RURAL WOMEN ACCESSIBILITY TO WATER RESOURCES AND THEIR RESILIENCE TO THE RESOURCES VARIABILITY: CASE STUDY OF MUHEZA DISTRICT, TANGA REGION

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ABSTRACT

The geographic location, landscape nature and hydrology make Muheza District the base catchment for Tanga, Korogwe, Pangani and Handeni Districts. Considering this, the study on how rural women in the face of climate change and anthropogenic activities on one hand, and national water policies and the Millennium Goals on the other, access water resources and manage its variability was executed. The district was represented by five purposefully selected villages namely, Kwelumbizi, Kizerui, Misalai, Kazita and Mgambo during the study conducted from December 2017 to April 2018. The study used *Escherichia coli* and total coliform as biological indicators of water quality whereas pH, and total dissolved solids and temperature were used as chemical and physical indicators of water quality, respectively. Biological data were collected by growing both *Escherichia coli* and total coliform from 216 water samples in the Incubator dgtl w/auto for twelve hours under 3MTMPetrifilmTM coliform count plates subjected to 44^{o}C and 37^{o}C, respectively. Colonies grown were counted by VHX Digital Microscope while pH was measured using digital ODM pH meter, and total dissolved solids measured using Mettler Toledo's TDS meter. The social aspects were collected using a combination of three techniques: questionnaire surveys, interview with key informants and focus group discussions. The findings indicated that communities face a number of constraints related to water collection especially during dry seasons, including low quality water as exhibited by unacceptable levels of coliform bacteria and pH level for acidic water. This study underscores the fact that sustainable utilization of water resources in Muheza Rural District is necessary as its hydrology is vital to the neighboring districts in Tanga Region and Tanga Municipality. Conducting another study to assess whether communities may have been affected by the coliform bacteria and whether the acidic water could have or may affect community healthy in the future is recommended.

DECLARATION

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

______________________ ______________________

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LIST OF ABBREVIATIONS AND SYMBOLS

AfDB	African Development Bank
CWSO	Community Water Supply Organizations
EC	European Commission
EWURA	Energy and Water Utilities Regulatory Authority
FAO	Food and Agriculture Organization of the United Nations
GDC	German Development cooperation
iWASH	Integrated Water Supply Sanitation and Hygiene
IEG	Independent Evaluation Group
IPCC	Intergovernmental Panel on Climate Change
MCC	Mongolia Water Compact
MDG	Millennium Development Goals
MKUKUTA	Mkakati wa Kukuza Uchumi na Kupunguza Umaskini Tanzania
NGO	Non-governmental Organization
ODK	Open Data Kit
OECD	Organization for Economic Co-operation and Development
ONGAWA	Organización No Gubernamental
PRSC	Poverty Reduction Strategy Credit
TAWASANET	Tanzania Water and Sanitation Network
TDS	Total Dissolved Solids
TFCG	Tanzania Forest Conservation Group
TMA	Tanzania Meteorological Agency
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization

UN-DCP	United Nations Drug Control Program
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WADA	Water and Development Alliance
WHO	World Health Organization
WSDP	Plymouth-Canton Educational Park

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Water quality is intrinsically linked with human health, poverty reduction, gender equality, food security, livelihoods, the preservation of ecosystems as well as economic growth and social development of societies (UNESCO, 2015). There is an extensive crisis on water in many parts of the world that is affecting the well-being of millions of the poorest people (OECD, 2012). This has been accelerated by the rapidly growing populations, urbanization, agricultural intensification, the loss of trees to land clearance, soil erosion and climate change (Aureli and Brelet, 2004).

Water is a very important component to the livelihoods and well-being of the world's population (IEG, 2010). Therefore, improving water supply management is seen as centrally important to poverty alleviation and to ensuring a sustainable future for millions of people with vulnerable livelihoods in marginal environments (IEG, 2010). From the United Nations reports (United Nations, 2011), 1.1 billion people, which means one in six of the world's population lack access to improved drinking water, and 2.4 billion lack sanitation. As a result, the burden of deaths and diseases related to unclean and yet inadequate water supply is high, with an estimated mortality of 3 million people a year, and millions more suffering from water-borne diseases (United Nations, 2011).

