to identify the various mechanisms associated with those changes. This design allows for relative quick and easy collection of variables only at once.

3.4 Sampling Methods

Purposive sampling was employed to select farmers of both sexes and age not less than 45 years. Higher age group respondents are thought to provide valuable information taking into consideration that climate change data variation needs long periods of time. Respondents included in the study were drawn from three villages divided into strata depending on their level of income; high income (>3000 TZS per day), middle income (1000 to 3000 TZS per day) and low income (<1 000 TZS per day) levels. Random sampling was used to select members from each stratum, thus allowing for equal chances of members participation. Also, the key informants were selected to gather more information with regard to changes in climate change patterns. This included District Agricultural Development Officer, Subject Matter Specialists (Environment and Agriculture) and Village Government leaders representing all the three villages in the area.

3.5 Sample Size

According to information from DADO, Micheweni is comprised of 2317 farmers and it was expected that only 25% of all farmers were of that age (>45 years) which is approximately 579 farmers. Matata *et al*. (2010) argues that a sample size ranging from

80 to 120 is adequate for most of social-economic studies in Sub Saharan Africa, hence a sample size for this study was 90 respondents representing 30 members from each of the three villages of Micheweni, Mjini wingwi and Majenzi.

According to District administration plan, each Sheha (Shehia leader) has got ten assistants each representing one of the villages forming the Shehia. In the selection of these 30 members from each Shehia, three members were randomly selected from each village, making a total of 90 members for all three Shehias of the study (Table 1).

Table 1: Demographic characteristics of Micheweni Constituency and sample drawn

	Population				
Shehia	Male	Female	Total	Households	Sampled h/h
Micheweni	3134	3063	6197	1127	30
Mjini wingwi	2305	2216	4521	853	30
Majenzi	1166	1204	2370	423	30
Total	6605	6483	13088	2403	90

Source: URT, 2013

3.6 Data Collection Methods and Analysis

3.6.1 Identification and assessment of climate change impacts

Primary data were collected through Questionnaires and Focus group discussions (FGD). Questionnaires (Appendix 1) were administered to the randomly selected households within each stratum. Both close-ended and open-ended questions were prepared to allow for better responses from the selected respondents. The collected data included identified climate change impacts for the entire period of 30 years and the assessment of the climate change production results per hectare today compared to the past (30) years production

data. These data were then analysed using Statistical Package for Social Sciences (SPSS) to generate descriptive statistics like frequency, mean, percentage and standard deviation while correlation and multiple linear regression analysis were used to test the magnitude of the relationship and influence among dependent variables (crops) and independent variables (climate variables). Qualitative data were analysed by involving the communities through group discussions where immediate feedback was produced.

In FGD with farmers and Key informants, interviews checklists (Appendices 2 and 3) were used to collect information. Key informants included 15 members in each village. The checklists aimed to collect data on the types of climate change impacts they faced with regard to their daily crop production. The impacts were then assessed to check their relation to small scale farming in the District.

3.6.2 Link between climate change variables and products in the District.

Secondary data were obtained from literature review and other secondary sources to supplement the primary information. Data on temperature and rainfall were collected from the Micheweni District Meteorological Station at Matangatuani while data on sea level rise were collected from the TMA headquarters at the Chake Chake airport - Pemba. Production data of four crops (i.e., cassava, banana, millet and rice) was collected from District Agricultural Development Office (DADO) while data on fish production were collected from the District Fisheries Office. All information collected on temperature, rainfall, sea level rise, fish and crop production reflected to a period of 30 years back.

Data on temperature, rainfall and sea level rise were analyzed using Trend analysis method to present patterns and trends of climate in the form of graphs and showing time series on the data collected. Collected information at District level on crops and fish

production was analyzed using Statistical Package for Social Sciences (SPSS), while data on the relationship between temperature, rainfall, sea level rise and changes in crop production in the district were analyzed using Correlation analysis method.

Correlation analysis method:

$$r = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum (X - \bar{X})^2 \sum (Y - \bar{Y})^2}}$$

Where,

r = Correlation coefficient

X = Independent variables (Temperature, rainfall and sea level rise)

Y = Dependent variables (Crop yield)

3.6.3 Assessment of climate change adaptation strategies

The unit of analysis for this objective was households at Shehia, Ward, District and Region. Households were stratified and within each stratum a sample of households was selected randomly. Data on identified adaptation practices against climate change impacts was collected from households and assessment was done to check their performance in the last 30 years using household questionnaires.

In-depth interview was done with relevant authorities from Shehia, Ward, District and Region to provide information on adaptation strategies using a checklist (Appendix 3). The required information included the short and long term analysis undertaken by small scale farmers on the use of improved seed varieties (maize, rice, millet, sorghum, etc.) enduring different soil and salt characteristics, drought and unexpected climate regimes. Analysis was also carried out on changes of farming practices and timing of farm

operations, increased use of manure and fertilizer, use of cropping mixes, better use of management tools including climate information, use of agriculture extension activities and education on climate change, awareness creation on climate change and adaptation strategies and changes in governmental and institutional policies and programmes.

At all administration levels, information was collected on how responsible officers effectively communicate with the Tanzania Meteorological Agency on any early warning systems and issues related to changes in climate patterns and how TMA communicate to regional and lower level authorities on providing such information to farming communities for implementation. Analysis of these data was done using Content Analysis method.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Household Socio-Economic Profile

This entails socio-economic characteristics of the respondents in the study area. It involves respondents' age, education level, sex and marital status, household dependants and income of respondents, type of agricultural crops, land ownership and size of land used for production. These factors are considered to be important when assessing the impacts of climate change and adaptation strategies at household level.

4.1.1 Demographic characteristics

The study indicated that 53% of the respondents' age ranged from 45 to 55 years old. This age range is considered to be an effective human capital age as opposed to 2% who aged above 76 years (Table 2).

Majority of the sample households were male headed (73%) the rest were headed by females (27%). About (70%) of the sample households had a primary level of education. The higher number of households with primary education is attributed to a slight increase in the number of educational facilities country wide. Households with no formal education were about 23% where Mjini wingwi ranked higher for people with no formal education (30%) than other villages in the area, where only (7%) of the respondents had secondary education attainment. This situation automatically brings negative implication towards future development of the District as a whole. The lower the level of education households possess in the area the higher the negative impacts to climate change as far as experiences and skills on adjustment is concerned.

Table 2: Respondents' characteristics in surveyed villages (n=90)

Socio-economic attributes	Response category	Responses Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Age	45 -55	18(60)	16(53)	14(47)	48(53)
	56 -65	8(27)	11(37)	9(30)	28(31)
	66 -75	3(10)	2(7)	7(23)	12(13)
	Above 76	1(3)	1(3)	0(0)	2(2)
Gender	Male	23(77)	21(70)	22(73)	66(73)
	Female	7(23)	9(30)	8(27)	24(27)
Education level	No formal	4(13)	9(30)	8(27)	21(23)
	Primary	23(77)	19(63)	21(70)	63(70)
	Secondary	3(10)	2(7)	1(3)	6(7)
Marital status	Single	0(0)	1(3)	1(3)	2(2)
	Married	25(83)	22(73)	23(77)	70(78)
	Divorced	2(7)	1(3)	2(7)	5(6)
	Widowed	3(10)	6(20)	4(13)	13(14)

NB: Numbers in parentheses indicate percentages

About 78% of the respondents were married compared to only 2% singles with more couples found in Micheweni village (36%). More males were reported in Micheweni village (35%) as compared to more females in Mjini wingwi (38%) and more divorcees recorded in Micheweni and Majenzi than Mjini wingwi where the highest level of widowed respondents was found in Mjini wingwi village (Table 2). Indications of more divorces in former villages were a result of being closer to district headquarter as compared to Mjini wingwi which is a bit far from the district. This shows the strictness of community in rural villages in preserving their marriage ties than the urban villages.

4.1.2 Household incomes

The study revealed that of the 532 household members from the total surveyed households (90), 442 members were dependants who are almost 83% of the total household members. There were more female dependants (54%) against 46% of male

dependants in the area. More male dependants were observed in Majenzi (35%) compared to more female dependants (37%) in Mjini wingwi (Table 3).

Furthermore, Table 3 shows that most of the income of the respondents was earned from crops production (41%) followed by fishing (20%) and formal employed sector by 18% (Table 3). Agriculture is still the main income generating activity (IGA) in this District followed by other important IGAs including petty business, sea weed farming, tree planting, stone / bricks mining, salt farming and lime making. Results indicate that Mjini wingwi earn more in crops farming (36%) as compared to Micheweni and Majenzi (33% and 31% respectively), whereas Micheweni earnings are more directed from fishing (40%) and formal employed sector (58%) than Mjini wingwi and Majenzi villages (Table 3).

Similar results were reported by Kangalawe *et al*. (2009) on climate change and variability impacts, vulnerability and adaptive capacity in Kasulu indicating that majority of the respondents (96.6%) accrued their income from crop cultivation as their main occupation but followed by livestock keeping. Petty business and self-employment were also dominant practices in Micheweni village while in Mjini wingwi income sources were also from bricks mining, beekeeping, and sale of lime and building poles from woodlots for building purposes. The average income per household per day was TZS 1 579 equivalent to 0.71 United States Dollar (Table 3).

