COMMUNITY PERCEPTION ON IMPACT OF CLIMATE CHANGES ON WATER RESOURCES: A CASE OF RURAL AREAS OF TEMEKE DISTRICT IN DAR ES SALAAM

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN RURAL DEVELOPMENT OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

Although various researches have been done on water resources, the extent to which impact on climate changes on water resources in Temeke District was empirically unknown. Therefore, the study was conducted in rural areas of Temeke District with the specific objectives to: (i) find out factors that affect water resources, (ii) examine the community perception on the impacts of climate change on water resources, (iii) determine community's awareness on climate change and water resources, and (iv) determine the measures taken by communities on the impact of climate change on water resources. Data were collected in November 2007 through focus group discussion, a questionnaire-based survey, key informants interviews, documentary review and participant observation. Questionnaire-based data were analysed using the Statistical Package for Social Sciences (SPSS) software. Chi-square test was used to show relationship between some variables. The chi-square test results showed that there was a relationship at ($p \leq 0.05$) between trends of crop production and perception on the impact of climate change on water resources. Index and likert scale were used to show the community perception. Findings of study revealed that 67% of the respondents were aware on the impact of climate change of water resources. Scores on index scale level of awareness of impact of climate change on water resources by sex is the same for male and female respondents**;** two-thirds of respondents (67%) had aware of it. The major conclusion from the study is that awareness of the respondents on the impact of climate change on water resources was high. Based on conclusion, it is recommended that human socio-economic activities and climate variability should be reduced by training communities to mitigate the impact of climate change on water resources. Government and NGOs should lay down proper policy mechanisms for promoting rural dwellers participation in water resources management in their areas.

DECLARATION

I, JOYCE JOSEPH KITUNDU do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work, and has never been submitted, nor is it concurrently being submitted for a degree award at any other Institution.

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(Supervisor)

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DEDICATION

This work is dedicated to Jesus Christ for his provision of guidance throughout my life and my beloved parents Mr. Joseph Kitundu and Mrs. Martha Kitundu, my sisters Agnes and Neema, my son Joseph, my brothers George, late Solomon, Nicholas, Steven, Wilfred, Peter, Sunday and Emanuel.

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LIST OF ABBREVIATIONS

CAN	Calcium Ammonium Nitrate
CBOs	Community Based Organizations
DAP	Diammonium Phosphate
DPMS	Donaldson Planning and Management Services
ENSO	El Nino Southern Oscillation
et al	and others
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
GDP	Gross Water Productivity
IPCC	Intergovernmental Panel for Climate Change
IRA	Institute of Resources Assessment
IWRM	Integrated Wetland Resource Management
MDGs	Millennium Development Goals
MWLD	Ministry of Water and Livestock Development
NAST	National Assessment Synthesis Team
NAWAPO	National Water Policy
NBS	National Bureau of Statistics
NGOs	Non-Governmental Organizations
NWI	National Water Initiative
NSGRP	National Strategy for Growth and Reduction of Poverty
RWS	Rain Water Systems
SA	Sulphate of Ammonia
SNAL	Sokoine National Agricultural Library
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan African

TV	Television
UDSM	University of Dar es Salaam
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention for Climate Change
UN	United Nations
URT	United Republic of Tanzania
USAID	United States Agency for International Development
WB	World Bank
WHO	World Health Organization of the United Nations

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Climate is the synthesis of the day-to-day weather conditions in a given area. The actual climate is characterized by long term statistics of the state of the atmosphere in that area or the meteorological elements in that area. It is also describe as the statistical description of weather and atmospheric conditions in a given region, over a specified period of time long enough to be representative (Maunder, 1992). Climatic change is defined as a shift of climate conditions in a directional incremental mode, with values of climatic elements changing significantly. In this study, climate change is used to refer to the change in the mean values of meteorological elements such as temperature or precipitation, during the course of a certain period of time.

Climate change is a global environmental issue that is raising great concerns. The Intergovernmental Panel for Climate Change (IPCC) has acknowledged that climate change is a reality. The impacts of climate change are apparent on all continents and these impacts will increase with the magnitude and rate of climate change. The most vulnerable are the marginalized ecosystems (coral reef, sea ice, tundra, mountains, low-lying coasts, and low-latitude agricultural systems) and the people who depend on them (IPCC, 1998).

The past few decades have seen significant increases in global temperatures resulting in climate changes and frequent occurrence of extreme weather conditions mainly due to human induced factors. The IPCC (2001) reported that global temperatures are expected to rise between 1.4ºC and 5.8ºC by 2100. Water is one of basic needs for livelihood of human beings. Like any other natural resource, water is finite and requires careful

management in order to cater for various competing needs. Human cultures, nourished by water, flourished or decayed according to available water for drinking, cultivation and navigation. Both surface and ground water surfaces are major sources of water for domestic, agricultural and industrial uses (URT, 2002a). It is reported that water resources make substantial contribution to rural livelihoods in terms of direct cash income and food security.

Recently, the United Nations Environment Programme (UNEP) and the United Nations Framework Convention for Climate Change (UNFCCC), based on the IPCC's Climate Change 2001 assessment report, discussed the major climate changes and their impacts. The impacts on water resources, agriculture and food security, sea level, ocean and coastal areas, biological diversities and ecosystems, human health, human settlements, energy and industry. Others included global mean surface temperature increase, regional temperature increases, precipitation increases and decreases and the occurrence of extreme events such as hurricanes. Global climate change will affect the water supply, although non-climatic changes such as water policy and management practices may have significant effects (Hulme, 1996).

Africa is one of the most vulnerable regions in the world to climate change. This vulnerability and the limitations of poor countries to adapt to climate change challenges were highlighted in climate change. The report established how human activities (burning fossil fuels and changes in land-use) are modifying the global climate, with temperature rises projected for next 100 years that could affect human welfare and the environment (IPCC, 2001). Expanding human populations and changes in global climate will exacerbate already severely strained freshwater resources in Africa (Ausubel, 1991; Chenje and Johnson, 1996; URT, 2003b). Also sustained variations in global climate can

have an enormous effect on distributions and interactions of species (Carpenter *et al.*, 1992).

There is evidence that climate change will impact Africa in various ways. For instance, the projected impacts of climate change and variability by 2100 in Africa may include increases of 1.0 ^{0}C to 4.7 ^{0}C in temperature, reduced rainfall by -2 to -25 percent, increased evapo-transpiration up to 132 percent, and reduced run-off by up to 50 percent (Magadza, 1996; Hulme, 1996). Of the potential effects of climate variability, the implications on water resources are among the most critical to society and ecosystems. This is because the small amount of water found in the biosphere has a large significance for ecosystems and society. The availability of water influences major biome types and potential agricultural productivity (Carpenter *et al.*, 1992). Similarly, humans depend on freshwater for drinking, irrigation, industry, transportation, recreation and fisheries.

World Bank (1998) has further identified the important factors as to why Africa is anticipated to have more adverse impacts. These include high dependency on agriculture and forest sectors, restricted population mobility, poor health facilities and high population growth rates. Furthermore, Africa tends to have a much higher share of their economy dependent on climate sensitive sectors such as agriculture than is the case with other continents. IPCC Assessments of regional impact of climate change, show two distinct warning periods, the first starting in the 1930s and ending in the 1940s and the second starting in 1980s and continuing to date. The frequency of El-Nino, Southern Oscillation (ENSO) episodes in East Africa has become irregular and shorter. Africa has limited capacity (financial, technological, and institutional) a situation which further limits the response of the continent to the predicted impacts of climate change.

Scientific evidence shows that East Africa is not shielded from global environmental change taking place in all regions. Both climatic and environment changes have resulted into declining agricultural productivity, deterioration of water quality and loss of biodiversity. Increasing human and animal population and other activities have resulted in changes in land use, land cover, desertification and general environmental degradation (Hulme, 1996).

Similar conditions have been experienced in Tanzania. Climate change has affected not only local communities but also sectors of economic development such as agriculture, water resources, health, forestry, livestock, coastal resources, wildlife and biodiversity (Liwenga *et al.*, 2007). Tanzania has natural treasures like the Indian Ocean; Rivers Rufiji, Ruvuma, Pangani, Ruvu; and Lakes Victoria, Nyasa, and Tanganyika which have experienced dynamic changes caused by both climate change and human activities. The droughts of 1981/82 and 1994/95 and El-Nino rains of 1995 to 1998 have reduced economic production and impaired the quality of life of the people (World Bank, 1998).

Rural areas of Temeke District are parts of the districts in Tanzania that have already felt the impacts of climate change. The effect of sea level rise, amongst other climatic events, has resulted into erosion and intrusion of sea water into fresh water wells, the only source of domestic water supply, making fisheries, aquaculture, and agriculture particularly vulnerable (URT, 2006). Furthermore, the impact of climate change on water resources in rural areas of Temeke District is not well known. Information on the community perception on impact of climate change on water resources in Temeke municipality is scanty thus constraining wise use and sustainable utilization of the water resources. Similarly, the extent of dependence on water resources in the Temeke rural areas by the local people is not well quantified. Also, there are frequent concerns that socio-economic

activities in Temeke rural areas may amount to extensive water scarcity, which may have a positive impact on water resources.

1.2 Problem Statement

Water is a fundamental resource for socio-economic development; water is for all life, including for human life (UN-Water, 2007). Humans depend on freshwater for drinking, irrigation, industry, transportation, recreation and fisheries (URT, 2002a). Water needed for human livelihoods and other sectoral use for sustainability development. However, the Government of the United Republic of Tanzania has developed various policies and strategies on water resources conservation in order to overcome the problem.

Various researches show that many people affected by the impact on climate change on water resources, there is increased risk of water .scarcity in different area in the world. It has been noted that the impact of climate change affected households especially in rural area. The population in rural areas of Temeke District typically suffers from limited access to water resources as a result A great many of these poor men and women, in rural settings base their livelihoods on 'informal activities' like small-scale cropping, livestock keeping, agro-processing and other micro-enterprises. In most of these activities adequate water is a crucial enabling resource.In view of above; the aim of the research was examine the community`s perception of climate change on water resources in rural areas of Temeke.

1.3 Justification of the Study

To date there are few previous studies that acknowledge complexities and problems associated with water resources regarding the improvement of societies' well being. There is some basic information on the assessment of water resources and utilization

characteristic for example water supply dynamics and causes of shortages, upstream/downstream competition for water and conflicts (Baur *et al.*, 2000). Technical issues allied to hydrological descriptions and modelling, water quality, and some environmental aspects (Faraji and Masenza, 1992), the irrigation water use efficiency and management (Machibya, 2003; Kaduma, 2008), major wetlands that are mostly associated with activities of greater economic importance such as large - scale farming, transportation and fisheries; save for the study by Mkavidanda and Kaswamila (2001).

The aim of this study was to examine the community perception on impact of climate change on water resource. This is in line with the Millennium Development Goal Number 7 stipulates a target to halve by 2015, the population of people without sustainable access to clean and safe drinking water and basic sanitation (UN, 2000). The 2025 Development Vision for Tanzania, which aims at achieving a high quality livelihood for its people, attain good governance through the rule of law and develop strong and competitive economy, recognizes the importance of water resources in the attainment of this vision (URT, 2000). Water is regarded as a main ingredient in poverty reduction through ensuring food security and self-sufficiency among other things (URT, 2000). “Improved health and alleviate poverty of rural population through enhanced access to adequate, safe and clean water” is the ultimate objective of the rural water supply sector (URT, 2002a). Similarly the problem is also in line with the National Strategy for Growth and Reduction of Poverty (NSGRP) as stipulated in Cluster II: Increased proportion of rural population with access to clean and safe water from 53% in 2003 to 65% in 2009 as well as and promoting efficient use of irrigation water (URT, 2005).

1.4 Research Objectives

1.4.1 Main objective

The main objective of the study was to examine the community perception on the impact of the climate change on water resources.

1.4.2 Specific objectives

Specifically the study intended to accomplish the following:

1. Find out factors which affect water resources;
2. Examine the perception of communities on the impacts of climate change on water resources in the study area;
3. Determine the community's awareness on climate change and water resources and;
4. Determine the measures taken by communities on the impact of climate change on water resources.

1.4.3 Research questions

The study was guided by the following research questions.

1. What factors affect water resources?
2. What are the perceptions of communities on the impacts of climate change on water resources?
3. Are the communities aware of climate change and its impact on water resources?
4. What are the measures taken by communities on the impact of climate change on water resources?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Terms

2.1.1 Water resources

Water is a colourless transparent liquid compound of oxygen and hydrogen which is found in seas, lakes and rivers, in the rain and also in the secretions of organisms. Water rotates through the hydrological cycle via evaporation, precipitation and runoff, and humans manage it by developing diversion, pumping, storage, transfer and treatment and distribution facilities (IPCC, 2001). Water is a one of basic needs for livelihoods of human beings. Like any other natural resource, it is finite and requires careful management in order to cater for the various competing needs. Human cultures, nourished by water, flourished or decayed according to available water for drinking, cultivation and navigation. Both surface and ground water are major sources of water for domestic, agricultural and industrial use (URT, 2002a). Water resource is, however, insufficient in Sub-Saharan Africa; its insufficiency is attributed to three factors: scarcity, low technology employed in availing it to people and poor management of available water.

Water is becoming scarcer in certain places, and its availability is major of social and economic concerns. Globally, water scarcity already affects four out of ten people. This situation is getting worse due to population growth, urbanization, and increased domestic and industrial water use (Benn, 2006). Currently, the world's population is projected to reach around eight (8) billion people in the year 2025 (UN, 2005). Despite limited and diminishing water resources, there is increasing demand for water due to population growth. Today, water still dominates our life, its presence continues to govern the locations of homes and cities, its availability or lack of it can cause deaths among people, animals

and plants, its intrinsic value may cause or exacerbate conflict, not only between states, but also between communities.

2.1.2 Climate

Climate is a major factor in the availability of water and Southern Africa's ability to be self-sufficient in food production. Both climate and water availability have, over generations, affected people's lives, influencing the years of plenty with good rains and years of scarcity with droughts (Arnell, 1999). Studies indicate that the annual rainfall has been decreasing in the previous ten years. Due to global warming, various environmental impacts have been documented including water resources, seawater rises, melting of glaciers, increase of floods, and drought alike. However, the lack of a long-term data base on hydrological variables in the streams limits objective correlation of the decrease of flows and ice cap reduction (IPCC, 2001).

On the effects of climate change on our planet, or how fast these changes will occur, the clear consensus is that significant impacts on the environment will be felt in the coming century. These impacts are not theoretical; they are already being felt in many parts of the United States and other countries. Climate change will affect the quality and quantity of water availability for municipal supply, food production, power generation, industrial use, and other vital services in many geographic locations, including areas that are not traditionally considered water-poor. The results of climate change are follows:

1) Increase in temperature

   Over the past century, the global average temperature has increased by approximately 0.6° C. Among the most undisputed predictions of climate change research is that average temperatures, particularly over land, will continue to increase. Estimates of the magnitude of this warming vary widely due to uncertainties in the models used to

predict warming. However, the temperature increase is generally predicted to accelerate over the coming century. As reported in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC, 2007), 11 of the 12 warmest years in the 150+ year instrumental record of global surface temperatures have occurred since 1995.

2) Increase in evaporation and precipitation

Another highly certain prediction of climate change research is that warmer temperatures will cause water to evaporate more readily, increasing total precipitation on a global scale as with predictions of temperature increase; estimates of the magnitude of precipitation increase vary widely. It is generally accepted, however, that the pattern of precipitation change will be highly complex and variable; some regions will receive more precipitation and others less than they do now.

3) Rising sea level

Warmer temperatures will contribute to sea level rise through both melting of polar ice and expansion of water volume due to ocean warming. The IPCC reports that average global ocean temperatures have increased to depths of at least 3000 metres (m) and that the ocean has been absorbing more than 80 percent of the heat added to the climate system. Estimates of the amount of sea level rise over the coming century range from 0.2-0.6 m (IPCC, 2007).