Water scarcity and stress affects many regions (Schultz, 2001) and people who are most affected by water scarcity are those living in the remote rural areas in Africa and most of these countries are in Sub-Saharan Africa (Ravenga and Cassar, 2002). Rural women are the ones most affected by water regime as they are more responsible for water-related duties (SASS, 2002). When there is water scarcity, women normally travel long distances in search of water (Cook *et al.,* 2016). Sometimes school girls helping their mothers end up dropping out of school and this has some implications for low literacy levels among women in Africa (Hart, 2008). For years this was not a problem as people used to move to other sources of water during the dry season, but due to rapid population growth, climate change and environmental degradation, migratory lifestyle is totally impossible (Garden-Outlaw and Engelman, 1997). Tanzania is one among the sub-Saharan countries and is equally affected by water scarcity problem (Mwingira *et al.,* 2011). Various efforts have been deployed in Tanzania since 1961, yet the problem remains prominent in most of its parts (Graham *et al.,* 2016).

The Government of Tanzania has embarked on a major sector reform process since 2002. It has created an ambitious National Water Sector Development Strategy that promotes, integrates water resources management and the development of urban and rural water supply. The strategy was adopted in 2006 where water management was decentralized (Wandiga *et al.,* 2010). Decentralization has meant that responsibility for water and sanitation service provision has shifted to local government authorities as well as owned by Community Water Supply Organizations (CWSO). These reforms have been backed by a significant increase of the budget starting in 2006 when the water sector was included among the priority sectors of the National Strategy for Growth and Reduction of Poverty (MKUKUTA) (UN, 2016).

Unfortunately, the Tanzanian water sector remains heavily dependent on external donors: 88% of the available funds are provided by external donor organizations who are the African Development Bank (AfDB), European Commission (EC) and German Development Cooperation (GDC). Other donors are the United States Agency for International Development (USAID/Tanzania), Integrated Water Supply Sanitation and

Hygiene (iWASH), Water and Development Alliance (WADA), partnership between three Institutions namely USAID, Coca-Cola Company and World Bank (Wandiga *et al.,* 2010). Tanzania Forest Conservation Group (TFCG) and Organización No Gubernamental (ONGAWA) have also been providing funds for water projects (Wandiga *et al.,* 2010).

However, despite the massively increased provision of water facilities over the past few decades and heavy investments brought in by the different actors, the utility serving to different parts of Tanzania has remained one of the worst performing water entities in Africa (Water Aid, 2010). The development of low-cost and unsustainable technical solutions to many aspects of water provision has left millions still suffering from water-related diseases. Lack of access to clean water, inadequate water for food production, walking relatively longer distances, pollution, environmental change; physical, social and economic burdens associated with water scarcity still put pressure to its people (Graham *et al.,* 2016). According to Ban Ki-moon, UN Secretary-General (2014), "safe drinking water and adequate sanitation are crucial for poverty reduction, crucial for sustainable development, and crucial for achieving Millennium Development Goals." Based on the above background, understanding how much the efforts gave way to a better life to local community members is necessary.

1.2 Problem Statement and Justification

Access to water and sanitation remains low in Tanzania (WHO/UNICEF, 2012). However, determining data on access is particularly difficult (FAO, 2010), which results in significant discrepancies (World Bank, 2006). In 2015, 50% of the population in Tanzania had access to basic water, 39.5% and 10.5% of urban and rural areas, respectively (UN, 2016). Regarding accessing quality water, only 24% of the Tanzanian population had access to quality water, 17% and 7% of urban and rural areas, respectively (UN, 2016).

The national standard for water supply access is 250-people/water point with less than 10 coliforms/100 mL and the walking distance should be less than 400 m from the farthest household. Nonetheless, currently people are more than 400-people/water point and walk for an average of 500 m for water collection and water coliform counts goes beyond 200 coliform/100 mL (TAWASANET, 2009). Projections indicate that by 2025, Tanzania will experience water stress (defined as average per capita water resources below 1500 m^3) due to population growth (World Bank, 2009) and climate change (Wandiga *et al.,* 2010). Therefore, to solve this paradox, various efforts have been deployed including the National Water Sector Development Program (WSDP) of 2006-2025.

Muheza District in the Tanga Region, had 204,461 people (NBS, 2012) in 137 villages, which are served by gravity systems from sources in the rainforests that are forming the East Usambara Nature Reserve, Zigi River and 25 boreholes (World Bank, 2009). Until early 1990s, the water systems were poorly organized. Local communities did not maintain the infrastructure, water quality was poor and some systems even failed to provide any water (Wandiga *et al.,* 2010). The national water policies of URT (1991) and URT (2002), which emphasized local participation and ownership, as well as payment for water and metering, made water resources to be valued and maintained (Rosen and Jeffrey, 1999). Together with investments financed as part of the development cooperation with different donors, the new approach achieved substantial improvements (Muheza District Report, 2009). On the contrary, the same source of information (Muheza District Report, 2009) underscores that as of 2009, water supply remained questionable with some parts of the district experiencing acute water shortage.