Table 3: Household incomes

		Responses			
Variables	Category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Dependants	Male	68(33)	65(32)	72(35)	205(46)
	Female	79(33)	88(37)	70(30)	237(54)
Income(Tshs)	Crops	6862545(33)	7531972(36)	6669483(31)	21064000(41)
	Fishing	4235073(40)	3190654(31)	2961273(29)	10387000(20)
	Petty business	1523000(36)	1368100(32)	1359800(32)	4250900(8)
	Employment	5349250(58)	1256380(14)	2554370(28)	9160000(18)
	Others	1969741(28)	2908750(41)	2143509(31)	7022000(13)
	Total	19939609	16255856	15688435	51883900

1 US$ = 2210 TZS; 1 Year = 365 days

4.1.3 Land ownership and size

There was a negligible difference between size of land owned and used by community for crop production, where 37% of all respondents were found to own 1 ha of land for cultivation. Community in Micheweni District possesses just small portions of land for crop production due to land scarcity relative to population increase. Further, it was found that 92% of the respondents cultivated their farms twice a year compared to those who farm only once per year. Almost 42% of the respondents have been identified to cultivate on the same piece of land for a period of 21 to 30 years, whereas 27% and 15% were those respondents who cultivated their farms for a duration of 11 to 20 and 31 to 40 years respectively (Table 4).

Table 4: Land ownership and cropping

		Responses			
Variables	Category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Farm area owned (ha)	0.5	11(37)	12(40)	9(30)	32(35)
	1	11(37)	11(37)	11(37)	33(37)
	>1	8(27)	7(23)	10(33)	25(28)
Cultivation seasons	Once	2(7)	1(3)	4(13)	7(8)
	Twice	28(93)	29(97)	26(87)	83(92)
Cropping duration (years)	1-10	2(7)	3(10)	3(10)	8(9)
	11-20	8(27)	9(30)	7(23)	24(27)
	21-30	15(50)	12(40)	11(37)	38(42)
	31-40	2(7)	4(13)	8(27)	14(15)
	41-50	2(7)	2(7)	1(3)	5(6)
	51-60	1(3)	0(0)	0(0)	1(1)

4.1.4 Types of agricultural crops

Results identified millet and cassava as the main staple food crops accounting almost 54% of all crops grown by households in these Shehias followed by cassava and bananas (13.3%). These crops are widely grown in the area due to the fact that the coral nature of the soil supports well the growth of these crops. Further, the area is semi-arid supporting drought resistant crops grown at minimum and maximum rainfall and temperatures respectively. Other staple food crops grown at small scale in the District include maize and bananas, rice and millet, rice with bananas, rice and cassava, bananas and millet, millet with maize, cassava and maize and rice with maize (Fig.2). These crops are mostly grown for household consumption, although selling is sometimes also practiced.

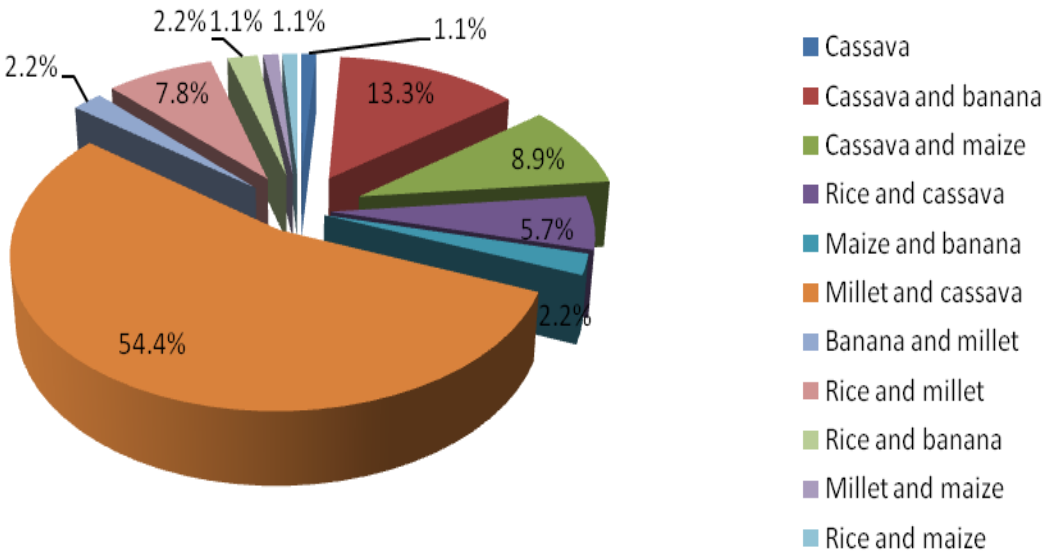

Figure 2: Types of agricultural crops grown in Micheweni District

4.2 Crop Production Improvement

4.2.1 Fertilizer application in respondents' farms

Of the total respondents interviewed, more than half (57%) reported to use fertilizer in their farms while 43% do not use any type of fertilizers. About 45% of those who use fertilizer were reported from Micheweni village against 46% who completely refused the use of any type of fertilizer in their farms reported from Majenzi. The most common fertilizer in use in the District is organic fertilizers (82%) (Table 5). This indicates that most of farmers have enough awareness and oriented on the use of less costly livestock and poultry manure plus other important organic fertilizers locally available within their surroundings. The average crop production per year for those who applied fertilizers in their farms was found to be 1895.3 kg as opposed to 529.3 kg for non-fertilizer users indicating that fertility is a very important factor for high crop production (Appendix 5).

Table 5: Type of Fertilizer used by respondents

Variables	Response category	Responses Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Fertilizer	Yes	23(77)	16(53)	12(40)	51(57)
	No	7(23)	14(47)	18(60)	39(43)
		(n=17)	(n=17)	(n=17)	(n=51)
Type	Inorganic	1(6)	5(29)	3(18)	9(18)
	Organic	16(94)	12(71)	14(82)	42(82)

4.2.2 Trends of crop production

Almost all respondents commented on the annual decreasing trend of crop production in the past 10 years, caused by various factors either under community controls or not. About 23% of the respondents reported crop pests and diseases as the major factors causing the decrease in crop production followed by land / soil infertility and low rainfall (21%), low rainfall per se (18%) and land / soil infertility associated with crop pests /diseases (18%).

Either, it was observed that 100% of all respondents interviewed face major problems in crop production leading to decreased food security in the district (Table 6). Specifically, 1987, 1994, 1998, 2000, 2004, 2009, and 2010 were reported by the community as years of high food decrease in the area.

Table 6: Production trend, causes and problems in crop production

		Responses			
Variables	Response category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Production	Increasing	0(0)	0(0)	0(0)	0(0)
	Decreasing	30(33)	30(33)	30(33)	90(100)
Causes	Land/Soil infertility	1(1)	1(1)	1(1)	3(3)
	Low rainfall	5(17)	6(20)	5(17)	16(18)
	Crop pests and diseases	9(30)	5(17)	7(23)	21(23)
	Land/soil infertility and low rainfall	4(13)	8(27)	7(23)	19(21)
	Drought	5(17)	2(7)	3(10)	10(11)
	Land/soil infertility and crop pests/diseases	3(10)	7(23)	6(20)	16(18)
	Land fragmentation	2(7)	0(0)	0(0)	2(2)
	Unavailability of improved seeds	0(0)	1(3)	0(0)	1(1)
	Sea level rise during high tides	1(3)	0(0)	1(3)	2(2)
Problems in production	Yes	30(33)	30(33)	30(33)	90(100)
	No	0(0)	0(0)	0(0)	0(0)

Furthermore, all Shehias reported crop diseases / pests and drought (62.2%), and crop diseases/pests associated with drought and salt water intrusion (34.4%) as among the major reasons for crop decreases (Fig. 3).

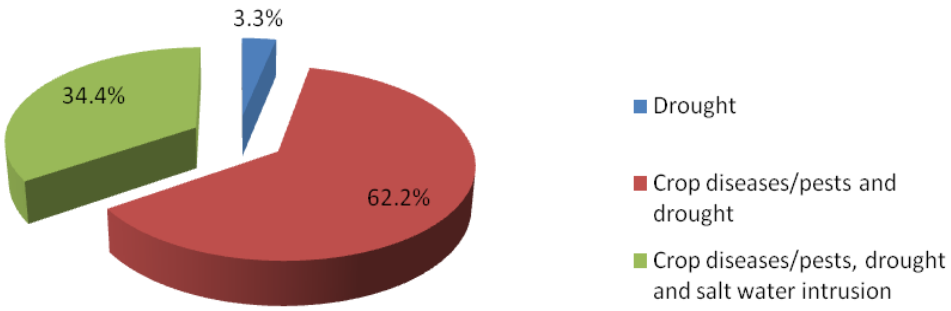

Figure 3: Reasons for decreasing crop production

4.2.3 Solution to decreased crop production

With regard to finding best solutions against problems on decreased crop production more than two-thirds of the respondents (67%) were found to have no any adopted solution with almost 38% from Mjini wingwi village. Solely use of improved seeds and use of improved seeds with fertilizer application were other suggested solutions of decreasing crop production at 19% and 6% respectively (Table 7). It was learnt from this study that most of the households were still lacking appropriate agricultural extension awareness from extension officers at District level.