4) Increase extreme events

The climate change processes act to intensify the hydrologic cycle, leading to increases in the occurrence and intensity of extreme climatologic events. This intensification is likely to be manifested by more intense and temporally variable precipitation, greater incidence of flooding and drought, more intense tropical storms, and increased wildfire activity.

5) Water utility impacts

The impacts of climate change on water resources will vary widely by region; it is relatively certain that no area will be untouched by these impacts. Potential climate change impacts on water utilities have been widely reported in many other organizations. These impacts can be broadly categorized as water quantity impacts, water quality impacts, operational reliability impacts, and financial and institutional impacts. In water quantity impacts the most widely publicized impacts of climate change on water resources concern availability of water supply. Direct impacts due to increasing temperature and precipitation variability include reduced in-stream flows, decreased snow pack, earlier and more intense snowmelt and runoff, and reduced aquifer recharge. In addition, warmer temperatures may lead to increased demand by both water utility customers and competing users, with peak demand potentially coinciding with periods of most restricted supply (IPCC, 2008).

Moreover, water quality impacts are extreme precipitation events which create well-known water treatment challenges by increasing sediments and pathogen loads, urban storm water runoff, and combined septic tank overflows. Source of water quality will be impacted by other, more gradual processes such as more widespread and persistent algal blooms, changes in watershed vegetation, and increased water temperature. Increasing of water temperature associated with eutrophication, disinfectant demand, and regrowth potential in coastal areas, rising sea levels and associated salt water intrusion may increasingly impact groundwater resources (IPCC, 2008).

Finally, operational reliability impacts occur when climate change will potentially impact utility infrastructure through a variety of means, including flood damage and pipe breaks due to soil drying and settling. Coastal facilities may be threatened by rising

sea level and increased corrosion due to salt water intrusion. Warmer temperatures will likely increase the range and proliferation of invasive nuisance species such as quagga/zebra mussels and milfoil. Reservoir management is likely to be greatly complicated by changes in runoff timing and intensity, particularly for reservoirs that are required to balance both water supply and flood control needs.

2.1.3 Climate change

Climate change is one of the most humanity`s pressing challenges in the 21st century (Mertz *et al.*, 2009). Climate is the synthesis of the day-to-day weather conditions in a given area. The actual climate is characterized by long term statistics of the state of the atmosphere in that area or the meteorological elements in that area. It is also described as the statistical description of weather and atmospheric conditions in a given region, over a specified period of time long enough to be representative (Maunder, 1992). Climatic change is defined as a shift of climate conditions in a directional incremental mode, with values of climatic elements changing significantly. In this study, climate change is used to refer to the change in the mean values of meteorological elements such as temperature or precipitation during the course of a certain period of time.

2.1.4 Perception

Perception is an effort task of determining what is out there in the world from sensory inputs. It is also defined as our sensory experience of the world around us and involves both the recognition of environmental stimuli and action in response to these stimuli.

2.2 Theoretical Framework

In the community perception on impact of climate change on water resources, there are four theories of perception which are naive realism, representative realism, idealism and

phenomenalism. Naïve realism is the common sense theory of perception. This theory is also known as “direct realism” or “common sense realism”. Naïve realism holds that the view of the world that we derive from our senses is to be taken at face value: there are objects out there in the world, and those objects have the properties that they appear to us to have (Jackson, 1977).

In representative realism, we do not perceive objects directly. Rather, objects cause us to have certain experiences, sense-data, and it is these to which we have direct access. Boghossian and Velleman (1989) were leading advocates of this theory they considered colour properties. There are two different ways of thinking about colour. The first is in scientific terms: colour is reflected with certain wavelengths of light. The second is in experiential terms: colour is a subjective experience that a normal observer has when they look at a coloured object. Representative realism holds that there are two completely different types of property, corresponding to this distinction. First, there are primary qualities, which objects have independent of any observer. An object is square, or heavy, for instance, irrespective of whether anyone perceives it to be such. Shape and weight are, therefore, primary qualities. Second, there are secondary qualities, which objects only have because they are perceived (Peacocke, 1984).

Idealism, persuaded by the thought that we have direct access only to our experiences of the world, and not to the world itself, has questioned whether there is anything beyond our experiences. Idealism denies the existence of mind-independent objects. The attraction of idealism is its economy. The idealist refuses to do so, holding that our experiences don’t represent objects, but rather constitute them, that there is nothing beyond them (McGilvray, 1994). Idealists had both an answer to the problem and a way of avoiding the absurd

suggestion that the answer is God. According to McDowell (1985), God constantly perceives everything.

A recent theory is phenomenalism. Phenomenalism is like idealism; it holds (roughly) that objects are dependent upon our perceptions of them. Unlike idealism, however, it is not committed to the existence of a God who constantly perceives everything (Hilbert, 1992). The study employed naive realism and representative realism as their theoretical setting. Therefore, they hold views that sense and experience can help communities to be aware on impact of climate change on water resources and the importance of water conservation.

2.3 Conceptual Framework

The conceptual framework as shown in Fig. 1 indicates the relationship between climate change on water resources and community perception on water bodies such as rainfall patterns, wells, ponds, streams, rivers, wetlands and mangroves. The climate change has affected human life, agriculture and food security, hydrology and water resources, coastal zones and marine ecosystem, human settlement, energy and industry. Perception on water can be looked into intently on increased or declined of water resources. Community perception can lose the diversity, water consumption, agricultural production and water consumption. Also community perception can help to utilize the water storage, to improve infrastructure for water, to collect and distribute and to implement the effective management of water for sustainable development.

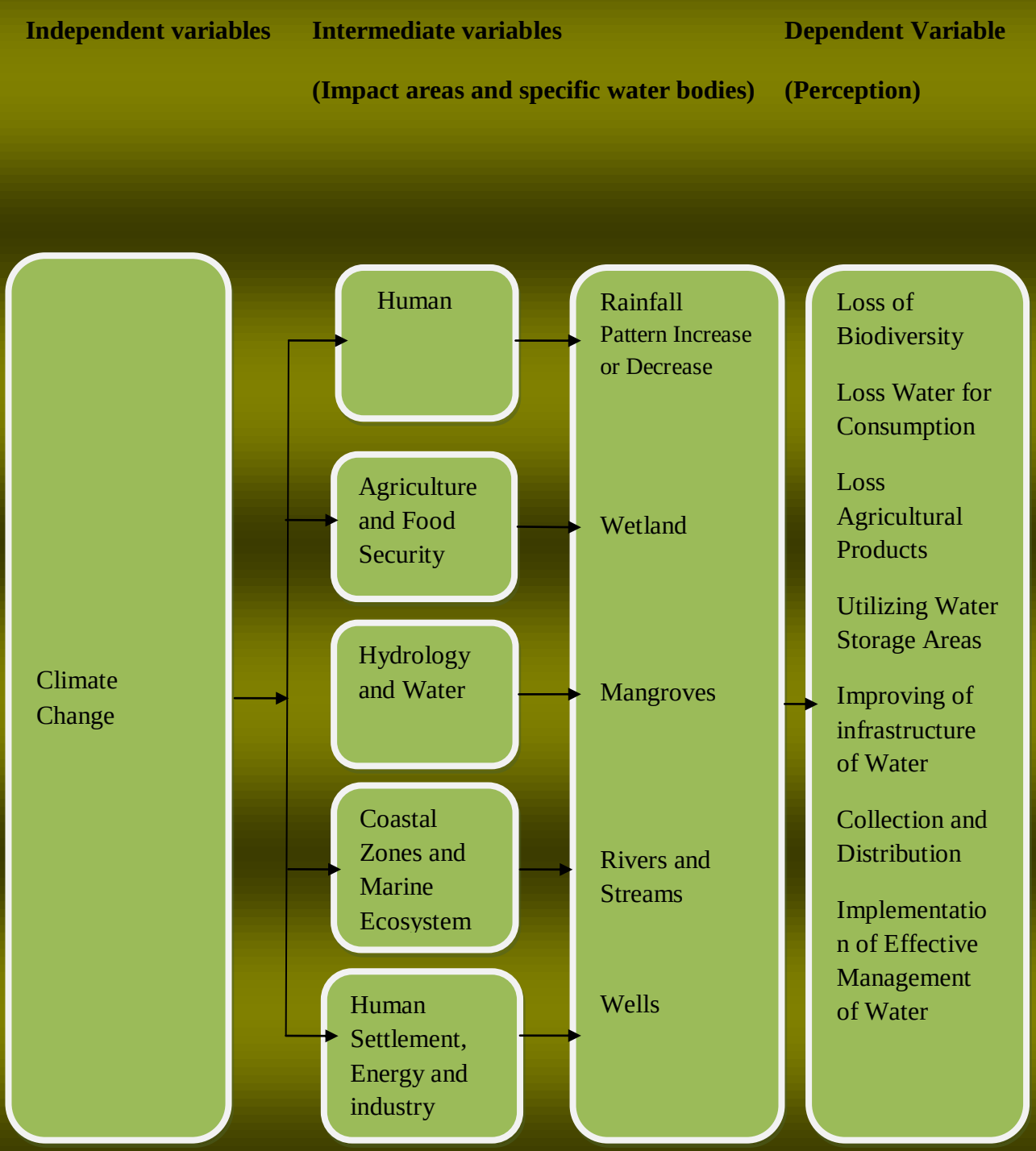

Figure 1: Conceptual framework. Source: Modified from IPCC (2001)

2.4 Climate Change and Water Resources Global Perspectives

Various global climate models tend to agree more on geographical changes in temperature than on rainfall (Meehl *et al.*, 2007; Kundzewicz *et al*., 2007). Nonetheless, scientists have looked at where the climate models tend to agree to suggest how climate change may affect water resources. The IPCC stated that there is high confidence that by mid-century, annual river runoff and water availability are projected to increase at high latitudes (and in some tropical wet areas) and decrease in some dry regions in the mid-latitudes and tropics. There is also high confidence that many semi-arid areas (e.g., Mediterranean basin, Western United States, Southern Africa and Northeast Brazil) will suffer a decrease in water resources due to climate change" (Bernstein *et al.*, 2007). It is also "very likely" that the frequency of heavy precipitation events will increase leading to adverse effects on surface water and groundwater quality although water scarcity may be relieved (Bernstein *et al.*, 2007).

Furthermore, climate change has several local level impacts. In Nepal, the most studied subject on the impact of climate change is retreating of glacier and snowline and its subsequent impact on the formation of glacial lakes. There is inadequate information on the relationship of climate change with droughts, landslides, floods, and cold and heat waves. Studies are also lacking on the impact of climate change on agriculture, biodiversity and other sectors. Nevertheless, poor local communities are the ones most affected by the impact of climate change. Poor communities have low awareness of global climate change and its impact. There is inadequate awareness even among the professionals working in governmental and non- governmental organizations, both at grass roots and at national levels. There is a need to raise the awareness of climate change and its impact among all types of stakeholders (Sharma, 2003).

Moreover, Australia in a changing climate, droughts are expected to become more severe in the south and east of Australia. The potential for replenishment of groundwater is expected to continue to decline and water quality is also likely to be affected. Rainfall is likely to be concentrated more in extreme rainfall events affecting water availability (both surface and groundwater), water quality, the balance between environmental and consumptive demand and allocation, as well as the design and safety of dams. Improved knowledge is needed to assist water managers to understand the wide range of impacts climate change will have on surface and groundwater resources and the demand for water (Bulkeley, 2000). Adaptation to changed water availability could require the sourcing of additional water supply and retrofitting water infrastructure, with the associated costs. It could also mean new ways of managing water.

The National Water Initiative (NWI) and other water management frameworks are central to dealing with reduced water availability due to climate change. Information on climate change will be essential for water managers as many scholars stated, climate change impact will lead to increasing levels of drought in Africa, if temperatures continue to rise. It can further lead to floods, starvation, landslides, drought and rising sea levels. According to the United Nations, climate change will affect Africa more than anywhere else in the world due to extreme poverty levels, high rates of population growth, over-reliance on rain-fed agriculture and over-dependence on natural resource-based livelihoods. Global temperature increase by the year 2100 will lead to less precipitation in Central Asia, the Mediterranean region, Africa, parts of Australia and New Zealand, associated with a greater probability of droughts (UNEP, 2007).

2.5 Climate Change Scenarios in Tanzania

Tanzania is likely to experience the same effects of the climate change impacts of the globe. It has been projected that there will be a general increase in temperature throughout Tanzania ranging from 21.8^0 C to 29.1^0 C (Hyera and Matari, 1996). This increase in temperature will be higher on the western parts of the country than in the eastern parts. The largest increase in temperature will be experienced during the cool months. The scenarios also indicated that the highest rainfall increase will be experienced in the North-Eastern highlands of the country which will receive between 40 percent and 50 percent more rainfall than the present levels. However, a 10 percent decrease in precipitation in some localized western parts of the country is anticipated, while no changes at all are anticipated in some of the central and coastal parts of the country (Maro, 2005).

2.6 Water Resources in Tanzania

The main sources of water in Tanzania are rivers and lakes. These rivers and lakes are not only sources of water but also of food, electricity, fishing, transport, communication and recreation for millions of people in Tanzania. Also, there are ponds and swamps in semi-arid and arid areas. There are nine river basins in Tanzania (Fig. 2) which are Pangani Rivers Basin, Wami/Ruvu Rivers Basin, Rufiji Rivers Basin, Ruvuma Rivers and Southern Coast Basin, Lake Nyasa Basin, Lake Rukwa Basin, Internal Drainage Basin (Lake Eyasi and Manyara, Natron and Bubu Complex) Basin, Lake Tanganyika Basin and Lake Victoria Basin (URT, 2002a). Ground water is a major source of water for many areas in Tanzania. Some of water sources decrease because of climate change and socio-cultural factors which affect water resources.