Therefore, there is still limited understanding on how much the problem has been solved, and whether the measures taken have reduced the burden. Very few studies including Moyo (2014) have attempted to quantify the burden of water resources to women while the important aspect of access time spent collecting water has remained largely unaddressed and unexamined (Graham *et al.,* 2016) along with the aspects related to amount of water needed, and quality and quantity of water collected. Therefore, this study aimed at providing updated information on how much time is spent by communities in water collection, the distance travelled and the quality of water collected. Furthermore, the study collected information on how local community members cope and adapt to the water variability in terms of both quality and quantity, and recommend appropriate strategies.

1.3 Objectives of the Study

1.3.1 Main objective

The study sought to investigate rural women accessibility to water resources and their resilience to the resources variability using Muheza district as a case study.

1.3.2 Specific objectives

i. To assess the historical access and water availability (quantity and quality) from the perspective of women from 1987 to 2017
ii. To investigate the efforts invested and progress reached towards accessibility and management of sufficient and quality water supply
iii. To assess perceived impacts of climate change and community resilience to the variations in quality and quantity of water resources

1.4 Research Questions

The study aims at answering the following questions.

i. Where did communities collect water during the period ranging from 1987 to 2017?
ii. What are the efforts invested and progress made towards accessing and management of high-quality water services?
iii. Are communities resilient to the variations in quality and quantity of water resources?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The role of Women in African Communities

In poor and developing countries women are often charged with the task of providing critical resources, including food and water for their family (UN, 2009). For instance, in Sub-Saharan Africa East Africa and Tanzania inclusive, women are responsible for 60 to 80 percent of food that is grown (Buor, 2003). Moreover, on average, 63% of rural households depend on women to obtain drinking water for the home, and as such women in Sub-Saharan Africa spend an average of about 40 billion hours a year collecting water (UN, 2009). Since climate change decreases water availability, the amount of time dedicated to collecting water might increase, leaving girls with less time to go to school and reinforcing the cycle of poverty (Nellemann *et al.,* 2011).

2.2 Women Access to Safe Water in Low-Income Countries

Although the amount of water on the earth is constant, the amount of available fresh water is actually shrinking (Gleick, 1998) while the demands for the resource is increasing (Rogers, 2000). This is partly because many watersheds on the planet have reached a tipping point (IPCC, 2001) due to the dramatic increase in world's population in the last century. As a result, more than one billion people globally still lack access to safe drinking water (Gleick, 1998) which suggests that water is still a problem in many parts of the world. The globe is experiencing such water related problems despite now being almost thirty years after the United Nations proclaimed the 1980s to be the International Drinking Water Supply and Sanitation Decade following advancement in better and more widely available technology to pipe water directly to population centers (Wallace and Coles, 2005).

Fetching water is mostly a task for women and children; therefore, they spend considerable time supplying water to their households (Rogers, 2000) depending on household size, distance, seasons and other variables such as household income (UN-DESA, 2008; UN-DCP, 2008). However, scant research has quantified the burden of this work among women (Moyo, 2014). Only recently, under pressure from such groups as Women for Water Partnership, has the gender-specific analysis of water-related policy issues been given attention (MCC, 2010).

2.3 Tanzania Water Variability and Climate Change

Climate Change has affected the water flow and accessibility to many communities in Tanzania due to rainfall variability. More than half of the country receives on the average less than 800 mm of rain per year (URT, 2007). The seasonal changes in atmospheric circulation and precipitation associated with unequal heating of land and sea that exist in the country account for extreme temporal variability in rainfall and even more extreme variability in river flows, which finally affects the water availability (Moyo, 2014).

Tanzania's annual renewable water resources are 2700 m^3 of water per person per year (World Resources Institute 2009-2010). The current amount is 2020 m^3 per person per year (URT, 2012) and will continue to drop over time as population increases, and it is anticipated that in 2025 population will reach 62 million people (World Resources Institute, 2010). If the current rate of population growth from previous censuses are put into perspective (i.e. 10 million in 1960 and 44.8 million in 2012), the country's per capita water resources will fall below 1700 m^3 per person (URT, 2012), making Tanzania one of the water-stressed countries. Water resource is projected to become one of the most pressing environmental problems with high impacts in Tanzania (IUFRO, 2007).