Table 7: Solution to crop production problems

	Responses			
	Micheweni	Mjini wingwi	Majenzi	Av.Total
Response category	(n=30)	(n=30)	(n=30)	(n=90)
Adoption of new farming technology	0(0)	0(0)	1(3)	1(1)
Use of improved seeds and fertilizers	2(7)	1(3)	2(7)	5(6)
Solely application of fertilizers	1(3)	1(3)	1(3)	3(3)
Use of improved seeds	8(27)	3(10)	6(20)	17(19)
Applying mixed cropping system	0(0)	1(3)	1(3)	2(2)
Improved seeds and crop rotation	1(3)	1(3)	0(0)	2(2)
No suggested solution	18(60)	23(77)	19(63)	60(67)

4.2.4 Climate trends

4.2.4.1 Rainfall

Figure 4 shows that there was a decrease of precipitation over the last 30 years. In 1986 the annual rainfall was about 196.2mm compared to 72.5mm in 2001 as recorded at Matangatuani Meteorological Station. In some seasons, rainfall starts earlier while in other seasons comes late and thus interfere crop schedules and production.

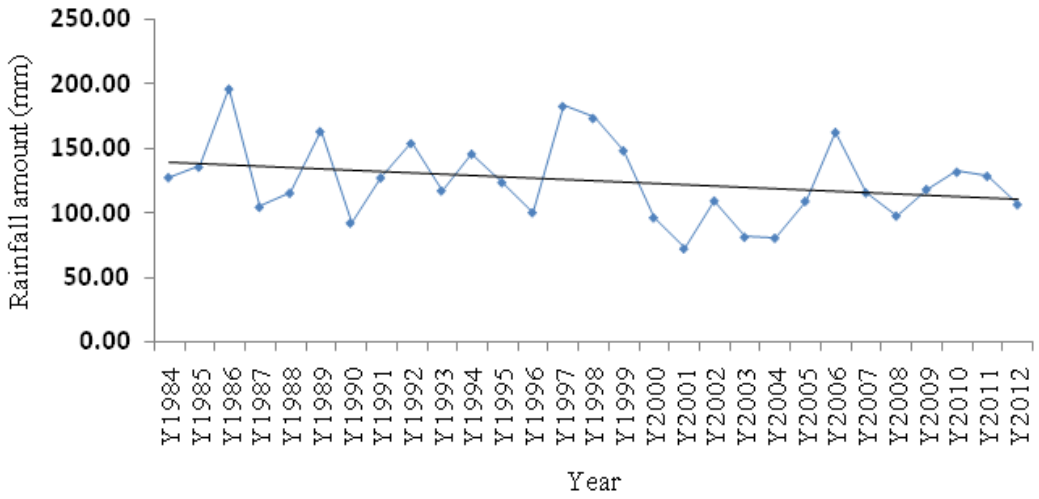

Figure 4: Mean annual rainfall (1984-2012) Matangatuani, Micheweni - Pemba

Source**:** TMA, 2014

Household surveys revealed the same phenomena. About 90% of the households reported that rainfall has shown a decrease trend over the past 10 years. Almost, all Shehias (Micheweni, Mjini wingwi and Majenzi) reported low annual rainfall intensity, unreliable and unevenly distribution during farming seasons (Table 8). All these phenomena contribute to the decrease in crop production (as observed in Section 4.2.2). Other factors believed to contribute to this decrease include loss of nutrients levels damage, use of unqualified seeds and salt intrusion due to pumpage of ground water.

Table 8: Response on rainfall characteristics in Micheweni District (n=90)

		Responses			
Rainfall	Response category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Trend	Increase	0(0)	0(0)	1(3)	1(1)
	Decrease	30(100)	30(100)	29(97)	89(99)
Intensity	High rain and for a long time	0(0)	1(3)	0(0)	1(1)
	High rain and for a very short time	26(87)	24(80)	26(87)	76(84)
	Low rain and for a long time	1(3)	1(3)	0(0)	2(2)
	Low rain and for a very short time	3(10)	4(13)	4(13)	11(12)
Distribution	Even distribution	0(0)	1(3)	1(3)	2(2)
	Uneven distribution	27(90)	26(87)	26(87)	79(88)
	No change	3(10)	3(10)	3(10)	9(10)

A study carried out by the University of Pretoria (Lina Häckner (2009) that sampled 8000 farmers in 11 countries in Africa showed that half of the African farmers perceived a long term decline in precipitation. One third of the respondents perceived a change in the timing of the rains, and one sixth perceived droughts to be more frequent compared to the past. Likewise, Lina Häckner (2009) interviewed 9500 farmers in 10 countries in Africa and found that significant number of the farmers reported decrease in precipitation. Both studies support the decrease of rainfall in Micheweni district for the past 30 years.

4.2.4.2 Temperature

The recorded temperature for the last 30 years at Matangatuani Meteorological Station varies across the period. In the first half of the period the trend presented relative uniform average minimum temperatures. In 1997 the mean temperature dropped to 19.2^{o}C with an abrupt increase to 20.7^{o}C in 1998, while in the second half of the period (1999-2012) the

trend of the mean temperature presents a gradual increase of up to 24.4^{o}C in 2012. Figure 5 shows these mean temperatures.

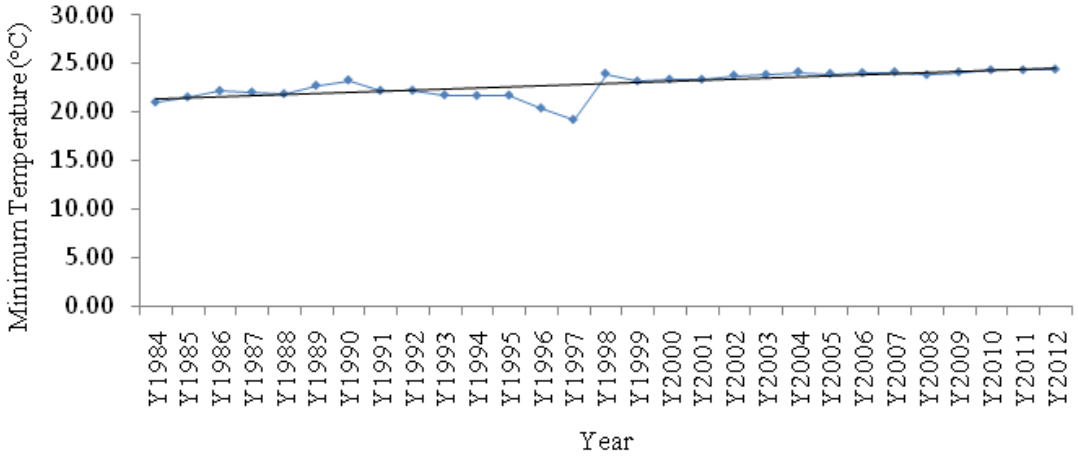

Figure 5: Mean annual minimum temperature (1984-2012) Matangatuani Micheweni, Pemba

Source: TMA, 2014

The temperature records were in line with responses from the sampled households where 97% of the respondents reported increase in temperature over the period of the last 10 years (Table 9). Extended periods of temperatures, crop pests and diseases, soil infertility and decreased rainfall in Micheweni District is the main cause of diminishing crop production (Table 9). The situation has either caused prolonged drought periods leading to death or failure of most crops depended by the community for their livelihood.

Table 9: Temperature trend and effects to agricultural crops (n=90)

Temperature		Responses			
		Micheweni	Mjini wingwi	Majenzi	Av.Total
	Response category	(n=30)	(n=30)	(n=30)	(n=90)
Trend	Increase	29(97)	29(97)	29(97)	87(97)
	Decrease	0(0)	1(3)	1(3)	2(2)
	No change	1(3)	0(0)	0(0)	1(1)
Effects	High temperatures	14(47)	8(27)	7(23)	29(32)
	Death of crops	0(0)	2(7)	1(3)	3(3)
	Crop pests and diseases	6(20)	11(37)	9(30)	26(29)
	Low rainfalls	4(13)	5(17)	5(17)	14(16)
	Sea water rise	0(0)	0(0)	1(3)	1(1)
	Infertile land	5(17)	4(13)	6(20)	15(17)
	No effects	1(3)	0(0)	1(3)	2(2)

Results from the temperature measurements reported the increase of mean annual maximum temperatures from 29.5^{o}C in 1984 to 30.2^{o}C in 1987 followed by a quick temperature decrease of up to 29.2^{o}C recorded in 1989. The mean annual temperatures increasing trend reached to maximum in 1992 recording a peak of 31.4^{o}C. This increasing trend of temperatures stipulates signs of crop failure and / or low crop production in the district (section 4.2.2). Figure 6 indicates that although there were relative increasing and decreasing trends of temperatures, the last 18 years up to 2012 recorded almost a regular temperature increasing trend. Results show maximum temperatures with significant correlation to cassava and millet production indicating that whenever there is an increase in maximum temperatures, there is a decrease of crops production. The crops are the two most common food crops in the community. Also, there was a decrease of banana production though it was insignificantly correlated to temperature (Table 10). For the other food crops, for instance, rice and fish products, there were no observed significance between the maximum temperatures and productions. This may be caused by other

variable factors like soil infertility, timing of planting etc; factors that were not put into considerations.