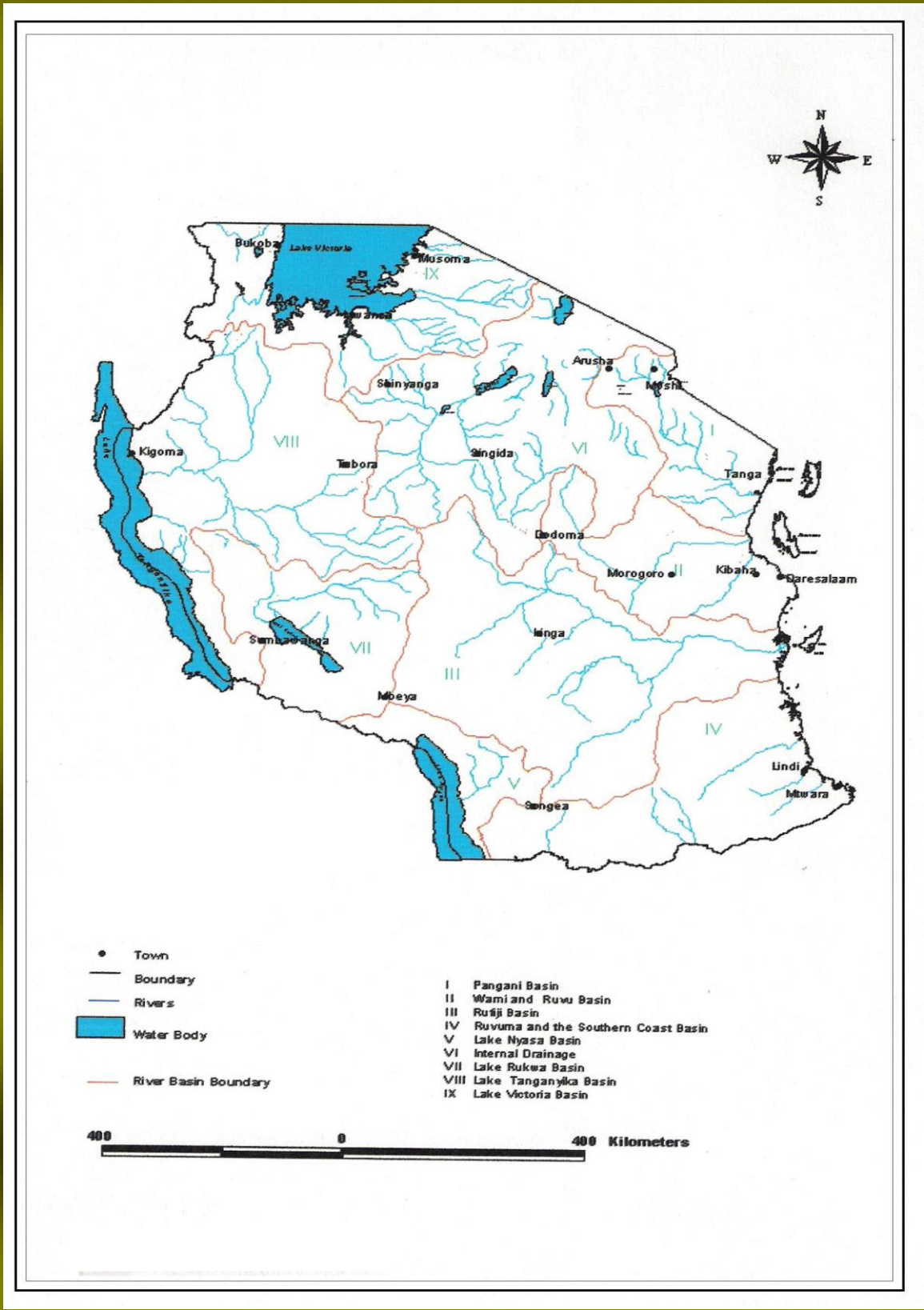

Figure 2: River basins in Tanzania

2.7 Water Resources in Rural Areas of Temeke District

Water Resources in Dar es Salaam region is divided into three main river systems which are Msimbazi river system in the centre, the Mbezi river system to the north, and The Mzinga and Kizinga river systems to the south. The Mzinga, Kizinga and Msimbazi river systems emanate from Pugu/Kisarawe hills which have catchment forest reserves. Kizinga and Mzinga Rivers flow into the Indian Ocean (URT, 2003a). Also there is Kimbiji Coastal Aquifer recharge that situated to the southern part of Dar es Salaam Region which is the source of deep groundwater.

Figure 3: Kimbiji coastal aquifer

2.8 Factors Affect Water Resources

The factors that affect water resources have been caused by climate change and climate variability can be positive or negative to the people. There is increasing evidence that climate change has already affected human and natural systems throughout the world, with immense negative impacts being felt in developing countries due to their dependence on climate sensitive economic sectors, such as rain-fed agriculture, and their limited economic, technological and human capacities. As a result, communities experience disproportionately high levels of death, social disruption and economic damage (IPCC, 2007).

2.8.1 Climate variability and climate change

All of the potential impacts of climate-related disasters: including economic losses, health problems and environmental disruptions; will also affect and be affected by water. Climate change differs from the other drivers. It is the only supply-side driver, ultimately determining how much water we have; the other drivers are demand-side drivers, influencing how much water we need. Climate change can directly affect the hydrologic cycle and, through it, the quantity and quality of water resources. It can lower minimum flows in rivers, affecting water availability and quality for its flora and fauna and for drinking water intake, energy production (hydropower), thermal plant cooling and navigation. Anthropogenic climate change can also directly affect demand for water, when demand for crops increases in certain seasons, for instance the implications of climate change on uncertainty in agriculture. The other drivers, by contrast, exert pressure on various water use sectors that, in turn, affect water resources.

Managing water has always been about managing naturally occurring variability. Climate change threatens to make this variability greater, shifting and intensifying the extremes,

and introduces greater uncertainty in the quantity and quality of supply over the long term. More subtly, climate change may alter the timing, magnitude and duration of precipitation events, which could pose problems (Ringler, 2007). Climate change is a global phenomenon; its impacts are more severely felt by poor people who are more vulnerable because of their high dependence on natural resources and their limited capacity to cope with climate variability and extremes (McCarthy *et al*., 2001).

The influence of climatic change on the availability of water is the subject of intense debate. If it persists, climatic zones are likely to migrate, leaving the climate of some regions dryer, others wetter, and many more variables unpredictable (Parry, 1992). Certain regions dependent on water (e.g. large population centre) will experience more water scarcity, while others will become more humid.

Climate change does have an impact on the Great Horn of African countries. The IPCC predicts that rainfall will decrease in the already arid areas of the Horn of Africa, and that drought and desertification will become more widespread (IPCC, 2001). As a result of the increasing scarcity of surface freshwater, groundwater aquifers are being mined.

2.8.2 Human socio-economic activities

2.8.2.1 Population growth and income

Population growth, urbanization, and migration strongly affect the sustainability of water resources. Other factors that affect water use are indirectly linked to population-income levels, a rise in living standards, modifications to landscapes and land use, contamination of water supplies, and inefficiency of water use caused by a failure to manage demand (Vorosmary *et al.*, 2000).

The world's population is growing rapidly; in 2020 it is projected to be 7.9 billion, 50 percent larger than in 1990 (Dyson, 1996). Most of this growth will be in countries where the inhabitants have low levels of household water consumption and in which the use of water-intensive appliances are likely to grow. Many of these countries are also rapidly urbanizing, and the task of obtaining sufficient water and distributing it to the newly urbanized households will be a major financial and environmental challenge to many authorities. However, the growth in the demand for food is probably the single most important cause of pressure on water resources: over the last generation, most of the increment in food supply has been obtained by an expansion in irrigated farming and/or the growing use of crops dependent on agronomic packages based on irrigation.

Looking ahead 30 to 50 years, in many regions, including the Far East and South Asia, most of the required increase in food production is expected to come from irrigated agriculture (Dyson, 1996). Average growth rate in the world averages 1.8 percent. The Horn of Africa is home to about 90 million people, with projections indicating that the population will exceed 112 million by the end of the century if past trends continue. It thus accounts for between one sixty and one-fifth of the territory and population of Sub Saharan Africa. Although the growth of population and demand for food is the predominant factor in the growing scarcity of water, other factors also contribute. Generally, demographic factors affect water consumption and the quality and health of natural ecosystems both directly and indirectly (Ringius, 1996).

By 2025, water availability in nine countries 21, mainly in eastern and southern Africa, is projected to be less than 1000 m^3/person/yr. Twelve countries would be limited to 1000–1700 m^3/person/yr, and the population at risk of water stress could be up to 460 million people, mainly in western Africa (UNEP, 2002). These estimates are based on population

growth rates only and do not take into account the variation in water resources due to climate change. In addition, one estimate shows the proportion of the African population at risk of water stress and scarcity increasing from 47 percent in 2000 to 65 percent in 2025. East Africa has more than value with growth rate at 4 percent. For instance Rwanda is home to a population of some 8.3 million people. Rwanda is the most densely populated country in Africa with an estimates annual population growth rate of nearly 3 percent which, if unchecked, will result in a doubling of the population within 20 years.

2.8.2.2 Urbanization

Urbanization, both by the degree and the rate of growth, can affect the levels of per capita water use, overtax water resources by concentrating demand in a small area, and overwhelm the existing infrastructure. It can also have a broader impact when freshwater resources must be transported from elsewhere. Increasing urbanization in coastal areas and urban expansion into regional areas are likely to increase the exposure of people and infrastructure to the impacts of climate change. People living in remote communities may be more vulnerable. The impacts will vary depending on the form of the settlement, geographic considerations and the nature of the local economy. As stress on water resources increases, competitions grow between agriculture fighting to retain its water allocations and cities needing to satisfy the rapidly growing population (FAO, 2005; Dungumaro and Maghimbi, 2001).

The physical infrastructure and the social and economic fabric of settlements are likely to be affected by climate change, especially by changed frequency of intensity of extreme weather events. Infrastructure such as buildings, roads, bridges, railways and ports are designed for a life of 20-50 years. Dams can be designed for a 100 year life. Planning decisions for development and the replacement or refurbishment of long-lived

infrastructures, need to take account of the different climate in the future including higher temperatures and changes in precipitation, water tables and humidity. Also urbanization changes vegetation in rural areas by clearing. There are two levels of clearing which are broad-acre and erosive clearing (McIntyre and Martine, 2007). Broad-acre clearance is clearance of an area cleared for future agricultural use while erosive one is small but gradual clearance of vegetation for pasture development, grazing and/or other human development activities (DPMS, 2001; Shaw *et al.,* 2002).

2.8.2.3 Migration

Water resources often affect migration decisions. Lack of water can be a push factor in the decision to migrate away from a location. Deforestation, desertification, drought, and lack of land to cultivate can significantly influence migration from rural areas to towns. Millions of people have become refugees due to dam building, environmental deterioration, or the destruction of environmental resources that they require to live or make a living. Water can also be a pull factor that induces people or industry to move to a region. For example, an industrial entity may choose to locate itself near water resources, and the employment opportunities it creates may influence the scale of future labour migration. Generally, population growth, urbanization, and migration strongly affect the sustainability of water resources (Ringler, 2007). Also the increase in municipal and industrial uses is likely to be less than five percent by the 2050s Mote *et al.* (1999), and Downing *et al.* (2003), both as cited by Kundzewicz *et al.,* 2007). Global irrigation demand is projected to increase from 1 to 3 percent by the 2020s and 2 to 7 percent by the 2070s (Kundzewicz *et al*., 2007).

2.8.2.4 Pollution

As demands for potable water have increased worldwide over the years, so have human impact on freshwater systems. According to the United Nations Environment Programme (UNEP), 48 percent of water used for domestic purposes, industry or agriculture is frequently returned to its source polluted or contaminated with chemicals or other harmful substances, reducing the amount of good quality water available to people. For example in Zimbabwe, the Mukuvisi river, which runs into Harare's drinking water supply, contains high amounts of nutrients, such as phosphorous and nitrogen, sulphate, calcium, magnesium and fluoride, aluminium and iron largely from industrial dumps along the river banks (UNEP, 2002).

2.8.2.5 Economic development

A country's level of freshwater use is tied to its level of economic development, and the correlation is strong enough that water use is often used as a measure of economic development. Overall, developing countries use less water per capita than industrialized countries. Freshwater is used to run industries, grow food, generate electricity, and carry pollution and wastes; so, increased industrialization is associated with increased water use per capita. Both the individual water use levels and the water used by society to support individuals and their ways of life are higher in industrialized countries. Within countries, income level also determines the structure of freshwater demand. In cities, wealthier individuals are more likely to be connected to piped water supplies and waterborne sanitation systems, as well as to consume larger amounts of products that require water to produce. Rural dwellers that are more likely to be poor often use less water because of inaccessibility of supply and lower consumption of goods and services (Richard, 2007).

Climate change and its accompanying risks have direct and indirect effects on development and economic growth. Sea level rise, climate variability and weather extremes such as heat waves, floods, cyclones, rising sea levels and extreme temperatures and droughts are severe, direct threats to human life and property. Tackling them requires mobilizing resources that may have to be reallocated from other investments. Their damage can substantially harm a country's gross domestic product (GDP). Economic performance is especially affected in developing countries because of their high and direct dependence on natural resources, notably rain-fed agriculture, and their inadequate access to economic and technological resources. Adverse climate conditions such as increased floods and droughts can also result in the underperformance of investments. Climate uncertainty and unpredictability can be powerful barriers to investments, and ultimately to economic growth, even in years when climate conditions are favourable (Richard, 2007).

Climate change and greater climate variability will increasingly affect the poorest and most marginalized groups, making them even more vulnerable to the impacts of climate change. Across developing countries losses associated with disasters are so large as to undermine development and poverty reduction goals. And yet climate risks are seldom adequately considered in infrastructure designs, agricultural investments and water management plans. Weather-related disasters such as floods and droughts are undermining economic development in many of the world's least developed countries, causing human suffering (Goudie, 1986).

2.8.3 Water scarcity in Tanzania

The issue of water scarcity is an enigmatic and controversial concept so that there is no single cohesive definition of what the concept really means. While the mainstream argument is that water scarcity literally means a shortage of freshwater resources, the

opposing argument by some scholars is that it is impossible to talk about a physical shortage of water due to the large amount of freshwater present, thus the perceived water scarcity. It is actually an inability to harness and provide the abundant water resources. The way forward seems to be an integration of both arguments as they are true; there are areas of the world where water scarcity is a physical phenomenon and in some areas it would be appropriate to call it an economic problem. This is the view maintained by Appelgren and Ohlson (1998) who argued that although water scarcity is commonly perceived as an often absolute shortage of a natural resource, when regarded from a management point of view, it may be better described as a lack of adaptive capacity and thus as a social resource scarcity.

The same argument is put forward by Abraham (2001) and Tatlock (2006) who stated the concept of water scarcity to be a social construct or, put in other terms, a matter of political and economic perception; it may be more useful to describe water scarcity as a particular mix of availability and demand at which water stress occurs, rather than a per capita figure. Water scarcity occurs when demand exceeds supply due to mismanagement of water sources, disruption in distribution contamination, natural causes, and population growth or widespread practices that consume excessive amounts of water (World Water Forum, 2000; UN, 2006). This means that its determination is more qualitative than quantitative, as the point at which water scarcity occurs may vary widely from one situation to another.

Water is the basic natural resource required to sustain life and provide various social needs as well as for economic development. Many parts of Tanzania face water stress situations; more than half of the country receives on average per year less than 800 mm of rainfall. About one third of the country has high land areas with rainfall over 1000 mm

(URT, 2002a). Water scarcity has been experienced in many places due to unreliable rainfall, multiplicity of competing uses, and degradation of sources and catchments. All these have led to conflicts between sectors of the economy (Hatibu, 2002).

In the early 2000s, Tanzania has 89 km^3 of annual renewable water resources and a population of 33.4 million equivalents to 2700 m^2 of water per person per year. Based on population statistics, in the year 2025, the annual renewable water resources per capita will be 1500 m^2 which is 45 percent less than the recommended annual renewable water resources. If we are not managing our water resources consumption now, there will be scarcity of water, as water stress situation is estimated to range between 1000 m^2 and 1600 m^2 per person per year (Meinzen-Dick and Appasamy, 2002). According to UN medium projection, in 2025 the population on the earth will be 7.8 billion, a 38 percent increase of the 2001 level (UNEP, 2001). Water resources on the other hand, are decreasing at an alarming rate (Molden and Sakthivadiel, 1999).

The water scarcity problem in Tanzania has been aggravated by uncoordinated agricultural and non-agricultural activities in the river basins, for example imbalance of water for primary diversions (irrigation, domestic and industrial uses as well as for diversions in secondary activities like hydropower production, environmental conservation, navigation and so on. This calls for good management of our water resources for the future benefit of all Tanzanians. Tanzania has enough fresh water resources (Fig. 2) in the form of the lakes covering about 60 000 km^2 (URT, 2002a).

2.9 Communities' Perceptions towards Impact of Climate Change on Water Resources

2.9.1 Community perception on climate change

Perceptions that climate change can only be addressed at the global scale, the highly publicized debates on carbon dioxide (CO^2) emissions reduction strategies (e.g. the Kyoto Protocol), may contribute to perceptions that climate change is an international scale problem that will be handled through federal policies and international agreements. The impacts of climate change will be felt most acutely at the local scale, however. Consequently, decision makers may mistakenly dismiss the need to develop locally-based adaptive management strategies. This perception also overlooks the fact that even if CO^2 emissions were halted tomorrow, warming is expected through the 21st century due to the persistence of existing CO^2 concentrations in the atmosphere. Some degree of adaptation will be required at the local level, therefore, even if emissions reduction objectives are achieved (Chen, 1981).