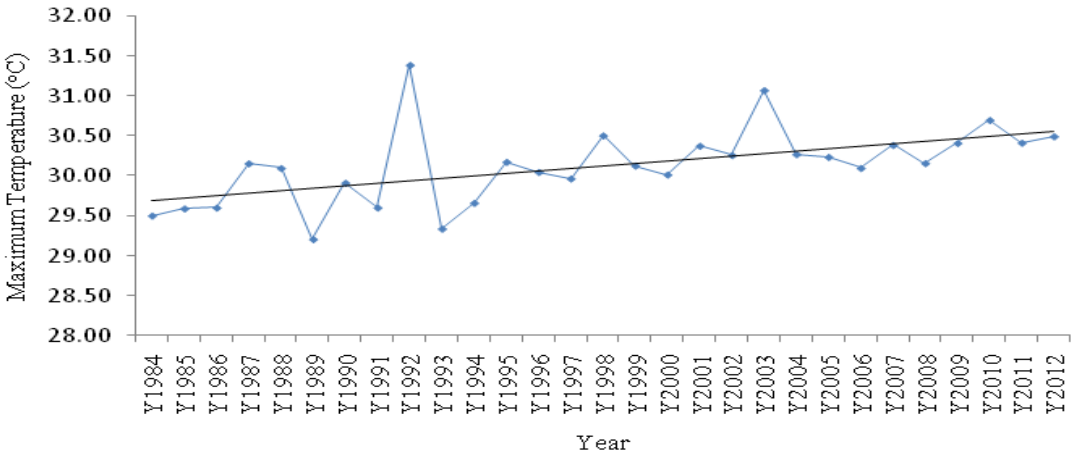

Figure 6: Mean annual maximum temperature (1984-2012) Matangatuani Micheweni, Pemba

Source: TMA, 2014

4.2.4.3 Sea level rise

During the initial years (1985 – 1997), there was a periodic decrease and increasing rise of sea level followed by an abrupt decreasing and increasing rate between 1997 and 2001 before recording the increasing trend between 2001 and 2011 (Fig.7). Results showed the highest annual average sea level rise of 2110 mm reported in 2010 where the lowest was 1980 mm recorded in 2001 with an average increase of 5mm/year (Fig. 7). The rise in sea level affected mostly paddy farming in lowland areas as compared to other crops grown in different areas resulting into decrease in rice production. However, for the last 30 years results (Table 10) indicated that fish catch was found to have a significant correlation to sea rise showing the actual decrease in production. In contrast, the highest fish catch (11 400 tons) recorded in 2012 was not reported on the same year of minimum sea level rise and as well the lowest catch was not observed in maximum sea level season,

hence contradicting. In addition to climatic variables collected, the implication of this scenario might be a result of some other variables not put into considerations during data collection. The provision of various advanced fishing gears to fishing community and rise in price of fish products within the internal and external markets could have contributed to this insignificance.

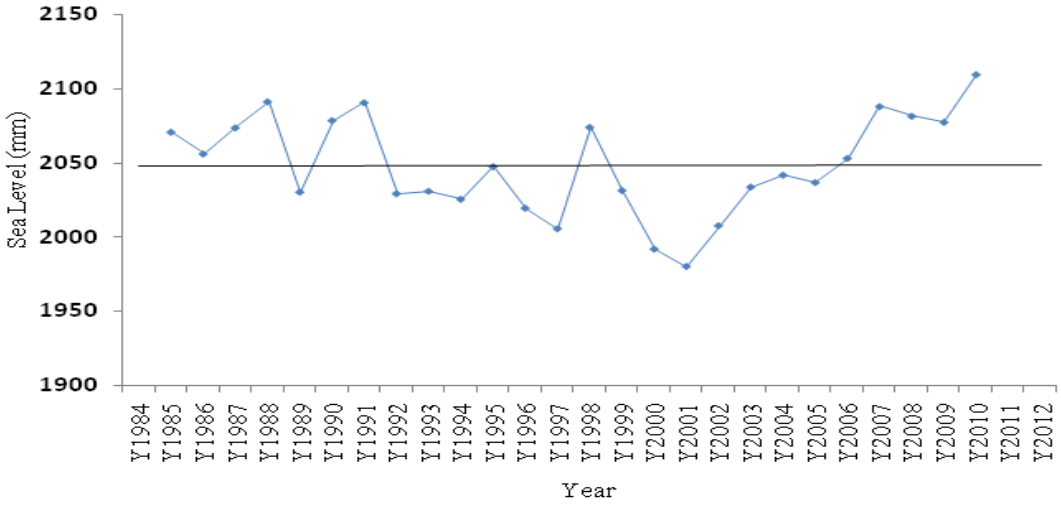

Figure 7: Mean annual sea level (1985-2010) Chake Chake airport– Pemba

Source: TMA, 2014

Table 10: Relationship between climate and agriculture/fish production

Agricultural produces	Sea level	Rainfall	Max. temp	Min. temp
Cassava	-0.214	0.123	-0.441*	-0.409*
Banana	0.007	0.144	-0.245	-0.248
Millet	0.083	0.176	-0.401*	-0.364
Rice	-0.016	0.225	-0.238	-0.432*
Fish	0.426*	-0.086	0.005	0.157

**. Correlation is significant at the 0.05 level*

4.3 Comparison of Monthly Mean Sea Level Height

For the period of 26 years, Zanzibar experienced a rising trend of sea level rise which affected most of the paddy farms. The trend shows a slight variation between the long

term monthly mean sea level at 20 years and the 2003 monthly mean sea level rise (Fig. 8). There was a decrease of long term monthly mean sea level against 2003 mean sea level. As well, Figure 9 depicts a big variation between the long term and 2001monthly mean sea level rise where the long term monthly mean sea level was higher than the 2001 mean sea level records.

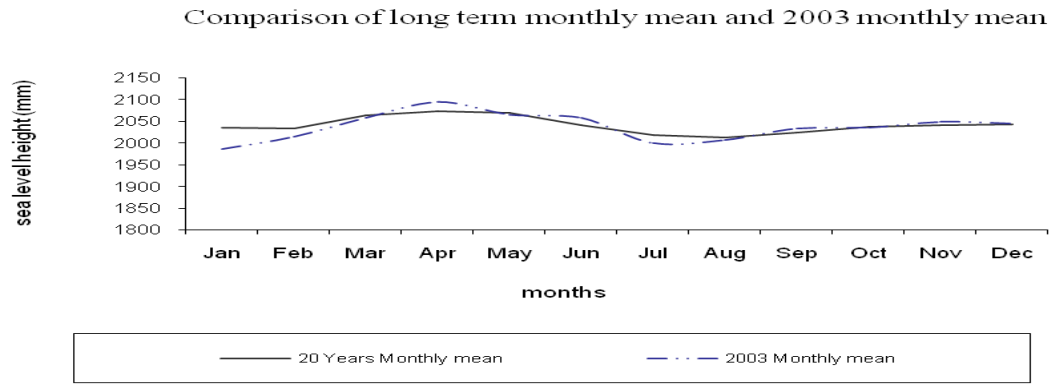

Figure 8: Comparison of long term and 2003 monthly mean sea level

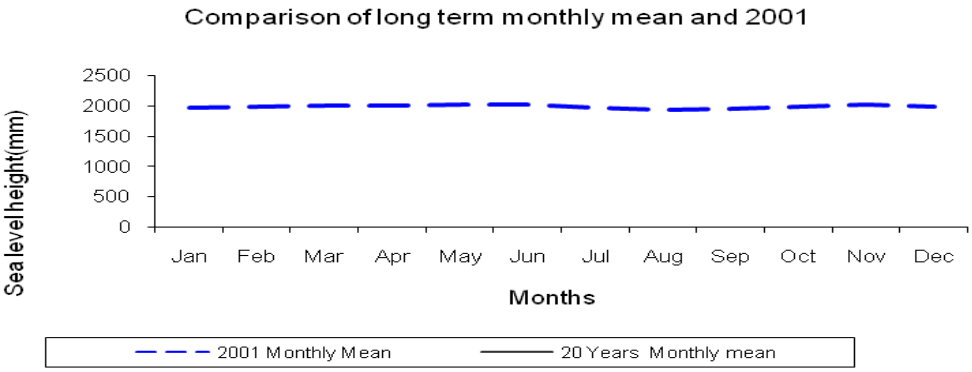

Figure 9: Comparison of long term and 2001 monthly mean sea level

4.4 Effects of Climate Change on Crops

4.4.1 Crops disappearance, affected crops and causes

Survey findings showed that 99% of all respondents from the study area agreed on the disappearing of some important food crops being grown before by farmers in the District

and so far the community has lost interest to continue raising these crops (Table 11). The crops have been found to cost famers in terms of time, energy and financial resources. The most affected crops include pumpkins, pigeon peas, cassava and green grams as well as banana and millet varieties (Table 11). In the past these crop varieties were found to be plenty in the District as their growth was well supported in semi-arid climates and coral rag areas. Community used to depend on these crops as the most staple food varieties and sometimes sold for cash income, but as time went on they slowly started to disappear in the vicinity, believed to be as a result of climate change. This is supported by Sanga *et al*. (2013) in small scale farmers' adaptation to climate change effects in Pangani river basin and Pemba where 72.8% of farmers asked to report on the changes happening in their respective areas and what they think could be the reason. The farmers believe that the disappearance of crops that used to be produced in their areas is a result of climate change.

Table 11: Crop disappearance and effects in the District (n=90)

		Responses			
Variables	Response category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Crops affection	Yes	30(100)	30(100)	29(97)	89(99)
	No	0(0)	0(0)	1(3)	1(1)
Affected crops	Cow peas	1(3)	0(0)	0(0)	1(1)
	Banana	3(10)	5(17)	3(10)	11(12)
	Green grams	4(13)	4(13)	4(13)	12(13)
	Pineapple	2(7)	2(7)	1(3)	5(6)
	Millet	3(10)	3(10)	5(17)	11(12)
	Sweet potatoes	2(7)	2(7)	2(7)	6(7)
	Cassava	4(13)	5(17)	3(10)	12(13)
	Pumpkins	5(17)	5(17)	5(17)	15(17)
	Sorghum	1(3)	1(3)	0(0)	2(2)
	Cocoyam	0(0)	0(0)	1(3)	1(1)
	Pigeon peas	5(17)	3(10)	6(20)	14(16)

Among the reasons for crop disappearance reported by farmers include low rainfall by 34.4% of the respondents, 23.3% crop pests / diseases and 22.2% extended drought periods. Other reasons mentioned in the District were land infertility, high temperatures, and the use of unimproved seeds which are not capable of growing (Fig.10).

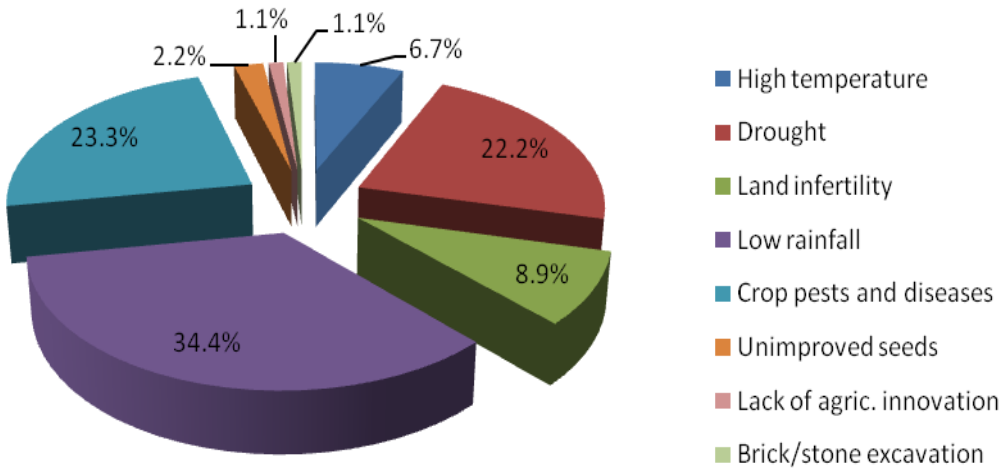

Figure 10: Reasons for crop disappearance

4.5 Climate Change Impacts and Disasters to Crop Farming in the District

4.5.1 Climate change awareness and impacts

Results from the study observed that 96% of all respondents were knowledgeable and aware on the term climate change through long period experiences with 100% from Mjini wingwi agreeing and 75% from Majenzi disagreeing on the term. Similar results were reported by Nyanga *et al*. (2011); Rao *et al.* (2011) and Osbahr *et al.* (2011) on studies assessing farmer perceptions in semi-arid environments of Africa. Almost 100% of the respondents agreed that their farming activities have been affected by change of climate year after year. The community cropping is still being seriously impacted by change of climate leaving farmers with less or no access to food for their livelihood.

Respondents also concluded on the results of these impacts being contributed entirely by low rainfall trend (Majenzi), high temperature (Mjini wingwi), sea level rise (Micheweni) and drought claimed by all of the respondents (Table 12). Juana *et al*. (2013) also mentioned the climate change impacts being low rainfall patterns, high temperatures and drought affecting most of the Sub Sahara African countries. However, Hassan (2010) reported the available land for agriculture as increasingly in short supply due to salinity as a result of climate change and sea level rise where people now experience low yield of agricultural crops accompanied by unpredictable flowering and fruiting.

Table 12: Climate change impacts on crop production in Micheweni (n=90)

		Responses			
		Micheweni	Mjini wingwi	Majenzi	Av.Total
Variables	Response category	(n=30)	(n=30)	(n=30)	(n=90)
Awareness on CC	Yes	29(97)	30(100)	27(90)	86(96)
	No	1(3)	0(0)	3(10)	4(4)
Effects of CC	Yes	30(100)	30(100)	30(100)	90(100)
	No	0(0)	0(0)	0(0)	0(0)
Effect of CC impacts	Low crop production	7(23)	8(27)	13(43)	28(31)
	Crop pests / diseases	12(40)	9(30)	6(20)	27(30)
	Soil infertility	7(23)	11(37)	9(30)	27(30)
	Sea water intrusion	4(13)	2(7)	2(7)	8(9)
Contributing factors of CC	Low rainfall	7(23)	9(30)	12(40)	28(31)
	High temperature	9(30)	11(37)	7(23)	27(30)
	Sea level rise	6(20)	2(7)	3(10)	11(12)
	Drought	8(27)	8(27)	8(27)	24(27)

Sea water intrusion in Micheweni District has also shown a big threat to agricultural production especially in rice fields where during high tides sea water enters into farms and force farmers to vacate the area until situation prevails (Plate 1). Of the most known severe climate change effects noticed by respondents in the last 10 years was the low

level of crop production, crop/seed death, and soil infertility reported by Micheweni, Mjini wingwi and Majenzi community respectively (Fig. 11).

Plate 1: Paddy plot vacated by farmers due to sea water intrusion

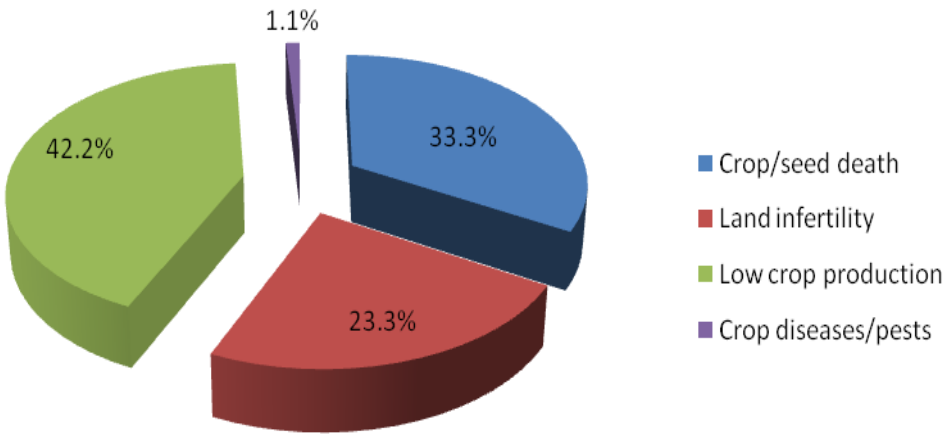

Figure 11: Climate change effects in Micheweni District

Figure 12 depicts that almost 70% of all surveyed households reported the duration of these climate change effects occurring more than three times in 10 years of cropping period and thus cause decreasing production rate of food crops in the District.