Different communities in the world have understood the climate change and its effects. Climate change, primarily perceived as an environmental issue, falls into conservation context. Climate change is beyond non-annex-country-mitigation is necessary, but adapting to future risk is more important. The challenge on community perception of climate change on water resources are as follows:

1. To change perception on climate change - climate change as paradigm shift in long-term planning.
2. To understand the impact of climate change in changing socioeconomic condition context
3. To perceive climate change adaptation as risk management – rather than trying to preserve/conserve present conditions.

2.9.2 Communities' perceptions on the impact of climate change on water resources

Community perception on water resource is one of the most important social factors determining their level of understanding about the water resource and its effects. In addition, people's perception influences their level of support and implementation to solve the problem of water resource through different alternative measures of conservation practices. People's perceptions of impact of climate change on water resource include but are not limited to, their awareness of the problem, their approaches to solving the problem, and their socioeconomic interactions along with their economic capacity to solve the problem (Lorenzoni *et al*., 2000).

2.10 Community's Awareness of Impact Climate Change on Water Resources

The pillar of socio-economic development is the function of investment in education and water resources, which co-exist symbiotically according to human capital development theory. In essence, education refers to the attainment of intellectual, moral and social instruction or attainment of knowledge and information about particular subjects or disciplines. Varying levels of education in a society reflect varying levels of degrees intellectually, morally and socially on awareness to issues related to wise use of resources. Community members must aware the root cause on impact of climate change and how to alleviate the water scarcity in their environment (Bulkeley, 2000).

More recently, global climate change has been a topic of intense scientific and political debate. Certain evidence is unequivocal; carbon dioxide concentrations (the most abundant greenhouse gas in the earth's atmosphere) have been increasing steadily for over a century. Specifically, CO_2 levels have increased by 30 percent since the late 1800s, and are higher now than they have been in the last 400 000 years (IPCC, 2001).

Moreover, in a changing climate, droughts are expected to become more severe in many parts in the world. The potential for replenishment of groundwater is expected to continue to decline and water quality is also likely to be affected. Rainfall is likely to be concentrated more in extreme rainfall events affecting water availability (both surface and groundwater), water quality, the balance between environmental and consumptive demand and allocation, as well as the design and safety of dams. Communities must understand methods and approaches to integrate climate change related risks into water management. For instance, community must assess the implications of changes in extreme rainfall events for water infrastructure (Bulkeley, 2000).

The impact of climate change on water resources were only related to their geographic boundaries. However, the area of coverage of climate is wide and beyond the local environment (Gurung, 2005). A number of awareness activities, such as slide shows, interactions, educational visits, visual documentaries and alike are required to increase the awareness of the communities and local stakeholders. The local people, especially adults, need to be aware of local weather and climate (temperature and rainfall) in order to understand well climate change in their area. Information about impact of climate change on water resources was provided by using different ways such as radio, Television (TV), magazines, workshops, booklets and posters.

2.11 Measures Taken by Communities on the Impact of Climate on Water Resources

2.11.1 Training public on impact of climate change on water resources

Different world governments must educate the mass on impact of climate change on water resources at all levels by training in order to raise public awareness of climate change. Government must start the program for develop community capacity to enhance the

public awareness on sustainable development and enhance their scientific and cultural capacity for their participation in sustainable development by reinforcing personnel training". In recent years, different governments have intensified its efforts to promote education, training and public awareness on climate change by organizing various kinds of lectures on climate change basic knowledge, conducting climate change training courses for policy makers at central and provincial levels, and organizing conferences such as Climate Change and Ecological Environment, as well as setting up an official bilingual website on climate change (Liu and Chen, 2000).

The Government has trained experts and people in order to reduce the impact of climate change on water resources by the following ways:

Firstly, the government must promote fully utilization to conserve water resources in all levels in order to raise public awareness, as an important work to address climate change and carry out it with care. For this purpose, government will take various measures to promote the climate change awareness of all levels of government officials and decision-makers of enterprises and institutions, to build up a high-quality leadership team with strong awareness of global climate change step by step.

Furthermore, all walks of life of the society will be fully employed to disseminate communities' efforts and policies for response to climate change and to promote public awareness of climate change on water resources by reinforcing the publicity, education and training on the impact of climate change. Measures in this regard include: making full use of mass media such as books, newspapers, periodicals, audio and video products to disseminate knowledge of climate change to stakeholders in all walks of life; advocating sustainable life styles including water-saving, garbage, recycling and reuse; incorporating climate change publicity and education into the framework of basic education, adult

education and higher education as an important component of societies overall quality education; holding various thematic training seminars targeting at different audiences and organizing different workshops on both popular and professional climate change science; taking full advantage of information technology to enrich the contents and functions of the government's climate change information websites and building them up into real, quick-response and effective platforms for information dissemination and communication (Madulu, 2000).

Secondly, the government must encourage public participation in water conservation. Measures include the incentive mechanisms that should be established to encourage the public and enterprise participation in climate change on the water resources issue and public supervision will be fully utilized, improving information publicity channels and regulations on climate change on water resources issues; widening the channels for public participation and supervision; giving full play to the media's supervision and the guidance function on public opinion; increasing transparency of decision-making on climate change impact on water resource issues; promoting the science and democracy in the area of climate change administration; and giving full play to the initiative of social communities and non-governmental organizations.

Thirdly, the government must reinforce the International cooperation and communication among communities. Measures in this regard include strengthening international cooperation on promoting public awareness on climate change on water resources issues; utilizing the experience of international good practice on climate change on water resources publicity and education; actively carrying out information exchange with foreign countries and exchanging publications, movies, televisions, audio and video tapes and other literature works on global climate change on water resources; building up an

open database on climate change on water resources and providing inquiry and information retrieval services for domestic agencies, research institutions, and schools.

2.11.2 Improve communication

Governments must improve communication between community, government and NGOs by giving modern information of the dissemination technologies, to build up communication for educating and training in order to raise public awareness and participation in climate change. For instance experts of water resources must work hard to create a friendly social environment to address climate change on water resources and transferring knowledge on climate change of impacts on water resources for both domestic and productive uses to all residents in communities as to raise the whole society's awareness on how climate change increased temperature and reduced rainfall in different areas in the world (Murray and Orindi, 2005).

Furthermore, government improves the inter-ministerial decision-making and coordination mechanism on climate change by establishing an action mechanism for response to climate change involving a wide range of enterprise and public participation. Government must establish a suitable and high-efficient institutional and management framework to address climate change in the future.

2.11.3 Institutions and mechanisms

Communities need technology for adaptation to climate change mainly include different technologies, including high-efficiency water-saving agro-technologies such as spray and drip irrigation and water-saving and reusing technology of industrial water. Moreover, treatment technology of industrial and household wastewater, household water-saving technology and high-efficiency flood-controlling technology, agro-biological technology,

agricultural breeding technology, production technology for new-type fertilizers and disease and pest control technology for cropland, forest, and grassland.

Furthermore, cultivation technology of fast-growing high-yield forest and high-efficiency firewood forest, technology for recovery and reconstruction of wetland, mangrove and coral reef ecosystems technology for observation and pre-warning of flood, drought, sea level rise, agricultural disasters, etc. Timely-acquisition of these technologies can greatly help Tanzania reinforce its capacity for adaptation to climate change.

Rainwater harvesting; broadly defined as the method of concentrating, diverting, collecting, storing, utilizing, and managing runoff for productive uses; is one of the approaches to integrated land and water management, which could contribute to recovery of agricultural production in dry areas as well as provide water for sustainable development. Rainwater can be collected into two ways: by run-off harvesting and by storage rain water. Runoff is collected mainly from roof-tops, ground catchments as well as passing streams (flood water harvesting), and road/footpath drainage. Different structures are used for storage-tanks, reservoirs, dams, water pans, etc. There are two types of rain water harvesting systems which are in-situ water conservation and run-off harvesting (storage rain water harvesting system and direct run-off harvesting system).

Tanzania should practice the Rain Water Systems (RWS) like other countries. The benefits of rain water harvesting systems are systems which are able to reduce erosion and water pollution, reduce damaging effects of floods, improve agricultural production, reduce conflicts, and improve water availability. Moreover, improve crop varieties: Morden and traditional (local) varieties like maize, groundnut, cowpeas and sorghum. Traditional varieties still formed the bulk of the crops grown, the late maturing and low-

seed yielding. Local variety of cowpea most preferred because of ability to yield abundant fodder in addition to seed, serious insect pest problems have limited adoption of improved high seed-producing cowpea. Also, non-yield factors such as market value, acceptability and cooking quality affect the adoption of improved maize varieties (Ministry of Water, 2006).

2.11.4 Needs for capacity building

Capacity building needs for development of human resources mainly include personnel training, international exchange programmes, discipline development, and professional training in the area of fundamental research on impact of climate change on water resources, policy analysis on mitigation and adaptation, information system development and project management. Capacity building needs for adaptation to climate change on water resources mainly include development of adaptation projects, case studies on extreme climatic events and improvement of climate observation systems.

In addition, the water experts will be responsible for deliberating and determining key national strategies, guidelines and measures taken on impact of climate change, as well as coordinating and resolving key issues related to climate change on water resources. Water experts whose capacity will be strengthened, is established with Government, relevant ministries and departments in order to fulfil their responsibilities, and strengthen coordination and cooperation, so as to achieve synergies and address climate change on water resources. Local governments at different levels shall enhance the organization and leadership on local responses to climate change on water resources, and formulate and implement local climate change programmes as a matter of priority. Local communities were keen to implement these measures taken by the community due to their vulnerability

to water scarcity and pollution, and need to improve their livelihoods. Also they motivate people to change so as to conserve water resources on their environment.

2.11.5 Strengthening laws, regulations, and policies on the impact of climate change

Communities have devised useful coping mechanisms to measure the impacts of climate change on water resources in order to face the current and potential hazards like drought, low rainfall and floods. For instance, to address newly-emerging impacts of climate on water resources in recent years, the Government of China has advocated the scientific approach of development and strategic thoughts of building a harmonious society, and accelerated building of a resource-conserving and environmentally friendly society, thus further reinforcing the policies and measures relevant to addressing climate change. In 2004, China drafted plans for short and long time in order to reduce impacts of climate change. Medium and long term energy development plan outlines 2004-2020 (draft) was approved by the State Council and in the same year, the first China medium and long term energy conservation plan was launched by National Development and Reform Commission (NDRC). Then in February 2005, the National People's Congress adopted the renewable energy law of the People's Republic of China, setting out the duties and obligations of the Government, enterprises and users in development and utilization of renewable energy and a series of policies and measures, including total volume target, mandatory grid connection, price management regulation, differentiated pricing, special funds, favourable taxing and so on (Chen, 1981).

Measures which have been taken by communities are the principal ways to deal with the unavoidable impacts of climate change. It is a mechanism to manage risks, adjust economic activities to reduce vulnerability, and to improve business certainty. In Africa, the impacts of changes in climate on water resources are minor compared to the problems

being faced in China where already there is climate variability. Community must understand the factors which affect water resources and take measures on the impact of climate change on water resources from household, grass root, region, and global levels (Chen, 1981).

Tanzania is among the countries which are at risk to be affected by the impacts of climate change on water resources. Projected changes in rainfall and sea level rise and more extreme weather may also bring risks to the security of our water resources, agricultural systems and settlements, and to the health of our people; risks which could be severe in parts of Tanzania. The current drought and its associated impacts on water supply have already galvanized public opinions for building resilience to climate change. Temperature increases of 2-3ºC could have irreversible effects on some natural ecosystems such as coral reefs, alpine areas and low-lying freshwater wetlands. Communities have taken measures including planning to reduce vulnerability on water resources by using codes and standards that take into account the impact of climate change on frequency and duration of rainfall, storm water capacity, and changes in wind speed. The finance and insurance industries help manage society's risks from weather related damages (Allen and Ingram, 2002).

2.11.6. Related policies on the impact of climate change on water resources

Water plays a crucial role in systems; therefore, there is a need to be integrated in natural resource studies (Falkenmark, 1990). In accordance with the requirement of carrying out the water development, Tanzania will combine its efforts to address climate change with the implementation of sustainable development strategy, the acceleration of building-up a resource-conserving and environmentally-friendly society, and an innovative country, which will be integrated into the overall national economic and social development plans

and regional plans. The related policies in Tanzania which must work together with National Water Policy in order to reduce and manage the impact on climate change on water resources in Tanzania are Health Policy, Environmental policy, Forestry Policy, Local Government Policy, Rural Development Policy and Strategy, Land and Settlement Policy, Energy Policy, and Agricultural Policy.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location and surface area

The study was conducted in rural areas o Temeke District in Dar es Salaam Region, particularly in Vijibweni, Mjimwema, Somangila, Kimbiji and Toangoma wards. Dar es Salaam Region lies between $6^{o}34'$ and $7^{o}10'$ latitudes South on Equator and, stretches about 100 km along the coast of the Indian Ocean. Dar es Salaam has about 1129 km^2 of land of which about 66 percent, 38 hectares, is utilized for agricultural and livestock production. Temeke Municipality is among the three Municipalities of Dar es Salaam Region; others are Kinondoni and llala. It comprises an area of 672 km^2 and is situated in the Southern Eastern part of Dar es Salaam City. It borders the Indian Ocean in the East, Mkuranga belt in the South, and Ilala Municipality in the Northwest (URT, 2003a). The study area was selected because the area has a high rate of water resources such as streams, ponds and wetlands. Temeke Municipality has 3 divisions which are Mbagala, Temeke and Chang`ombe. It has 24 wards which are Azimio, Chamazi, Chang'ombe, Charambe, Keko, Kigamboni, Kibada, Kimbiji, Kisarawe, Kurasini, Makongorowe, Mbagala Kuu, Mbagala, Miburani, Mjimwema, Mtoni, Pembamnazi, Sandali, Somangila, Tandika, Temeke, Toangoma, Vijibweni, and Yombo Vituka.

3.1.2 Justification for study area selection

Rural Areas of Temeke District were selected for the study by considering certain peculiar characteristics of the area. The study area is endowed with a large number of rivers like River Kizinga and River Mzinga which flow into Indian Ocean. Also it has large Kimbiji aquifer which is the source of underground water (URT, 2003a). Most of people who have

lived in the study area depend on the water which comes from those rivers and the underground water for their income.

3.1.3 Climate of the study area

Dar es Salaam Region usually receives about 700 to 1000 mm of rainfall per year with two seasons of rain: long rain and short rains. The short rains rain from November to December, and the long rains rain from March to May. The climate is typically tropical, with hot weather throughout the year. The temperatures range between 26^{o}C and 35^{o}C. The air temperature is related to the sea-water temperature, which is cooler during July to September, with average maximum temperatures of about 30^{o}C and minimum temperature of about 22^{o}C. The humidity is about 83 percent maximum per annual and 64 percent minimum per annual (URT, 2003a).

3.1.4 Demography

Temeke District is among the high- density areas in Dar- es- Salaam; the population of Temeke Municipality was 771 100 million, 382 255 females and 387 245 males (URT, 2002b). Generally, the city reported to have a population growth rate of 4.2% per annum. The population in Dar es Salaam is a mixture of people from all parts of Tanzania. The major language of Dar es Salaam people is Kiswahili (URT, 2003b).

3.1.5 Economic activities

A large proportion of the people of the area are engage in small business or manual labour. Economic activities in Temeke District include industrial production, commercial services and work in the public sector. Other economic activities include petty businesses such as vegetable and fruit production, poultry keeping, and street food. These economic activities provide employment for them (URT, 2003b).

Figure 4: Map of Temeke District showing the wards for the study

3.2 Research Design and Sampling Procedure

3.2.1 Research design

The study employed a cross- sectional research design: Kedir *et al*. (1999); Saunders *et al.* (2007) define cross -sectional survey as a method of collecting data at one point in a time from a selected sample of respondents. The method consumes less time in data gathering, although more triangulation and probing is needed in order to get valuable information. This type of design was selected because it is most common in survey research to compare the extents to which at least two groups of people differ on the dependant variable (De Vaus, 1993).