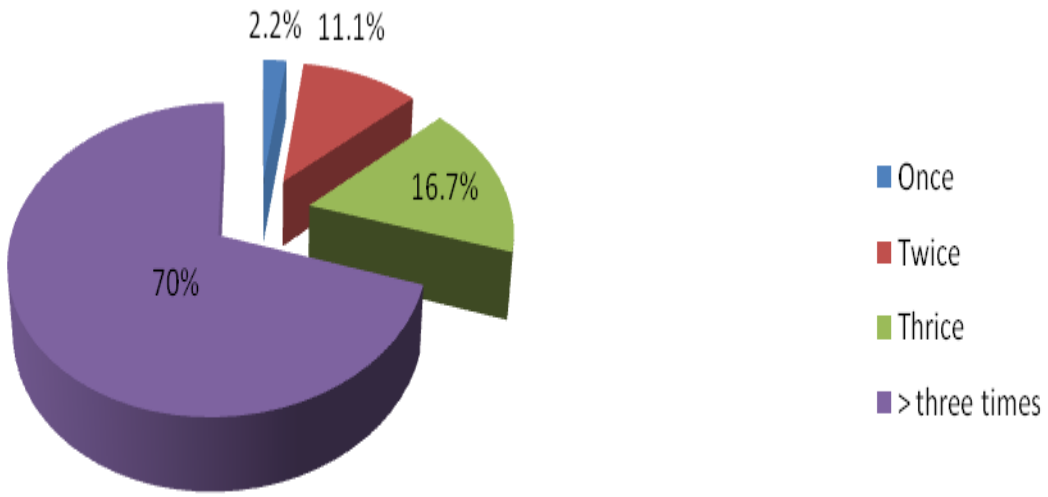

Figure 12: Duration of climate change effects at Micheweni District

4.5.2 Information sharing on climate change impacts in the District

Most of the interviewed respondents reported that for the last 10 years the District did not formulate any information network among Shehia leaders, agricultural extension officers and district officials to convey alert messages whenever climate change impacts and disaster reports were revealed from Tanzania Meteorological Authority (TMA). This lack of reliable information system and networks created an ill coordination among officials and farmers as they were unable to gain the required information in time and hence farmers invested energy to prepare their fields for cropping for nothing. Table 13 shows that about 83.3% of the surveyed respondents commented on the poor information system existed in the District with 35% support from Majenzi community and therefore exposing community agricultural activities open to climate change impacts. Besides the problem of

community missing timely and reliable climate change information, no injuries and /or deaths were reported during the past El Niño and Tsunami disasters (Table 13).

Table 13: Responses on information sharing in the District (n=90)

		Responses			
Variables	Response category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Information sharing	Yes	5(17)	6(20)	4(13)	15(17)
	No	25(83)	24(80)	26(87)	75(83)

4.5.3 Sea water rise and intrusion into community farms in the District

Findings of the study show that about 56% of the surveyed respondents in the area responded negatively against 44% who agreed on problems they face associated to sea water rise in their farms (Table 14). Rise in sea water has affected mostly the rice farms which are at lowland areas practiced by a few number of farmers compared to farmers of other crops whose farms are less affected by sea water. Repercussion of sea water rise was the increased salinity to rice farms therefore vacating the area for long time until the coming rainfall seasons to dilute excessive salts. The effect of sea water intrusion into farmers' fields (rice) was claimed by 100% of the surveyed respondents being source of decreasing yield in the crop production for years (Table 14).

Table 14: Effects of sea water rise and intrusion in Micheweni District (n=90)

		Responses			
Variables	Response category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Sea water rise	Yes	16(53)	13(43)	11(37)	40(44)
	No	14(47)	17(57)	19(63)	50(56)
Sea water intrusion	Increase yield	0(0)	0(0)	0(0)	0(0)
	Decreased yield	30(100)	30(100)	30(100)	90(100)

4.6 Climate Change Adaptation Strategies in Micheweni District

4.6.1 Strategies and limiting factors to adaptation

Climate change in Micheweni poses a lot of negative impacts to general agricultural production, contributing to decrease in crop production threatening food security of the people. Prior to this situation the community has managed to apply reliable and sound strategies to overcome the problem. According to this study, various adaptation strategies were recommended by respondents aimed at eliminating or otherwise reducing the impacts to the extent that crop production in the District would be otherwise enhanced. About 20% of the respondents recommended the use of improved seeds as the most adaptation strategy followed by crop rotation/diversification (18%), the use of new crop varieties (18%), the adjustment of sowing dates (14%), fertilizer application (11%) and the use of mixed cropping (10%) among others.

In addition to adaptation strategies undertaken to combat climate change impacts, there were some limitations that hindered implementation of the steps taken by the community in the study area. These limitations include low income levels of the community, fish / salt farming in mangroves, lack of appropriate skills and technology among farmers and lack of improved seed varieties (Table 15). Otherwise, government policy reforms could be given special considerations to climate change adaptation. Juana *et al*. (2013) on the other hand indicated barriers to climate change adaptations as being high cost of adaptation measures and population growth among Africa countries.

Table 15: Respondents views on climate change impacts and adaptation (n=90)

Variables	Response category	Responses Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Adaptation Strategy	Crop rotation/diversification	8(27)	3(10)	5(17)	16(18)
	Use of improved seeds	3(10)	8(27)	7(23)	18(20)
	Fertilizer application	4(13)	3(10)	3(10)	10(11)
	Irrigation/community migration	3(10)	2(7)	2(7)	7(8)
	Use of indigenous crop species	0(0)	1(3)	0(0)	1(1)
	Adjustment of sowing dates	4(13)	5(17)	4(13)	13(14)
	Employing mixed cropping	3(10)	3(10)	3(10)	9(10)
	Use of new crop varieties	5(17)	5(17)	6(20)	16(18)
Limitation factors	Human population increase/growth	0(0)	1(3)	1(3)	2(2)
	Low income levels	10(33)	8(27)	7(23)	25(28)
	Lack of adequate arable land	1(3)	2(7)	1(3)	4(4)
	Cultural/traditional backgrounds	1(3)	3(10)	2(7)	6(7)
	Lack of appropriate skills and technology	3(10)	5(17)	5(17)	13(14)
	Lack of improved seed varieties	3(10)	4(13)	4(13)	11(12)
	Lack of alternative support	2(7)	2(7)	2(7)	6(7)
	Frequencies of crop disease outbreaks and pest infestations	1(3)	1(3)	2(7)	4(4)
	Fish and salt farming	9(30)	4(13)	6(20)	19(21)

Another important adaptation strategy commonly and widely used by the community in the area involves planting of mangroves along farm banks to reduce impacts and speed of sea water to enter the rice farms during high tides (Plate 2).

Plate 2: Adaptation strategies of sea water rising through mangrove planting

In supporting the community efforts to combat impacts of climate change, the Revolutionary Government of Zanzibar (RGoZ) through Tanzania Social Action Fund (TASAF) supported the construction of 800 m long ridge at Ukele paddy farms as an adaptation strategy. This construction saved 49 hectares of paddy farms in the area costing 269 988 560 TZS; 150 000 000 TZS from TASAF and 119 988 560 TZS from RGoZ (Plate 3).

Plate 3: Adaptation strategy of climate change through ridge construction at Ukele, Micheweni

Low income level of the community is one of the big challenges towards climate change adaptation strategies in the district where people rush to engage themselves in non-environmental friendly activities. Illegal tree felling / fishing, charcoal and lime making are among the most IGAs practiced by the community to increase household incomes but, so far are exposed to environmental degradation. Although sea weed, fish and salt farming are legally permitted by the government for improvement of livelihoods, they are not friendly to environment. Fish and salt farming practices are characterized by clear felling of several mangroves resulting into land left bare and exposed to severe environmental impacts (Plate 4).

Plate 4: Salt farms contribute severe cutting of mangroves at Micheweni District

4.6.2 Adjustments against climate change adaptation barriers

To employ proper adjustments against climate change adaptation barriers, 30% of respondents' suggestions were directed towards construction of dikes (ridging) along farm boundaries, 27% establishment of tree planting programmes, 18% employing awareness and sensitization programmes and 11% adjusting planting times plus

protection of existing community and natural forests (Table 16). Tree planting programmes are expected to reduce community future firewood and building poles shortages while awareness and sensitization programs could raise community understanding on climate change education (Table 16).

Table 16: Adjustment responses on climate change adaptation barriers (n=90)

		Responses			
Variables	Adaptive measure	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Adjustments	Change of the cropping pattern	0(0)	2(7)	0(0)	2(2)
	Ridging	15(50)	7(23)	5(17)	27(30)
	Tree planting programs	5(17)	8(27)	11(37)	24(27)
	Use of organic fertilizers	0(0)	0(0)	1(3)	1(1)
	Awareness and sensitization programs	5(17)	7(23)	4(13)	16(18)
	Protection of existing forests	2(7)	2(7)	0(0)	4(4)
	Use of different sectoral laws enforcement	1(3)	3(10)	2(7)	6(7)
	Adjusting planting times	2(7)	1(3)	7(23)	10(11)

Nevertheless, these adjustment efforts were constrained by a number of factors as reported by the respondents. Most of the constraints claimed by all respondents in the area involved inadequate working facilities, human population growth and lack of cohesion and unity among community members. Other constraints to adaptation involved inadequate cropping / environmental skills and illiteracy (Majenzi), deliberate uprooting of transplants and absence of strong by-laws within the community (Mjini wingwi) and low income levels and unavailability of improved seeds among farmers as reported by Micheweni village (Table 17).