3.2.2 Population of study

Population is a group of individuals who have one or more common characteristics that are of interest to the researcher (Best and Kahn, 1998). The population for research was all rural households in Temeke District. However, they were represented by those who lived-in Vijibweni, Mjimwema, Kimbiji, Somangira and Toangoma Wards. The population of study is shown in the Table 1.

Table 1: Population of study

S/ No	Respondents	Number of Respondents
1.	Water officers	5
2.	Environment officers	2
3.	Land officer	1
5.	Agriculture officers	3
6.	Ward Executive officer	5
7.	NGOs Coordinators	4
8.	Community Members	80
	Total	**100**

3.2.3 Sample size

The household was used as the sampling unit since it is the most appropriate unit of measurement when assessing the level of poverty and standards of living in a society (Bailey, 1994). A total of 100 respondents was selected from the five wards. The sample size was large enough since it was much higher than the minimum recommended sample of 30 cases, according to Bailey (1994).

3.2.4 Sampling procedure

3.2.4.1 Simple random sampling

According to the method described by Creswell (1994), individual members were selected randomly by using a table of random numbers, thus each member had equal chances of being selected. The sample for the study was obtained by using a four- stage sampling procedure as follows: The first stage involved purposive selection of one Division out of three Divisions of Temeke District. In the second stage twelve ten-cell units in each ward were selected randomly.

3.2.4.2 Purpose sampling

The second stage involved a purposive selection of five wards. The Division and Wards were selected on the basis of their having adversity of opportunities for households to generate income through water resources. The key informants were selected purposively according to the role they performed in the society. These included traditional leaders, government officials, NGOs officials and CBOs officials.

3.2.4.3 Snowball sampling

Some of the respondents for in-depth discussion were selected by using snowball technique, whereby after interviewing one respondent, he/she asked to recommend other activities that caused climate change or water scarcity in the area.

3.3 Data Collection Procedures

3.3.1 Preliminary survey

A preliminary survey was conducted in order to solicit background information and familiarize with the study area. Pre-testing of the research tools was done by interviewing 30 respondents from two wards namely, Kibada and Pemba mnazi in order to test the validity and reliability of questionnaires and familiarise with the study area in which 15 respondents were sampled from each ward. Thereafter, the research instruments were modified accordingly.

3.3.2 Primary data

Both closed and open ended questions were used to collect information in order to meet the objectives presented. The questionnaire comprised the questions was administered to household heads or their representatives. The questions was formulated in English and translated in Swahili language to allow for easy communication during the interview. Also, key informants interviews and focus group discussions (FGD) were hold to get information to supplement that collected using the questionnaire.

3.3.3 Secondary data

Secondary information was collected from previous research reports from government at the ministerial level, local government offices, Tanzania Meteorology Authority (TMA) and libraries including Sokoine National Agricultural Library (SNAL), University of Dar

es Salaam (UDSM), Institute of Resources Assessment (IRA), electronic materials and other sources relevant to the study's objectives.

3.4 Quantitative and Qualitative methods

Questionnaire copies were distributed to the selected respondents in the wards and each respondent took forty five minutes to one hour to complete writing responses under supervision. The questionnaire contained both open-ended and close ended questions about the community perception of climate change on water resources (Appendix 2). Qualitative methods were used for collection of primary data, namely individual in depth interview, key informants, focus group discussion and participant observation.

3.5 Data Collection Instruments

3.5.1 Individual in-depth interview

Individual in-depth interview which was concerned with interviewing individuals with question probes to small group of subject. The questions usually constructions were open ended.

3.5.2 Key informant approach

Key informants were interviewed to collect qualitative data to supplement quantitative data. The key informants interviewed included knowledgeable individuals; particularly pastoralists, farmers, fishermen, division leaders, Water Ministry officers, Municipality officials and water resource stakeholders. Checklists of items for discussion were used to interview selected key informants in collecting primary qualitative data (Appendix 7).

3.5.3 Focus group discussion

Focus Group Discussions were used in order to get information to supplement information collected through other methods. Before FGDs, people were grouped by sex, occupation and age. Each FGD comprised 6-10 people for maximum participation and freedom of expressing their feelings and opinions (Kothari, 2004). Topics for discussion were designed to examine the community perception on the impact climate change on water resources. The discussants were given options to give their comments. This helped to supplement and cross check information obtained using other methods (Appendix 6).

3.5.4 Participant observation

Participant observation is a mean of collecting information which gives a firsthand account of the situation under study and when combined with interviewing and document analysis it allows for holistic interpretation of the problem under study (Merrian, 1988).

3.6 Data Processing and Analysis

Data processing and analysis were conducted at Sokoine University of Agriculture, Morogoro, Tanzania. The data collection was sorted, coded and summarized prior to analysis. Analysis was done by using the Statistical Package for Social Sciences (SPSS) computer software in conformity with the objectives of the study. Descriptive statistics including frequencies, standard deviations, percentages, and minimum and maximum values were computed to derive tables from the analysis. Chi-square test was used to determine relationships between some variables (Connor-Linton, 2006). Also index and likert scale were used to show community perceptions on impact of climate change on water resources.

3.7. Limitations of the Study

One of the limitations of the study was that some of the respondents who were selected were reluctant to give information. Therefore, the researcher had to select other respondents for interview. This exercise proved to be time consuming and tedious.

Another limitation was that some people were illiterate; this made the data collection process more time consuming.

In addition to that, the study was conducted during working hours; thus some of the respondents, particularly officials, were not available at the working stations which made the researcher spend a lot of time making repetitive visits to their working places for interviews.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Demographic and Socio-Economic Characteristics of the Respondents

4.1.1 Demographic characteristics of the respondents

The demographic characteristics of the respondents are presented in Tables 2. Parameters for demographic characteristics include sex, age, marital status, education, occupation and household size.

Sex composition in Table 2 revealed that 49% were females and 51% were males. Age is one of the most important demographic variables and is the primary basis for demographic classification in vital statistics, census, and surveys (NBS, 2005). From the age distribution of respondents as presented in Table 2, the study showed that the majority of the respondents were in the age group of 26-50 (63%), followed by the age group of between 51-75 years (17%), age group less than 25 years (16%), and age group more than 76 years (4%). The domination of the 26-50 age group indicate that the community comprised higher percent of energetic people who could contribute to household income by doing different socio-economic activities. A study conducted by Yanda *et al.* (2001) in Singida reported that 70 percent of the respondents were in the age between 31-50 years, which reflected energetic people with full engagement in socio-economic activities. Chi-square test results indicated that there was no significant relationship at $p \geq 0.05$ level between age of respondents and perception of the impact of climate change on water resources (Table 3).

Education is a key determinant of the life style and status an individual enjoys in the society (NBS, 2005). The education level for people was categorized as follows: people who had attended school and people who had not attended school. In the case of level of

education, the results revealed that the largest percentage of the respondents (40%) had attended primary school education; 28% of the respondents had not gone to school; 22% of the respondents had attended secondary school education; 9% of the respondents had attended college education; and 1% of the respondents had attended University.

The standard of education the respondents had implies that the respondents were educated enough to respond to the questionnaires reasonably and give responses that represented their knowledge and experiences in uses and management of water resources. Such categorization increased the ability of individuals to understand, interpret and practise water conservation practices in their areas. As Kajembe (1994) pointed out, education tends to create awareness, positive attitudes, values, and motivation. It also tends to stimulate self-confidence and self-reliance. Therefore, if all other factors are constant, the level of education can contribute positively to household income, and people may use the acquired education on water resources. The chi-square test results revealed that there was a significant relationship at $p \leq 0.05$ between education of respondents and perception of impact of climate change on water resources (Table 3).

People in the study area were also asked about their occupations. The purpose was to determine the economic activities which were done by the people so as to earn income to sustain their households. The occupations were divided into two categories namely employed and self employed. The survey results in Table 2 revealed that 58% of the respondents were farmers; 10% were pastoralists; 13% were businessmen; 16% were employers; and 3% did others activities. Those who were employed in public and private sectors as civil servants were teachers, agricultural officers, health officers, social welfare officers, and environmental officers. The findings also showed that few of the respondents were self-employed as musicians, fishermen, food vendors, household keepers, artists,

craft men, charcoal makers, sand sellers, sandstone sellers, gravel sellers, brick makers, carpenters, tailors, builders, and salt makers. The result concurs with (Katani, 1999) who argued that economic factors are those related to the financial status, which include purchasing power and labour costs. This heterogeneous situation of the respondents' occupation leads to the impact of climate change on water resources. The chi-square test results revealed that there was a significant relationship at $p \leq 0.05$ between occupation of respondents and perception of impact of climate change on water resources (Table 3).

Table 2: Socio- Demographic characteristics of respondents (N=100)

Variables	Component	Frequency	Percent
Sex	Male	51.0	51.0
	Female	49.0	49.0
	Total	**100.0**	**100.0**
Age	< 26 years	16.0	16.0
	26-50 years	63.0	63.0
	51-75 years	17.0	17.0
	+76 years	4.0	4.0
	Total	**100.0**	**100.0**
Marital status	Married	54.0	54.0
	Unmarried	22.0	22.0
	Widow	14.0	14.0
	Divorced	10.0	10.0
	Total	**100.0**	**100.0**
Education level	Never gone to school	28.0	28.0
	Primary school	40.0	40.0
	Secondary school	22.0	22.0
	College	9.0	9.0
	University	1.0	1.0
	Total	**100.0**	**100.0**
Occupation	Farming	58.0	58.0
	Salaried employment	16.0	16.0
	Business	13.0	13.0
	Livestock	10.0	10.0
	Others	3.0	3.0
	Total	**100.0**	**100.0**
Household size	1- 3 members	34.0	34.0
	4-5 members	54.0	54.0
	+6	12.0	12.0
	Total	**100.0**	**100.0**

Marital status influences the degree of responsibilities pertinent to household and resource management. Therefore, the respondents were asked to state whether they were single, married, divorced, or widowed (Table 2). The married couples were compelled to utilize water resources in their environment to meet their households' basic requirements. The result tallies with Sima (2008) who said that the use of resources to generate households' income is directly and indirectly influenced by marital status.

Greater proportions of the respondents in rural areas of Temeke District were involved in various income generating activities by using water resources. The results in Table 2 indicate that 54% households had an average of 4 to 5 persons, followed by 34% of the households which had an average of 1 to 3 people, and 12% of the households which had an average of more than 6 people. The average household size was 5.3 individuals, which is slightly larger than the national average of five people reported by NBS (2005) and URT (2003b). The results showed that family size is an important factor for household income. The result is similar to Yanda *et al.* (2001) who reported that wetland productivity is based on available labour. One of the limiting factors in rural productivity is shortage of labour force. These results are similar to those reported by Mhinte (2000) in Kilosa District who argued that an increase in number of members in the household implies more mouths to feed, but on the other hand it implies more availability of labour. Men were the leaders of households in that community. Chi-square test results indicated that there was no significant relationship at $p \geq 0.05$ level between age of respondents and perception of the impact of climate change on water resources (Table 3).

Out of the hundred respondents, 22% were unmarried; 54% were married; 10% were divorced and 14% were widows. There were few heads of households (widows) who had lost their spouses. Having small proportion of female respondents in the study area can be

explained by the fact that most Tanzanian households in the rural areas are often headed by men. The majority of men control resources of the family. The result tallies with World Bank (1998) which reported that in rural Tanzania, female household heads were only 5.8 percent.

Table 3: Respondents opinions' based on age, education level and occupation

Variable	Perception of Impact of Climate Change on Water Resources			
	Frequency	Percent	p-value	χ^2
Never gone to school	28	28.0	66.182ns	0.368
Primary school	40	40.0	104.407ns	0.235
Secondary school	22	22.0	84.425**	0.007
College	9	9.0	18.000ns	0.103
University	1	1.0	1.000ns	1.800
Occupation				
Farming	58	58.0	136.245*	0.039
Paid employment	16	16.0	47.543ns	0.245
Livestock	10	10.0	30.000ns	0.157
Business	13	13.0	22.425ns	0.350
Others	3	3.0	3.00ns	0.111
Age				
<25 years	16	16.0	25.597ns	0.400
26-50 years	63	63.0	176.504ns	0.320
51-75 years	17	17.0	25.598ns	0.401
+76	4	4.0	6.39925ns	0.160

ns not statistically significant at ($p>0.05$)
* statistically significant at the 5% level
** statistically significant at the 1% level

Table 4 shows the different ethnic groups of people who lived in the study area. The Zaramo ethnic group comprised 37%; the Sukuma comprised 38% the Nyamwezi were 8%; the Ha were 5%; the Ndengereko were 4%; the Gogo were 4%; the Sambaa were 3%; and the Nyiramba were 1%. The majority of the respondents were coming from up-country in order to get needs for their lives. This situation leads to urbanization. The findings are similar with those by Kiunsi (1984) who argued that growth population destroyed vegetation in urban areas.

Table 4: Origin of the respondents

	Regions	Frequency	Percent
Originality	Dar es Salaam	38.0	38.0
	Mwanza	18.0	18.0
	Shinyanga	20.0	20.0
	Kigoma	8.0	8.0
	Dodoma	5.0	5.0
	Coast	4.0	4.0
	Tabora	4.0	4.0
	Tanga	3.0	3.0
	Singida	1.0	1.0
	Total	**100.0**	**100.0**
Ethnic groups	Zaramo	38.0	38.0
	Sukuma	37.0	37.0
	Ha	8.0	8.0
	Gogo	5.0	5.0
	Ndengereko	4.0	4.0
	Nyamwezi	4.0	4.0
	Sambaa	3.0	3.0
	Nyiramba	1.0	1.0
Total		**100.0**	**100.0**

4.1.2 Socio-economic characteristics of the respondents

Respondents were asked the reasons which made them to establish in the study area. The findings are summarized in Table 5 and reveal that 25% of the respondents were established in the study area because of fertility of the soil; 3% of the respondents were established there because of availability of grazing land and pastures; 21% of the respondents had immigrated due to marriage; 12% of the respondents were established there because of closeness to their working places; 29% of the respondents had followed their relatives; 4% of the respondents were established there because of lack of land elsewhere; and 5% of the respondents were established these because of availability of water. Generally, people migrate from other regions in order to increase their income through different socio-economic activities which influence the destruction of the water resources.

In Table 5, the respondents were asked whether they owned some plots; the results revealed that 90% of them owned plots, but 10% of them did not own any plot. About one-third (32%) of the respondents owned plots through buying; 30% of the respondents had been given land by their relatives; 25% of the respondents had inherited the plots; 7% of the respondents had bought the plots following official procedures; and 6% of the respondents had no response. The respondents were also asked about the size of the land (plots) they owned. The study revealed that 28% of the respondents owned less than one acre; 39% owned 1 to 5 acres; 15% owned 6 to 10 acres; and 8% owned more than 10 acres. Generally, the sizes of the plots owned ranged from less than one acre up to more than 10 acres. The result concurs with URT (2003a) which observed that most of smallholder farmers own below 2 acres.

Table 5: Socio-economic characteristics of the respondents

		Frequency	Percent
Reasons for migration	Fertility of the soil	25.0	25.0
	Availability of grazing land and pastures	3.0	3.0
	Migration due to marriage	21.0	21.0
	Living close to work places	12.0	12.0
	Following relatives	29.0	29.0
	Lack of land in others areas	4.0	4.0
	Availability of water	5.0	5.0
	Total	**100.0**	**100.0**
Plot ownership	Yes	90.0	90.0
	No	10.0	10.0
	Total	**100.0**	**100.0**
Acquiring plots	Through buying	32.0	32.0
	Through relatives	30.0	30.0
	Inheritance	25.0	25.0
	Official procedure	7.0	7.0
	No response	6.0	6.0
	Total	**100.0**	**100.0**
Plot size	< one acre	28.0	28.0
	1-5 acres	39 0	39 0
	6-10 acres	15.0	15.0
	+10 acres	8.0	8.0
	Total	**90**	**90**

4.1.3 Crops and cropping systems in rural areas of Temeke District

Table 6 shows crops and cropping systems in rural areas of Temeke District. About 76% of the respondents had grown crops, but 24% of the respondents had not grown any crop. Respondents practised different cropping systems; 35% of the respondents practised monoculture; 40% practised mixed cropping; 2% practised shifting cultivation; and 23% respondents did not practise any cropping system. Respondents were asked which crops they grew in dry seasons, and the findings revealed that 22% of the respondents grew rice; 14% grew maize; 22% grew groundnuts, 14% grew cassavas; 4% grew yams, 18% grew tomatoes; and 6% respondents grew vegetables.

During FGDs, the discussants said that in the dry seasons they were irrigating their farms by using rivers Mzinga and Kizinga. These tallied with Barker *et al.* (2000) who argued that water productivity in irrigation is the amount of crop produced or gross value of output per unit volume of water used.

Table 6: Crops and cropping systems in Temeke rural district

Do you grow any crops	**Percent**
No	24.0
Yes	76.0
Total	**100.0**
If Yes, which cropping system do you practise	**Percent**
Monoculture	35.0
Mixed cropping	40.0
Shifting cultivation	2.0
No response	23.0
Total	**100.0**
Which crops have you grown during dry season?	Percent
Rice	22.0
Maize	14.0
Groundnuts	22.0
Cassava	14.0
Yam	4.0
Tomatoes	18.0
Vegetables	6.0
Total	**100**

4.2 Factors which Affect Water Resources

Factors which affect water resources are human socio-economic activities, climate change and climate variability in rural areas of Temeke District as a result rainfall and temperature trends changed when compared with previous years.

4.2.1 Climate change and climate vulnerability

4.2.1.1 Rainfall trends

In focus group discussions the discussants said that the amount of rainfall had decreased in previous two decades coupled with rain seasons change and unpredictability. The changes in rain seasons was associated with short rains (*vuli*) which commonly used to start in September but during this research it was beginning in late January. It was no longer raining in some years. As a result of prolonged dry seasons, drought had affected community livelihoods. The interviews revealed further that in the study area rainfall had been fluctuating considerably during the previous 10 years in terms of amounts, spatial and temporal distribution. In the study area, rainfall is locally perceived as one of the main climatic variability indicators. Change in rainfall seasonal calendar was another indicator used by communities to describe climate change and vulnerability. Similarly, mean annual data from the Tanzania Meteorology Authority (TMA) over the past ten years, 1998 to 2008 indicate that the amount of rainfall has slightly been falling in rural areas of Temeke District as seen in (Fig. 5).

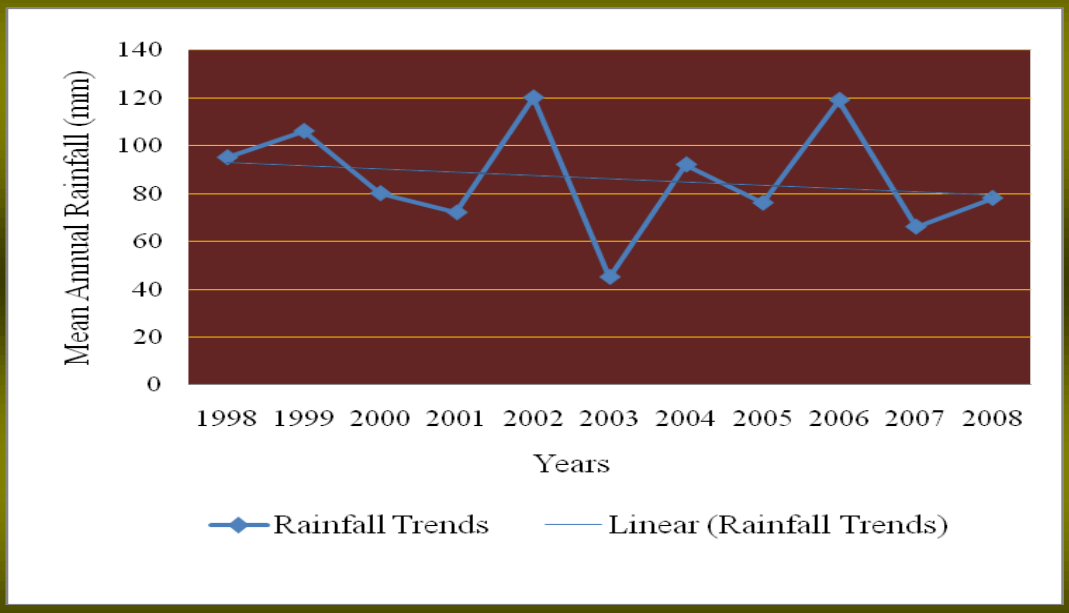

Figure 5: Rainfall trends in Temeke District 1998-2008. Source TMA, 2009

4.2.1.2 Temperature trends

Regarding temperature, all the respondents in the study area reported that average temperature had increased as compared to the past (late 1960s and 1970s). According to Bulkeley (2000) the ability of the earth's atmosphere to trap solar radiation and increase global temperature (the so-called "greenhouse effect") has been recognized for at least 150 years. The results are similar to the data released by Tanzania Meteorology Authority (TMA) which show that during 1998 to 2008 period the annual temperature trends in rural Temeke District were increased compared to previous years (Fig. 6).

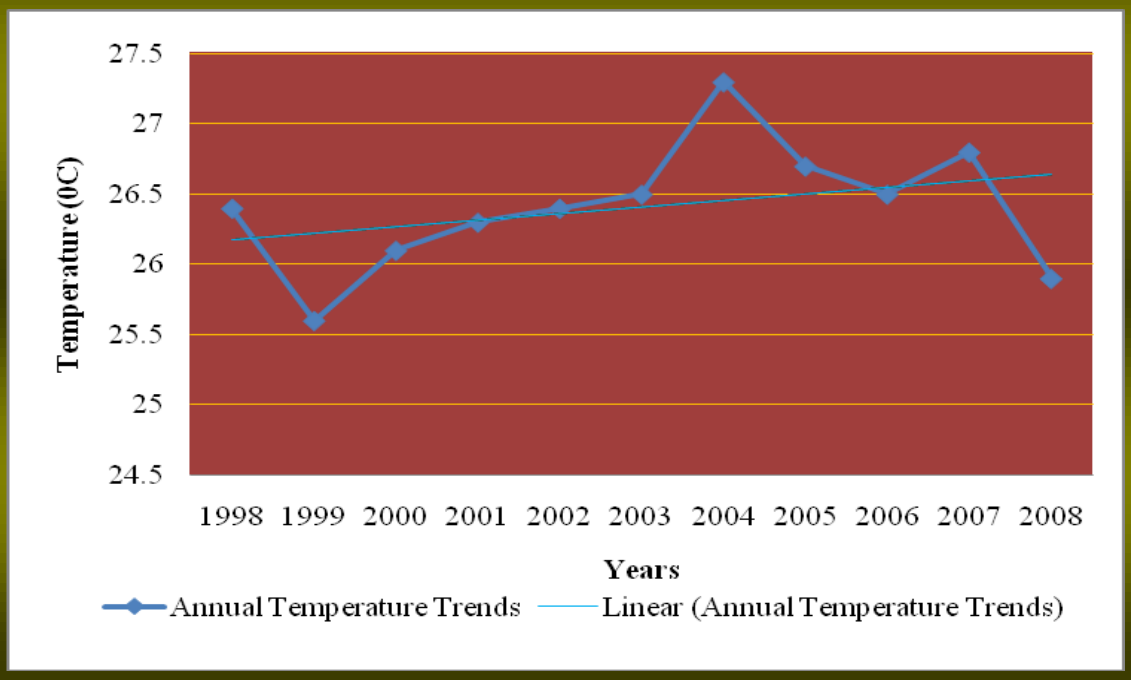

Figure 6: Spatial temperature variations in Temeke District 1998-2008. Source TMA, 2009

4.2.2 Human socio-economic activities

4.2.2.1 Activities thought to affect water resources

Table 7 shows the activities that were thought by the respondents to affect water resources. Respondents were asked which activities that they thought had affected water resources. The results revealed that one-third (22%) of the respondents said that the activities which had affected water resources most was agriculture; 34% of the respondents said settlement; 26% mentioned industries; 10% respondents mentioned cattle grazing, and 8% mentioned sandstone. Also, the respondents were asked changes related to utilization of wetlands. The results revealed that 75% of the respondents said yes while 25% said no, meaning that they used and did not use wetlands, respectively.

The results revealed that human activities had caused an impact of climate change and decline of the water resources in the study area. There is clear evidence of a relationship between climate change and variability and human economic activities. This result concurs with Luoga *et al*. (2000) who argued that there was a strong relationship between economic development and vulnerability to disasters.

Table 7: Activities affect water resources

Activities thought to affect water resources mostly	**Percent**
Agriculture	22.0
Settlement	34.0
Industrial activities	26.0
Cattle grazing	10.0
Sand stones	8.0
Total	**100.0**
Changes which related to the utilization of wetland in the area	**Percent**
Yes	75.0
No	25.0
Total	**100.0**

4.2.2.2 Numbers of houses increasing

Respondents were asked whether numbers of houses in the study area were increasing or decreasing. The findings (Table 8) revealed that 97% of the respondents said that the numbers of houses were increasing (1500 houses) while 3% of the respondents said that numbers of houses had decreased (200 houses). The findings revealed that settlement increased in the area because there was enough water for domestic purpose and commercial purpose.. This result tallies with Turton and Warner's (2002) who argued that in a situation where water resources are relatively finite within any given country, doubling of that country's population will cut into half the volume of water available per capita.

Table 8: Number of houses

Number of houses	Category	Percent
2500	Increasing	97.0
200	Decreasing	3.0
2700	**Total**	**100.0**

4.3 Community's Perception on Impact of Climate Change on Water Resources

4.3.1 Community's perception towards climate change

Climate change was perceived by both human activities and natural factors such as changes of seasons, immigrants and socio-economic activities, as a result shift in crop seasons, declining crops, and increased hunger, food shortage and water scarcity. The data in Table 9 show the years since the respondents had settled in the study area. Respondents were asked when they had established in the study area. The results revealed that 6% of the respondents had settled there between 1950 to 1959; 9% of the respondents had settled there in 1960 to 1969; 14% of the respondents had settled there in 1970 to 1979; 20% of the respondents had settled there in 1980 to 1989; 34% of the respondents had settled there in 1990 to 1999; and 17% of the respondents had settled there in 2000 up to now. The majority of the respondents had settled in the study area between 1950 and 2007. Since they had settled there for many years, they were able to show realistically their perceptions on impact of climate change on water resources because they had long experience to stay in the study area.

Table 9: Establishing time in the study area

Years group	Percent
1950-1959	6.0
1960-1969	9.0
1970-1979	14.0
1980-1989	20.0
1990-1999	34.0
2000+	17.0
Total	100.0

Data in Table 10 show the trends of crop production for the previous ten years. The respondents were asked about trends of level of crop production for ten years to find whether they were associated with wards or not. About 50% of the respondents of Vijibweni said that crop production had decreased. The results showed that crop production had decreased because of climate variability in the areas. The findings revealed that chi-square test results indicated there was significant relationship at ($p \leq 0.05$) level between trends of crop production and wards in the study area on perception on the impact of climate change on water resources (Table 10). The results tally with (Smit *et al.*, 1999) who argued that exceeding the limits of social resiliency through denial of climatic reality will lead to agricultural production decline, financial failures, collapse of ecological and social support systems, and regional displacement and out-migration from vulnerable regions.

Table 10: Trends of crop production for last 10 years

Name of wards	Increasing	Constant	Decreasing	Total	χ^2	P Value
			(%)			
Mjimwema	25	25	50	100	8.690ns	0.369
Somangira	10.0	35.0	55.0	100.0	8.123ns	0.422
Toangoma	5.0	30.0	65.0	100.0	5.582*	0.018
Vijibweni	10.0	20.0	70.0	100.0	-0.234*	0.017
Kimbiji	5.0	15.0	80.0	100.0	-.0.237*	0. 019

ns Not statistically significant (p> 0.05)
* Statistically significant at the 5% level.

Table 11 shows responses on changes in climate and settlement. The respondents were asked whether there was any climatic changes over the previous ten years; about four-fifths (79.2%) of them said that there were changes while 20.8% said that there were none. In addition, respondents were asked whether they liked to live in that area. The findings showed that 39% of the respondents did not like while 61% liked to live there. Therefore, the majority of the respondents liked to live there because water resources were available.

The results revealed that people in the study area had the perception of impact of climate change by using weather parameters such as temperature, rainfall, wind and humidity. The findings agree with those by Mulama (2006) who argues that the climate in Africa has changed rapidly; so corrective measures should take place instantly.

Table 11: Climatic changes and settlement

Do you think it is wise to live in this area?	Percent
No	39.0
Yes	61.0
Total	**100.0**
Is there any climatic changes over the ten years	
No	20.8
Yes	79.2
Total	**100.0**

4.3.2 Community perceptions towards climate change on water resource

Key informants described the main impacts of climate change on water resources can be temperature increase, shortage of rainfall, floods, hurricanes, and human socio-economic activities like agriculture, cutting trees for timbers, firewood, charcoal, poles for building houses and pollution from different industries. Some of the changes mentioned by the FGDs at Vijibweni, Kimbiji, Mjimwema, Toangoma and Somangira included drought in 1984, prolonged dry seasons these days, and low rainfall in 1996, followed by heavy rainfall in 1997/98 which caused floods. This period was characterized as El Niño period. Other changes which were mentioned were: sea level rise, temperature increase, rain uncertainty, rainfall unreliability in few months with rain that starts late and ends up within a short time, and long dry periods.

Vijibweni area water was affected by chemicals and oils from textile industry which are thrown out into River Kizinga and Mzinga. At Kimbiji aquifer, people were driven out and some business men took that place for tourism business. The findings of the study showed that the most popular perceived agents of the impact of climate change on water resources were climate change and socio-economic activities. The study findings were comparable with those by IPCC (2007), which found that human socio-economic activities and climate change affect water resources.

In Table 12 the respondents were asked about the impact of climate change on water resources in study area. About 10% of the respondents said El Niño; 30% of the respondents said drought; 8% of the respondents said rainfall decrease; 6% of the respondents said rainfall unpredictability; 22% of the respondents said floods; 20% of the respondents said temperature increase; and 4% of the respondents said sea-level rise. The results revealed that the majority of the respondents in the study area perceived climate in

terms of temperature, rainfall patterns, drought, and human activities such as agriculture and deforestation. Those activities were increasing water scarcity. According to Richard (2007), increasing water scarcity causes water productivity to become a global concern due to the argument that less water will be available for agriculture because of increasing water demands for domestic, municipal, industrial, and environmental purposes. Despite its scarcity, water continues to be misused (Oweis and Hachum, 2004).

Table 12: Community perception of climate change on water resources for ten years

Year	Event	Frequency	Percent
1997/1998	El Niño	10	10.0
1998	Floods	22	22.0
1999-2007	Rainfall decrease	8	8.0
2000-2007	Rainfall unpredictability	6	6.0
2007	Sea level rise	4	4.0
2008	Drought	30	30.0
2008-2009	Temperature increase	20	20.0

4.3.3 Community perception towards water resources conservation

The respondents were also asked a series of questions aimed at assessing their perceptions towards water resources conservation. Descriptive analysis of respondents' perceptions towards water resources conservation is presented in Table 13. The respondents were required to state yes, don't know or no for each statement. More than four-fifths (85.3%) of the respondents agreed that water resources conservation could be protected through planting trees and grasses; 17.3% of the respondents agreed on crop rotation; 82% respondents agreed on farming far away from the sources of water; 76.8% respondents did not settle near water sources; 21.3% respondents did not use industrial fertilizers; and 16% respondents grew drought tolerant crops. The results showed that the respondents were knowledgeable about water resources conservation. The Tanzania government and

people have made commendable efforts for water conservation by using traditional ways and new technologies.