Table 17: Constraining factors to climate change adaptations (n=90)

Variables	Response factors	Responses Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Constraints	Inadequate cropping / environmental skills	5(17)	8(27)	12(40)	25(28)
	Inadequate working facilities	7(23)	7(23)	7(23)	21(23)
	Deliberate uprooting of transplants	1(3)	3(10)	1(3)	5(6)
	Human population growth	1(3)	1(3)	1(3)	3(3)
	Lack of cohesion and unity among community members	2(7)	2(7)	2(7)	6(7)
	Low income levels	8(27)	6(20)	2(7)	16(18)
	Absence of by-laws	1(3)	1(3)	0(0)	2(2)
	Illiteracy	1(3)	2(7)	3(10)	6(7)
	Unavailability of improved seeds	4(13)	0(0)	2(7)	6(7)

4.7 Assisting Institutions to Climate Change Victims

Results from this survey showed that for the last 10 years in the district the community has suffered a lot from various impacts, especially those associated to climate change. Nonetheless, no reliable contributions towards the impacts were provided to help the affected families. Only 36% of respondents responded to have been provided with sorts of assistance as compared to 64% who completely denied to receive any type of assistance during climate change impacts occurrences (Table 18). Mostly, the types of assistance provided were in the form of funds by 57%, food stuff (23%), seeds (17%) and inorganic fertilizers (3%) originating mainly from relatives, government institutions and NGOs / CBOs (Table 18).

Table 18: Type and source of assistance to households (n=90)

		Responses			
Variables	Response category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Assistance	Yes	14(47)	7(23)	11(37)	32(36)
	No	16(53)	23(77)	19(63)	58(64)
Type	Funds	23(77)	16(53)	12(40)	51(57)
	Food	7(23)	7(23)	7(23)	21(23)
	Seeds	0(0)	7(23)	8(27)	15(17)
	Inorganic fertilizers	0(0)	0(0)	3(10)	3(3)
Origin	Not applicable	18(60)	15(50)	13(43)	46(51)
	Government	3(10)	3(10)	9(30)	15(17)
	NGOs / CBOs	3(10)	0(0)	1(3)	4(4)
	Relatives	6(20)	12(40)	7(23)	25(28)

4.8 Climate Change Impacts towards Crop Production and Food Shortages

The findings show that 100% and 98% of all respondents claim decrease of crop production and food shortages for the last 10 years respectively (Table 19). According to the respondents, the causes of this food shortage in the District are mostly drought, high temperatures and low rainfall. Other causes mentioned include lack of agricultural inputs, technology and improved seed (Table 19).

Table 19: Food shortages in Micheweni District (n=90)

		Responses			
Variables	Response category	Micheweni (n=30)	Mjini wingwi (n=30)	Majenzi (n=30)	Av.Total (n=90)
Relationship	Increase	0(0)	0(0)	0(0)	0(0)
	Decrease	30(100)	30(100)	30(100)	90(100)
Food shortage status	Yes	28(93)	30(100)	30(100)	88(98)
	No	2(7)	0(0)	0(0)	2(2)
Shortages factor	Drought	8(27)	9(30)	14(47)	31(34)
	Low rainfall	11(37)	9(30)	7(23)	27(30)
	High temperatures	9(30)	11(37)	8(27)	28(31)
	Others	2(7)	1(3)	1(3)	4(4)

4.9 Focus Group Discussions (FGD) and Key Informants

Information from these groups were gathered through formal and informal discussions using a checklist (Appendix 2 and 3) involved District extension officers (environment, fisheries and agriculture), village government leaders (Shehas), conservation clubs and some village influential people. Reports from group discussions showed that all members have lived in the area for more than 45 years with long experiences on climate change and its impacts where 100% of the respondents reported the decrease of agricultural crop production for the last 10 years in the District. With regard to climate change impacts, it was observed that 98% and 96% of the respondents admitted the presence of low rainfall and high temperature trends respectively, while 98% of the respondents claimed food production decrease.

Furthermore, the results indicated that 80% and 100% of the FGD respondents reported decrease in rainfall and increase in temperature respectively, associated with prolonged drought periods and food shortages for the last 10 years in the District. To solve the problem of food shortages, 93% of the respondents proposed fertilizer application as the best option against the use of disease resistant seeds, use of crop rotation and use of crop mixes.

As it was shown in the discussion in the case of food shortages, for those who were given such assistance, 91% of them admitted to get assistance from government sources and their relatives. It was found that all of the respondents were, in one way or another affected by climate change in crop production and 56% highlighted tree planting as a means to overcome the impact followed by ridge / wall construction around sea shores or cropping sites bordered by sea. With respect to early warning alerts during climate change disasters, 51% of the respondents admitted to get reliable information from the

media as opposed to 49% who completely refused to get any early warning information and from nowhere. For those who acknowledged getting such information on climate disasters realized their roles of reporting such information to their village leaders and agricultural officers and sharing the knowledge and experiences among others for further considerations.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

Extended periods of high temperatures and low rainfall were found to cause major climate impacts to crop production in Micheweni District resulting into food insecurity. Drought periods associated with crop pests and diseases, land infertility, uneven rainfall distribution and sea water intrusion in farmers' plots were claimed as major causes of decreasing food production, disappearance and death of some important food crops in the District.

There is no strong correlation between climate factors and crop production in the District and this can be due to other factors that were not considered during data collection. Factors like higher price of fish catch and provision of improved fishing gears could have increased fish production without considering impacts of sea waves and high currents as a result of changing climate.

Apart from being limited by other factors, various climate change adaptation strategies were suggested by community to minimize and / or otherwise eliminate climate change impacts to the extent that crop production in the District would be enhanced. The use of improved seeds and new crop varieties, crop rotation practice and diversification, adjustment of sowing dates, mixed cropping and fertilizer application were a priority. However, these community are lacking a strong organization to distribute climate change information to them when need occurs. Community initiatives through government support so far have been directed toward ridge construction and mobilizing community

through tree planting among the strategies, though fish and salt farming constrain the adaptation efforts.

5.2 Recommendations

Based on study findings the following are recommended:

(i) The community should establish drought resistant and short term crops so as to get early crop returns before impacted by changes in climate.

(ii) Agricultural extension officers and other District officers through their respective institutions should ensure farmers provision of improved and disease resistant seeds timely for acquiring high crop production.

(iii) The farmers should establish rainwater harvesting system to utilize this water during drought seasons.

(iv) In order to cope with the prevailing climate change and escape unnecessary crop failures and damages the community should make use of the Matangatuani Meteorological center to get reliable climate information.

(v) For the future benefit of the community in Micheweni, this study requests for a follow up research in order to explore more detailed information on climate change and / or other related fields.

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APPENDICES

Appendix 1: Household questionnaire

A: General information

1. Enumerator's name …… Date …… Quest. No. ……
2. Name of household head ……. Sex ….. (M/ F) Age…… (yrs)
3. Village ……Ward…… Shehia ……. District ……
4. Marital status …….
    1. Single
    2. Married
    3. Divorced
    4. Widowed

5. Household composition

ID	Name	Sex	Age	Relation to HH	Education level
1					
2					
3					
4					
5					
6					
7					

6. Household income (per annum) Total TShs……..

7. How much do you earn from each household income sources

Source of income	Tshs
Crop	
Fishing	
Petty business	
Employment	
Others	

B. Identification and assessment of climate change impacts

8. What is the area of farm (ha) do you own?
   a. < hectare ( )
   b. One hectare ( )
   c. > hectare ( )

9. For how long have you been farming in this particular land? …….....

10. What are the main crops you cultivate in this piece of land?
   a. Rice ( )
   b. Millets ( )
   c. Cassava ( )
   d. Maize ( )
   e. Banana ( )
   f. Others (Specify) ( )

11. How many seasons per year do you cultivate in this piece of land?
   a. Once ( )
   b. Twice ( )
   c. Thrice ( )
   d. More than thrice ( )

12. Do you use fertilizer in your farm?
   a. Yes ( )
   b. No ( )

13. If you use fertilizer which type do you use?
   a. Inorganic ( )
   b. Organic / Manure ( )

14. If the answer in 13 above is **yes**, how much do you harvest per year in your farm? ……. (Kg)

15. If the answer in 13 above is **No,** how much do you harvest per year in your farm? ……. (Kg)

16. What is the trend of crop production in your farm per year for 10 years period?
   a. Increasing ( )
   b. Decreasing ( )

17. What could be the reasons for 16 above?
   a. Increase (Reasons)
……..
   b. Decrease (Reasons)
……..

18. Do you face any problems in crops production in your farm?
    Yes ( )
    No ( )

19. If the answer in 18 above is Yes what could be the reasons? (Multiple response)
    a. Diseases/pests ( )
    b. Drought ( )
    c. Floods ( )
    d. Sea water intrusion ( )
    e. Others (Specify) ……..