Table 13: Likert scale of perception towards conservation on water resources

Items	Yes	Don't know	No
Through planting trees	85.3	1.3	13.3
Through planting grasses	17.3	8.0	74.7
Through crop rotation	80.0	8.0	12.0
By leaving near the source of water	82.0	10.0	8.0
By dig farms far away from the sources of water	21.3	8.0	70.7
Don't use industrial fertilizer	76.8	1.3	22.7
Don't settle near the source water resources	16.0	5.3	78.7
Grow tolerant crops	16.0	5.3	78.7

Furthermore, the majority of the respondents had knowledge of the causes of water scarcity as observed by The African Water Vision for 2025 which has been designed to avoid the disastrous consequences of water scarcity and lead to a future where the full potential in Africa's water resources can be readily unleashed to stimulate and sustain growth in the region's economic development and social well-being (Donkor, 2003).

During FGDs at Somangira, Kimbiji and Toangoma, discussants said that they protected water by planting new trees before cutting the old ones. The result indicated that respondents had a high level of knowledge about water resources conservation and awareness of the main root impact of climate change on water resources. These findings are similar to those reported by IPPC (2007).

4.3.4 Community perception on water shortage is linked to climatic changes

Table 14 shows that the community perception on water shortage was linked to climatic change. The respondents were asked about problems of water shortage. The results revealed that 21% of the respondents said no while 79% said yes. Moreover, respondents

were asked whether there was the problem of water shortage linked to climate change and when it had started. About three quarters (74%) of the respondents agreed and 26% of them disagreed. Eight percent of the respondents (8%) said the problem started between 1981 and 1990; 72% of the respondents said the problem started between 1991 and 2000; and 20% of the respondents said that the problem started since 2001 up to date. The result shows that the community perception on water shortage was linked to climate change. These results are similar to those found by Bulkeley (2000) in Australia about the public having common knowledge of climate change.

Table 14: Community perception on water shortage is linked to climatic changes

Does this ward have the problems of water shortage?	**Percent**
No	21.0
Yes	79.0
Total	**100.0**
Is the problem of water shortage linked to climate change?	**Percent**
Yes	74.0
No	26.0
Total	**100.0**
If yes, when did the problem start?	**Percent**
Between 1981 and 1990	8.0
Between 1991 and 2000	72.0
2001+	20.0
Total	**100.0**

4.4 Awareness on Impact of Climate Change on Water Resources

4.4.1 Awareness on impact of climate change on crop production and natural resources

The respondents were asked whether there was a good trend of crop production for the previous ten years. Eleven percent (11%) of the respondents confirmed that crop production had increased; 64% said that crop production had decreased; and 25% said that there was constant crop production. Moreover, the respondents were asked about the

natural appearance at the first time; and the results showed that 30% of them answered that there were natural bushes, tall grasses, trees, animals and birds. Slightly more than one-fifth of them (21%) said that there were natural bushes, trees, tall grasses and animals; 12% said that there were natural bushes, tall grasses and birds; 9% said that there were natural tall grasses and trees; 8% said that there were village settlement; 18% of the respondents developed place for agriculture; 2% respondents said all of the above.

More than three quarters of the respondents (87%) said that the coverage of wetlands had decreased; 12% of the respondents said that the coverage of wetlands had expanded; and 3% respondents said that the coverage of wetlands had not changed. The findings revealed that 54% of the respondents said that the level of encroachment was moderate and 46% said that the level of encroachment were low (Table 15).

The findings revealed that people in the study area were well aware of the climate change and had clear opinions on the changes, especially trends in crop production and natural vegetation appearance. These findings on changes which were caused by changes of rainfall patterns and variation in temperature are similar to arguments by Liwenga *et al.* (2007) who contend that climate elements such as rainfall, temperature and wind are normally used by local people to describe climate change and variability.

Table 15: Awareness on climate change impact on trend of crop production and natural resources

What is the trend of crop production for the last 10 years	**Percent**
Increasing	11.0
Constant	25.0
Decreasing	64.0
Total	**100.0**
How was this area looking at the first time of your establishment	**Percent**
Natural with bushes tall grasses, animals, trees & birds	30.0
Natural with bushes, tall grasses, animals & trees	21.0
Natural with trees, tall grasses & birds	12
Village settlement	9.0
Already developed for agriculture	8.0
All of the above	2.0
Total	**100.0**
What can you say about the coverage of the wetlands; is it still the same as when you were first established here	**Percent**
It has decreased in size	85.0
It has expanded	12.0
No change	3.0
Total	**100.0**
How would you describe the level of encroachment since you were first established here	**Percent**
Moderate	54.0
Low	46.0
Total	**100.0**

4.4.2 Awareness on water availability and uses

The respondents were asked about types of water which were available in the study area, and 28% of them said that there were wells; 68% said that there were rivers; and 2% of the respondents said that there were ponds. Also, the respondents were asked about types of water they used; 1% of the respondents said that they used taped water; 28% used untapped water; 60% used boreholes, and 11% used other types of water. Furthermore, the respondents were asked how many buckets of water they used per day in their families. The findings revealed that 48% of them used 0 to 10 buckets; 39% used 11 to 20; and 13% used more than 21 buckets. The respondents were also asked the use of water at home, and the results revealed that 65% of them used water for domestic purposes; 19% used water for vegetable irrigation; and 16% used water for commercial

purposes (Table 16). These findings are similar with those by Bord *et al.* (2000) who argue that the public must understand the impact of climate change on water resources and manage it.

Table 16: Awareness on water availability and uses

Types of water resources available in your home area	**Percent**
Well	28.0
River	68.0
Pond	4.0
Total	**100.0**
Types of water used in the study area	**Percent**
Taped	1.0
Untapped	28.0
Boreholes	60.0
Others	11.0
Total	**100.0**
Buckets of water you use for your family per day	**Percent**
0-10	48.0
11-20	39.0
21+	13.0
Total	**100.0**
Uses of water use at home	**Percent**
Domestic purpose	65.0
Irrigation vegetables	19.0
Commercial purpose	16.0
Total	**100.0**

4.4.3 Awareness on irrigation and use of industrial fertilizers and pesticides

Respondents were asked whether farming irrigation was one of their activities and where they got water. The findings revealed that 44% of the respondents got water for irrigation from rivers; 34% of them got water from wetlands; 12% of the respondents got water from canals; and 10% of the respondents got water from wells. The respondents were also asked whether they used industrial fertilizers and pesticides. Twenty seven percent (27%) of them said no while 73% said yes. The respondents were also asked how often they used fertilizers and pesticides. Twenty seven percent (27%) of them used those agro-chemicals

more frequently; 48% of them used them moderately; and 25% did not use them (Table 17).

Focus group discussants discussed about effects of applying fertilizers in their farms. It was found that the common types of fertilizers used for crop production were Urea, CAN, SA, TSP and DAP. Industrial fertilizers were said to have affected the land and water resources. Therefore, the findings showed that respondents' perceptions and knowledge on industrial fertilizers use in farms were also energetic by several factors that influenced them to participate in water conservation activities at their areas. These findings are similar to those reported by IPPC (2007).

Experiences from interviews indicated a general awareness in the study area that climate change and variability had been a reality in the area. Most rural farming communities in Tanzania are aware of climate variability and have risk compassion methods, for example multing-cropping and inter-planting of many variabilities etc (Kangalawe *et al.,* 2007). The traditional rain–fed subsistence agriculture is extremely vulnerable to changing climatic patterns, especially from shifts in conditions in growing seasons.

Key informants in the study area perceived climate change depending on the level of education, livelihood activities, location and age. Through focus group discussions, it was realized that much of the concerns regarding changes in temperature had occurred during the previous 10 years.

Table 17: Awareness on irrigation and use of industrial fertilizers and pesticides

If irrigation is one of your activities, where do you get water?	Percent
River	44.0
Always available from wetland	34.0
Canal	12.0
Well	10.0
Total	**100.0**
Uses of industrial fertilizer and pesticides	
No	27.0
Yes	73.0
Total	**100.0**
How often you use fertilizer	
More frequently	27.0
Moderate	48.0
Don't use	25.0
Total	**100.0**

4.4.4 Scores of likert scale knowledge on impact of climate change on water resources in percentage

In order to determine the knowledge of respondents about impact of climate change on water resources, an index scale was developed using a list of statements presented in Table 18. For each variable, "strongly agree" or "agree" response was given a value of 1, which indicated high perception while "uncertain", "disagree" or "strongly disagree" response was given a value of 0, which indicated low perception. In this case, an index scale whose points ranged from 27 to 46 was used to determine respondents' knowledge on impact of climate change on water resources. A summary of the respondents is presented in Table 18. The knowledge levels were categorized into low, medium and high. Scores of 27 to 35 were considered as low knowledge; 36 to 37 were considered as medium knowledge; and 38 to 46 scores were considered as high knowledge on impact of climate change on water resources.

Table 18: Score of scale likert knowledge on climate change on water resources

Score	Frequency	Percent
27.00	1	1.0
29.00	2	2.0
30.00	2	2.0
31.00	1	1.0
32.00	3	3.0
33.00	1	1.0
34.00	10	10.0
35.00	3	3.0
36.00	10	10.0
37.00	13	13.0
38.00	13	13.0
39.00	14	14.0
40.00	9	9.0
41.00	3	3.0
42.00	5	5.0
43.00	5	5.0
44.00	1	1.0
45.00	3	3.0
46.00	1	1.0
Level of knowledge of on climate change on water resources		
Low	10	10.0
Medium	35	35.0
High	67	67.0
Total	**100**	**100.0**

4.4.5 Levels of awareness about impact of climate change on water resources by sex

The levels of awareness on impact of climate change on water resources by sex shows in Fig.7. Women and men had the same levels of awareness. About 67% of the respondents had higher awareness on impact of climate change and 33% had low awareness. One-third (33%) of the respondents had low awareness because their income depended on water, and they had no alternative ways.

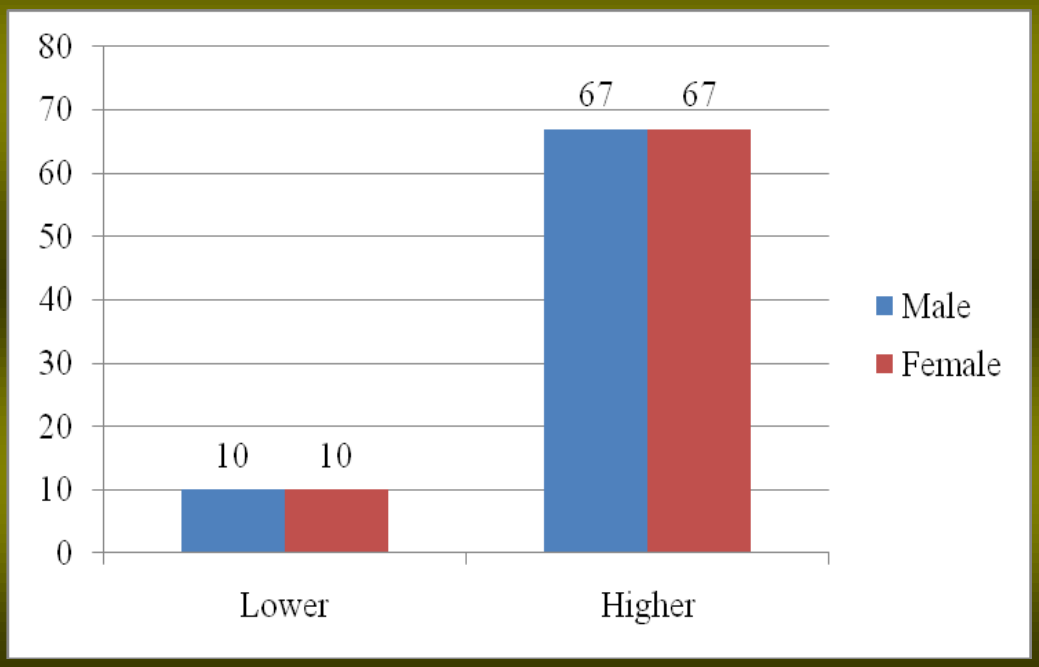

Figure 7: Levels of awareness on impact of climate change on water resources

4.5 Measures Taken by Communities on Impact of Climate Change on Water Resource in Temeke Rural District

4.5.1 Community measures towards conservation on water resources

The respondents were asked a series of questions, which aimed at assessing the water community measures towards conservation of water resources. Descriptive analyses of respondents' awareness on measures taken for water conservation are presented in Table 19. The respondents were required to state "yes" or "no" for each of the statements that was read to them. The results on index scale showed that the respondents were knowledgeable about water resources conservation. About 78.7% of the respondents agreed that water resources must be protected through planting trees and grasses; 62.7% did not dig near the source of water; 73.3% didn't cut trees; 90.3% said that use other energy sources instead of firewood and charcoal; 77.3% said practice of crop rotation; 13.3% didn't use industrial fertilizers; 20% didn't live near the source of water sources; 78.7% didn't cut firewood; 13.3% didn't dig sandstone and quarry; 66.7% learned other

new ways of water conservation; 8% used traditional ways of water conservation; and 4% didn't know.

The findings revealed that respondents were aware about the root causes of water destruction in the study area, and they were practising water management. Local people were very familiar with impact of climate changes in their places. They were strongly aware of the impact of climate change on water resources and had clear opinions about the climate changes in seasons, especially depending on rainfall patterns, temperature and the intensity of climate events like drought and floods. This result corresponds with what Maganga (1998) reports arguing that community members use indigenous methods to manage water resources, for example mixed cropping, early planting, farming in wetlands , early maturity/drought resistant crops, change of crop types, increase of farm size, agro-pastoralism, weather forecast/outlook, farm implementation, water exploitation and storage and food storage methods. The result concurs with Kagya (2002) who similarly observed that people with formal education stood a better chance of adopting new technologies for planting trees provided they have access to necessary resources**.**

During focus group discussions, discussants said that climate change adaptation policies need to be integrated into long-term planning for sustainable development and poverty alleviation policies, also reconcile short-term needs with long-term goals Furthermore, they said to promote indigenous/local technologies so as to understand local livelihoods, vulnerabilities and climate-livelihood interactions

Table 19: Index scale for respondent's responses to conservation on water resources

Item	Yes	No
Planting trees	78.7	21.3
Don't dig near the water source	62.7	37.3
Don't cut trees	73.3	26.7
Use other energy source instead of firewood and charcoal	90.3	9.3
Crop rotation	77.3	22.3
Don't use fertilizer	13.3	86.7
Don't live near the water sources	20.0	80.0
Don't cut firewood	78.7	21.3
Don't dig sandstone and quarry	13.3	86.7
Learn new ways of water conservation	66.7	33.3
Use traditional ways of water resources conservation	8.0	92.0
Does not know	4.0	96.0

Focus group discussion, discussants said that rainfall decreased in their areas. Therefore, community must know how to manage water resources. This result was similar with (Low, 2005) who argued that measures of decreasing areas rainfall may include adjusting water management so as to increase source of water supply, improve distribution and conserve available water. The National Water Policy of 2002 is the leading tool for activities in different levels of water resources management. The policy emphasizes the prioritization of water uses, hence ensuring the social and economic activities as well as environmental services so as to increase sectoral productivity. Recognizing that water is a basic human necessity, the policy gives priority to adequate quantity and acceptable quality for all (URT, 2002a).

Furthermore, focus group discussants indicated that people had the perception and knowledge on water resources but there was still a gap in practice. This involved social, economic, organizational, policy issues and technical factors. Water stress and the

pressing need to renegotiate inter-sectoral allocation are usually factors that force changes in the way water conservation knowledge about water resources is important, but it must be coupled with openness to implement appropriate prevention strategies on issues that are related to water resources. Consequently, the notion of measures taken against to climate change is seldom regarded as a high priority by governments and individuals, and thus loses out in terms of funding and institutional support (Barker *et al.*, 2000).

Therefore, respondents indicated a high level of knowledge about water resources conservation. Similar observations were made by IPCC (2008) who argued that increasing human economic activities among people results in high risk of water resources destruction. In Tanzania, 98% of the population in the rural areas depend on firewood for cooking (NBS, 2004). Key informants explained that community and government must take measures to mitigate impact of climate change on water resouces by using traditional and new technologies such as water exploitation methods, water storage methods (rain harvesting) and water management and planning.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the findings and objectives of the study on perception community on the impact of climate change on water resources, it is concluded that the respondents were much aware of the factors that affect water resources in Temeke Rural District. The respondents said that the average temperature had increased as compared to the previous years and amount of rainfall had decreased in the recent two decades as a result of changes in rain seasons. Therefore, it is concluded that the human socio-economic activities such as agriculture, settlements, industrial activities, cattle grazing, and sandstone affected water resources.

Based on the findings of the research, which showed that the majority of the respondents had settled in the study area since 1950 to 2007 and 64% of the respondents said that crop production for the previous ten years had decreased, it is concluded that community members were much aware of the impact of climate change on water resources by using weather parameters such as temperature, rainfall, wind and humidity. The impact of climate change caused extreme events such as drought in 1984, low rainfall in 1996, and floods in 1997/98 in the area. Chemicals and oils from textiles and industries had polluted water resources, especially rivers Kizinga and Mzinga and the Indian Ocean The majority of respondents had perception that water shortage was linked to climatic changes and knew when the problem had started and the causes.

On the basis of the findings which showed that Community were aware about impact of climate change and water resource by looking at their natural surroundings` appearance at

the first time up to the time of this research such as natural bushes, tall grasses, trees, animals and birds and coverage of wetlands, which had decreased, it is concluded that community members had awareness on water availability and its uses in the area. Generally, respondents were using more than 10 to 21 buckets of water per day for domestic purposes. Community had awareness on irrigation and use of industrial fertilizers and pesticides. Therefore, respondents used different industrial fertilizers in farms which affected the land and water resources.

Since after water scarcity occurred because of natural events and human socio- resources conservation by planting trees and grasses, crop rotation, digging farms far economic activities, the respondents agreed that taking various measures on water away from the sources of water, not using industrial fertilizers in their farms, harvesting rainfall, and growing drought tolerant crops would mitigate the impact of climate change on water resources.

5.2 Recommendations

From the study findings and conclusion made above, the following recommendations are drawn:

i) The government and meteorology stations must work together to inform and warn society about the impact of climate change on water resources before the impact occurs. Therefore, there is a need for the government to strengthen, expand and support short and long term plans for water conservation programmes in the area in order to reduce factors affecting water resources in early flood warning systems to reduce the losses, promote diversification of crops that consume less water and promote water conservation mechanisms such as rainwater harvesting, at household and community levels.

ii) People of rural areas of Temeke district must change human economic activities which impact negatively on the water resources by doing off-farm activities (OFAS) like local petty trade, video shows and transportation so as to increase income without degrading the environment.

iii) The Government should provide formal education from the grassroots to the national level about the impact of climate change on water resources.

iv) The Government should strengthen partnerships**.** Water programme managers need the help of many partners, including water stakeholders, community and local governments for accountability in planning, implementation and management to building trust, as effective management involves pluralistic governance.

v) Community had perception on impact of climate change on water resources but people had no other alternative ways to increase their income for livelihoods. Therefore, the government must show people other alternative places before transferring them to other places and show them appropriate strategic plans put forward to organize uses/utilization of water resources in a sustainable manner.

vi) People were aware about the impact of climate change on water resources. Therefore, the government should sensitize rural dwellers on water

management practices in rural areas by educating them by using modern technologies for water conservation.

vii) The Government should measure by mobilising communities to take measures on the impact of climate change on water resources by building capacity in financial resources.

viii) The Government must open institutional and human capacity development initiatives to prepare institutions for current and future water and related challenges.

ix) The Government and donors should find funds for researches on the impact of climate change on water resources from grassroots, regional and international levels in order to develop analytic tools which will enable community to understand and deal with impacts of climate change on water resources.

x) Government and communities must improve the social and physical infrastructure such as settlements, roads, water tanks/reservoirs etc in order to overcome the water stress in rural areas.

xi) Government and NGOs must innovate researches for developing appropriate, realistic and sustainable solutions. Research can address the key knowledge gaps about impact of climate change on water resources which are needed to implement the National Water Initiative and other water management initiatives.

xii) Communities must pay the environmental services as an incentive for improving water management efforts and for supporting sustainable ecosystems and water security.

xiii) The Government should recognize and actively promote indigenous measures like use of new technologies of irrigation and traditional farming techniques to protect watershed, crop and livelihood diversification and improved building technologies like rainwater harvesting.

xiv) The Government should formulate policies which actively involve indigenous and traditional communities in the international, regional and local on climate change on water resources; and inform people about water sectors and follow it in order to make decisions for favourable investment on the impact of climate on water resources.

xv) There is a need to develop data on climate change on water resources in order to measure the impact on water resources. Water managers need information and baseline data to understand how climate change is altering the water resources and inform long-term planning.

xvi) The Government should plan for extreme water events in order to cope with community-based disaster risk reduction resulting from climate change on water resources including storms, excess of water and lack of water.

xvii) The Government, stakeholders and community should work with the water industry to ensure that climate change impacts and risks are incorporated in water resources and infrastructure planning and management including assessing the implications of changes in extreme rainfall events for water infrastructures.

xviii) The Government should educate people to understand the impacts of climate change on water resources and methods and approaches to integrating climate change related risks into water management interventions. Also, water experts should educate rural dwellers on the impact of climate change on water resources in order to increase watersheds sustainable and resilience**.** Many elements of a "watershed approach" will increase the resilience of watersheds to climate change and increase the sustainability of aquatic systems.

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APPENDICES

Appendix 1: List of key variables and operational definitions

VARIABLES	OPERATIONAL DEFINITIONS
DEPENDENT VARIABLES	
Sustainable Development	Development which capable of continuing for long time at the same time.
INDEPENDENT VARIABLES	
Community	Group of people in a large society who are came in same way.
Perception	Particular way of understanding thing quickly and easily.
Climate	It is the synthesis of the day-to-day weather conditions in a given area
Climate change	Climate change is a long significant change in the average wealthier of a region or of the earth as a whole.
Water management	It is process that involves the use, control and accessibility of water for a desired end-use.
Water sources	The sources of water, which are useful or potentially useful to humans. They include oceans, seas, lakes, dams, rivers, wells, springs and rainfall.
BACKGROUND VARIABLES	
Age	Number of years of the stakeholder
Family economic status	Index of family assets and housing condition
Occupation	Any work/profession of a respondent
Sex	Male or female in population

Appendix 2: Questionnaire on community response on the impact of climate change on water resources

A: General Information

Date	
Name of division	
Name of ward	
Name of Municipality	
Interviewee number	

B: Interviewee information

Gender	**Age**	**Originality**	**Marriage status**	**Education**
1=Male		Region	1=Married	1=Not been to school
2=Female		Municipality	2=Unmarried	2=Primary school.
		Tribe	3=Widowed	3=Secondary school
			4=Divorced	4=college
Working status and type (occupation)				5=University
1=Farming		Household size		
2=Livestock		1-3 people		
3=Business		4-6people		
4=Paid employment		7-10		
5=Others (specify)…		+10		

C: Research information

1. When did you establish in this area? (State year) ( )

2. Where were you born?

i) within the village

ii) within the ward

iii) within the district/Municipality ( )

iv) within the region

v) outside the region

3. If it is outside the village/ward where were you born?

Date of birth	Place of birth

4. Which reasons made you to establish in this area?

i) Fertility of the soil/agricultural purposes

ii) Availability of grazing land and pasture

iii) Migration due to marriage ( )

iv) Close my the working place/employment

v) Following parents/relatives

vi) Lack of land in other area

vii) Availability of water

viii) Other reasons, (please specify).....

5(a) Do you own some plot(s)?

1. YES ( ) 2. NO ( )

5(b) If YES, how did you acquire the plots?

i) Through buying

ii) Through a friend/relative (free of charge)

iii) Inheritance

iv) Official procedure ( )

v) Other reasons, please mention.....

5(c) If NO, how did you get access to land?

i) I am employed here

ii) I have renter the place ( )

iii) Other reasons, please mention.....

6. What is the size of your plot(s)/house(s)

i). Less than one hectare or acre

ii). Between one and five hectare or acre ( )

iii). Between six and ten hectare or acre

iv). Over ten hectare or acre (please specify)

7. What is the trend of production for the last 10 years?

i) Increasing

ii) Constant ( )

iii) Decreasing

8. If it is decreasing what are the reasons

i) Drought

ii) Floods ( )

iii) Land degradation

9 What was this area looking like at the first time of your establishment?

i) Natural with bushes, tall grasses, animals, trees and birds

ii) Natural with bushes, tall grasses, animals and trees

iii) Natural with trees, tall grasses and birds

iv) Natural with tall grasses and trees ( )

v) Village settlement

vi) Already developed for agriculture

vii) All of the above

viii) Others (please specify)

10. What can you say about the coverage of the wetlands/swamp/valley bottom; is it still the same as to when you first established here?

i) It is decreased in size

ii) It has expanded ( )

iii) No change

iv) Others (please specify).....

11. How would you describe the level of encroachment since you first established here?

i). High

ii). Moderate ( )

iii). Low

Others (please specify).....

12. What do you think is the major activity in this area?

i). Rain fed agriculture

ii). Irrigated agriculture

iii). Fishing ( )

iv). Livestock

Others (please specify).....

13. Do you cultivate some crops?

1. YES 2. NO ( )

14a). If YES, which cropping system do you practice?

i). Monoculture.

ii). Mixed cropping ( )

iii). Shifting cultivation

b) If irrigation is one of your activities, where do you get water?

i). River

ii). Always available from wetland

iii). Canal ( )

iv). Groundwater well

v) Others (please specify).....

c) If it is river or canal, please give the name and the distance from the main source……

15. Which crops are grown in this area during dry season? (Please put a tick)

i) Rice ( )

ii) Maize ( )

iii) Groundnuts ( )

iv) Cassava ( )

v) Yam ( )

vi) Tomatoes ( )

vii) Vegetables (specify) ( )

viii) Others (please specify) . ( )

16a) Do you use industrial fertilizers or pesticides?

1. YES ( ) 2. NO ( )

16b) If YES, please mention the type of fertilizers and pesticides you are using

i). ……

ii). …….....

16c) How often you apply fertilizer?

i) More frequently

ii) Moderate ( )

iii) Others (please identify).....

17a) How many households were occupying this area originally?

……

17b) Is number of household (population) in the area increasing or decreasing?

i). Decreasing

ii). Increasing ( )

18. Which activities you do to increase your income?

i) Charcoal

ii) Building poles

iii) Firewood ( )

iv) Agriculture

v) Livestock

vi) Others (specify).....

19(a) Do you think your activities are affecting wetlands?

1. YES ( ) 2. NO ( )

19 (b) If YES how? and if no, why do you think so?

i). ……

ii). ……..

20. Which activities do you think affect wetland most?

i) Agriculture

ii) Settlement ( )

iii) Cattle grazing

iv) Others (please specify) …….....

21 Why do you think so and how? (Please explain)

i). ……

ii). ……...

22. What problems and constrains you are facing since you established in this area?

i). ……

ii)……

23. Have you noticed any changes that are directly related to the utilization of this wetland area?

1. YES ( ) 2.NO ( )

24. If YES, what are the changes? (Please list)

i). ……

ii)……....

25. Do you think it is wise to leave this area without any use?

1. YES ( ) 2. NO ( )

26. Please explain why you think so?

i). ……....

ii). ……...

27. How do you perceive the idea of leaving this wetland area?

……

D: Water related issues

1. What types of water resources are available in your home area?

i) Lake

ii) River ( )

iii) Pond

iv) Groundwater

2. What type of water is used in the area?

i) Taped

ii) Untapped

iii) Boreholes ( )

iv) Others (mention).....

3 How much water do you use for your family per day? Or how many buckets?

i) 0-10

ii) 10-20 ( )

iii) More than 20

4. What are the uses of water resources in your home?

i) Domestic purposes

ii) Agriculture purposes ( )

iii) Commercial/ industrial purposes

5. Does this ward have the problem of water shortage?

a) YES ( ) b) NO ( )

b) If YES please describe this problem.

……

6. Is the problem of water shortage linked to climatic changes? eg due to long periods of

a) YES ( ) b).NO ( )

7. If YES since when and what are the causes?

YEAR	**CAUSES**

8. What are you doing to address this problem of water?

……

……

……

Appendix 3: Index scale for measuring awareness towards water resources

Statements on awareness of water resources	Yes	No
Discussion about water resources in community is good practice		
Water resources is not valued in the community		
Knowledge of water resources is useful in individual life		
Attitudes towards the use of water resources in the community		
Culture is one of the ways of destructing water resources in the community		
Media have contributed to better understanding on water resources		

Appendix 4: Likert scale of knowledge of climate change on water resources

Items	**Yes**	**Don't know**	**No**
Through planting trees			
Through planting grasses			
By leaving near the source of water			
By dig farms far away from the sources of water			
Don't use industrial fertilizer			
Don't settle near the source water resources			
Others			

Appendix 5: Likert scale for perception towards the impact of climate change on water resources

Let us now discuss about your attitude towards the impact of climate change on water resources. Say whether you strongly agree, agree, uncertain, disagree and strongly disagree on each statement.

No	Statement	S/agree	Agree	Uncertain	Disagree	S/disagree
1.	Water resources are fundamental to living things.					
2.	To cultivate near the source of water can cause water availability					
3	To transfer people from near the source of water resource is good idea					
4	To leave the habit of burning charcoal and use fire					
5.	Livestock activities near the source of water can cause water availability.					
6.	Protection of water is your responsibility					
7.	Protection of water is the government responsibility					
8.	Climate change is source of water scarcity.					
9	Climate change have caused by human economy activities					
10	Urbanization and fishing activities can affect water resources					
11	There are some effects of climate change on water resources					
12	There is regulation and policies which concerned on water resources					

Appendix 6: Focus group discussions questionnaire

(i) A guide for water resources

Have you ever heard anything on water resources?

Do you know, what are the water resources?

Have you ever seen source of water resources?

Do you know any types of water resources?

(ii) Description of causes and effects of water resources

Do you know any causes of water resources?

Do you know any type of water resources?

Which factors are affecting water resources?

Does culture of the community support water resources destruction?

(iii) Description of Water Resources Conservation

Have you ever heard about water conservation?

Have you practice any way of water conservation?

Have you exposed to any kind of training\seminar\meetings on water resources conservation?

What are the problems encountered on implemented of the conservation of water resources?

(iv) Community`s Perception towards Water Resources

What are the main problems affecting awareness of people towards water resources?

Which factors influencing people's perception towards water resources? Suggest ways for overcoming those factors influencing people's perception towards water resources.

Appendix 7: Key informant questionnaire

Name: …….....

Gender: (1) Male (….) Age:

(2) Female ( ) Nationality: ……

Region: ……..... District: ……

Education: ……..

Profession: …….

1. What are you doing to address the problem of water?

……

2 Have you practice any way of water conservation? If YES explain it.

……

3 What are the problems encountered on implemented of the conservation of water resources?

.....

4. What strategies are used to cope with that problem?

……....

5 Does culture of the community support water resources destruction?

……

6. Have you exposed to any kind of training\seminar\meetings on water resources conservation in that area? If yes when?

……....

7 .Suggest ways for overcoming those factors which influencing people's perception towards water resources:

.....

.....

.....