20. How do you solve the problem encountered in 18 above?
    ..……..……..……..

21. What has been the trend of rainfall for 10 years period?
    a. Decreases ( )
    b. Increases ( )

22. What has been the intensity of rainfall?
    a. High rain and for a long time ( )
    b. High rain and for a very short time ( )
    c. Low rain and for a long time ( )
    d. Low rain and for a very short time ( )
    e. I don't see any change ( )

23. What has been the distribution of rainfall?
    a. Evenly distributed ( )
    b. Uneven distribution ( )
    c. I don't see any change ( )

24. What has been the trend of temperature in the area for 10 years period?
    a. Decreases ( )
    b. Increases ( )
    c. I don't see any change ( )

25. If there are any changes what is the frequency of change in the trends of climate effects in the area?

S/N	Type of effect	Frequency
1		
2		
3		
4		
5		

26. Have you noticed any change or disappearance of some of the crops that were being grown before in the area?
    a. Yes ( )
    b. No ( )

27. If the answer in 26 above is **Yes**, list the crops in the table below:

Name of the crop now disappeared		
1		2
3		4
5		6
7		8

28. What is the reason for crop disappearing
    ……
    ……
    …….

29. Have you heard of the term climate change?
    a. Yes ( )
    b. No ( )

30. Is your farming activity affected by climate change impacts?
    a. Yes ( )
    b. No ( )

31. If the answer in 30 above is yes what climate change impacts are associated to your farming activity?
    a. Low crop production ( )
    b. Diseases/pests ( )
    c. Soil infertility ( )
    d. Sea water intrusion ( )
    e. Others (Specify) ( )

32. What causes the impacts mentioned in 31 above?
    a. Low rainfall ( )
    b. High temperatures ( )
    c. Sea level rise ( )
    d. Drought ( )
    e. Others (Specify) ( )

33. What climate related disasters and extremes have affected your land?
.....

34. How have these affected the land? .....

35. How many seasons has this area been affected by a flood/drought in 10 years?
    a. None ( )
    b. Once ( )
    c. Twice ( )
    d. Thrice ( )
    e. More than thrice ( )

36. Did you receive any alert about the flood/drought before it happened?
    a. Yes ( )
    b. No ( )

37. Was anyone in your household injured in the flood/drought?
    a. Yes ( )
    b. No ( )

38. Did anyone in your household die during the flood/drought?
    a. Yes ( )
    b. No ( )

C. Linkage between rainfall, temperature, sea level rise and small scale crop production

39. Do you face any problems associated to sea level rise in your farm/s?
    Yes / No ( )

40. If the answer is Yes mention such problems
    ……
    ……
    ……

41. What has been the effect of sea water intrusion on the crop production in farmers' fields?
    a. Increased yield ( )
    b. Decreased yield ( )
    c. Don't see any change ( )

D. Identification and assessment of climate change adaptation strategies.

42. What are the major climate change adaptation strategies in your district?
    a. ……...
    b. ……...
    c. ……
    d. ……...
    e. ……

43. What factors have hindered implementation of adaptation to climate change measures and up-scaling of best practices?
    a. ……..
    b. ……..
    c. ……..
    d. ……..
    e. ……..

44. What adjustments have you made to cope with the change in trends of rainfall, temperature and sea level rise?
    a. ……
    b. ……
    c. ……
    d. ……
    e. ……

45 Basing on the coping strategy you have mentioned in 44 above, can you explain why you decided to take that option?

S/N	Reasons	Reason
1		
2		
3		
4		
5		

46. In everything you have been doing to cop with change in trends of rainfall and temperature, what has been the main constraints?
    a. ……
    b. ……
    c. ……
    d. … ……..
    e. …….

47. Does your household get any assistance when your crop production is affected by climate change?
    Yes / No ( )

48. If Yes mention type of assistance provided
    a. …….
    b. …….
    c. …….
    d. …….
    e. …….

49. Where does this type of assistance come from?

a.	Government	( )
b.	NGOs/CBOs	( )
c.	Relatives	( )
d.	Private sector	( )
e.	Others (Specify)	( )

50. How can you relate climate change impacts to crop production in your village?

a.	Increasing	( )
b.	Decreasing	( )
c.	Constant	( )
d.	I don't know	( )

51 Have you faced any shortage of food in the past 5-10 years?

a. Yes	( )
b. No	( )

52. If the answer in 51 above is Yes what was the cause of this shortage?

a.	Drought	( )
b.	Floods	( )
c.	Low rainfall	( )
d.	High temperatures	( )
e.	Others (Specify)	( )

Appendix 2: Checklist for Focus Group Discussion

1. What do you understand by the term climate change?

2. What climate change impacts do you face in your village/shehia/ward/ district?

3. What is the capacity of farmers' production in your district/village?

4. What crops are mostly raised in the district?

5. How is the trend of rainfall in the past 10 years in the district?

6. How is the trend of temperature in the past 10 years in the district?

7. Which important crops have disappeared in the last 10 years in your village / district?

8. In seasons of food shortages where do people get assistance?

9. How and where do you get information concerning climate change?

10. How do you communicate information on climate change?

11. What measures / precautions do you take to combat climate change impacts in your district/ village?

12. How can you relate climate change impacts to crop production in your village?

13. What causes the impacts of climate change in your district?

Appendix 3: Checklist for Key Informants

1. How long have you been in this village/district?..... years

2. What are the general conditions of agricultural production in the district for the past 5-10 years? .....

3. What can you comment on climate change situation in the district for the past 5-10 years? ..……

4. What is the situation of food production in the district for the past 5-10 years? .....

5. What is the situation of rainfall in the district for the last 10 years?

6. What is the situation of temperature in the district for the last 10 years?

7. Is there any food shortage in the district? Yes / No

8. If the answer is Yes what could be the cause of this shortage? .....

9. What do you think could be done to solve this food shortage? .....

10. In case of food shortages where do people get assistance? .....

11. Have you encountered any climate change impacts to crop production in the district? Yes / No

12. What measures do you take to overcome climate change impacts? ……

13. Do you get any early warning information on climate change in your district? ……

14. Where do you get this information? ……

15. What is your role as a community member when climate change impacts threaten crop production in the district? ……

16. Do you share knowledge and experience to others when climate change early warnings are revealed to your district from high level officials?

Yes / No

Appendix 4: Fish production against climate parameters

Fish production (Tons)		Annual Av. Sea level (mm)		Annual Average. Minimum Temp		Annual Average Max Temperatures		Annual Av. Rainfall	
Year	**Tons**	**Year**	**Average**	**Year**	**Average**	**Year**	**Average**	**Year**	**Average**
1984	2851	1985	2071	1983	21.8	1983	30.4	1983	104.1
1985	2922	1986	2056	1984	21	1984	29.5	1984	127.7
1986	1610	1987	2074	1985	21.5	1985	29.6	1985	135.8
1987	1727	1988	2091	1986	22.2	1986	29.6	1986	196.2
1988	973	1989	2030	1987	22	1987	30.2	1987	104.7
1989	2885	1990	2079	1988	21.9	1988	30.1	1988	115.6
1990	3220	1991	2091	1989	22.7	1989	29.2	1989	163.3
1991	2506	1992	2029	1990	23.3	1990	29.9	1990	92.4
1992	1246	1993	2031	1991	22.2	1991	29.6	1991	127.4
1993	674	1994	2025	1992	22.2	1992	31.4	1992	154.1
1994	788	1995	2047	1993	21.7	1993	29.3	1993	117.3
1995	2748	1996	2019	1994	21.7	1994	29.7	1994	145.9
1996	944	1997	2006	1995	21.7	1995	30.2	1995	123.8
1997	1048	1998	2074	1996	20.4	1996	30	1996	100.5
1998	1124	1999	2031	1997	19.2	1997	30	1997	182.9
1999	506	2000	1992	1998	24	1998	30.5	1998	173.5
2000	736	2001	1980	1999	23.2	1999	30.1	1999	148.5
2001	1484	2002	2008	2000	23.4	2000	30	2000	96.4
2002	928	2003	2034	2001	23.4	2001	30.4	2001	72.5
2003	114	2004	2042	2002	23.8	2002	30.3	2002	109.5
2004	1433	2005	2037	2003	23.9	2003	31.1	2003	81.5
2005	2238	2006	2053	2004	24.1	2004	30.3	2004	80.7
2006	443	2007	2088	2005	24	2005	30.2	2005	109.2
2007	1384	2008	2082	2006	24	2006	30.1	2006	162.8
2008	1163	2009	2077	2007	24.1	2007	30.4	2007	115.9
2009	929	2010	2110	2008	23.8	2008	30.2	2008	97.9
2010	3650			2009	24.1	2009	30.4	2009	118.4
2011	980			2010	24.3	2010	30.7	2010	131.9
2012	11400			2011	24.3	2011	30.4	2011	128.7
2013	7004			2012	24.4	2012	30.5	2012	106.7

Appendix 5: Crop production capacity at fertility and no fertility application, Micheweni

Fertilizer application		No fertilizer	
Kg	**Frequency**	**Kg**	**Frequency**
1150	2	200	1
1162	1	250	2
1180	1	285	1
1255	1	300	1
1256	1	335	1
1320	1	380	1
1358	1	400	1
1550	2	428	1
1650	1	435	1
1950	1	437	1
2000	2	440	1
2050	1	445	1
2150	2	450	1
2155	1	455	1
2250	2	468	1
2258	1	480	2
2300	1	490	1
2380	1	560	1
2420	1	600	1
2450	2	650	2
2500	3	680	1
2600	2	750	2
2650	1	770	1
2800	2	775	1
2880	1	800	1
2950	1	850	2
3100	1	880	1
3150	2	950	1
3200	1	1000	1
3350	1	1100	1
3500	2	1150	1
3525	1	1200	1
3750	1	1250	2
3950	1	0	0
4000	2	0	0
4050	1	0	0
4200	1	0	0
4260	1	0	0
96659	**51**	**20643**	**39**
Average	**1895.3**	**Average**	**529.3**