Climate Change is already and will continue to negatively impact on water resources, which are so vital for Tanzania's socio-economic development. Findings already indicate changes in the hydrology of the various vital river basins in Tanzania (Schut, 2016). Muheza District is one of the areas that are prone to water stress and scarcity in the future (URT, 1997). Despite the area being in highland and full of forest vegetation and water streams, tree cutting, lumbering and wood collection severely affects the water quantity and quality (Schut, 2016).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area Description

The study was conducted in five villages located in Amani Division of Muheza District, namely Kwelumbizi, Zirai, Misalai, Kazita and Mgambo. Two of the five villages are from Zirai ward (Kwelumbizi and Kizerui and the other three (Misalai, Kazita, and Mgambo) are from Misalai ward. All the villages are located on the highlands close to the East Usambara Amani Nature Forest reserve (Figure 1). The villages experience warm and wet season characterized by two major rainfall seasons, with long rains from March to May and short rains from October to December (Schut, 2016).

Figure 1: Muheza District Map Showing Study Area

3.2 Sampling and Data Collection

3.2.1 Sampling design

The design was stratified sampling with the sub villages as strata and a proportional allocation of the sample within each stratum. Subsequently, the five villages were randomly selected within the two wards as per Traat (1999). To select households within each village, a sketch map of the village was drawn and further divided into segments (Vehovar, 1997) that were demarcated using readily identifiable features (i.e. paths/roads and/or rivers for their easy identification on the ground). This helped in having representatives from each segment without biasness. Lists of households in each sub-village was obtained from the village registers. Each household was individualized with reference and thereafter randomly selected samples of the households were obtained (Traat, 1999). Consequently, each segment had 10 % of the households (European Union, 1998) to fill in the questionnaire. Kizerui village had 23 households, Kwelumbizi village had 46 households; Misalai village had 34 households; Kazita village had 30 households and Mgambo village had 35 households; (n=168 respondents for questionnaire surveys).

On the other hand, systematic sampling was used in water resource mapping. As result, forty-eight (48) water sources and 168 households were visited and water samples for quality assessment collected following The Energy and Water Utilities Regulatory Authority (EWURA, 2014) procedures.

Water samples for assessment of water quality were collected from household versus their water sources, one sample was obtained from each household and one sample to the respective water source. Moreover, there were focus group discussions (FGDs), which involved 5-6 community members comprising different occupations, education level, sex, income, age and different leadership positions in the five villages. Secondary data on water utilities were also collected from ONGAWA head office especially on the financial assistantship. Also, village government leaders and members of conservation organizations such as ONGAWA and TFCG representatives, teachers and farmers who had stayed in the areas for at least six years were purposively selected as Key Informants (KIs) considering their leadership and life experiences (Kaswamila, 2006).

3.2.2 Data collection

3.2.2.1 Historical access to water resources and water quantity

Both closed and open-ending questionnaires were adopted to collect information on access, water quantity, ways of ensuring water accessibility as well as time spent and distance travelled to and from the water sources. With the aid of Mobile run trucker, locations on the ground of all water sources and residences of household-respondents were marked, distance traveled and time spent in water collection (i.e. time to and from water sources plus time spent collecting water) derived as a ground truthing procedure. Focus group discussions and key informants were additionally used to triangulate information obtained from questionnaires.

3.2.2.2 Water quality

The physical and biological parameters indicating water quality measured include pH, temperature, and total dissolved substances (TDS). The pH was measured using digital ODM pH-1, model txv3 pH meter while TDS was measured using Mettler Toledo's wide range of TDS meter. Biological parameters which were *Escherichia coli* (*E. coli*) and total coliform were analyzed in the laboratory. Moreover, the water samples collected from both water sources and households were cultured immediately after arriving at the field laboratory. The process involved incubating (Incubator dgtl w/auto) the water samples for a maximum of twelve hours under 3MTMPetrifilmTM coliform count plates at 37^{o}C, and

$44^{o}C$ for the growth of Total coliform and *E. coli* respectively, and colonies counted with the aid of the VHX Digital Microscope (EWURA, 2014).

3.2.3 Efforts and progress towards accessibility and management of water quality

Both closed and open questionnaires were used to collect information on efforts (infrastructure development, and time spent) invested in water projects, progress made by the local, national or international organizations towards improving access to water and ensuring adequate and safe water supply, whereas secondary data from ONGAWA were used to collect information on financial inputs used on water projects. In addition, current status on accessibility, distance to water sources and number of households/users per water point were recorded to serve as further indicators of the various strategies and progress of the water component of MDG target 7c, and the National WSDP.

3.2.4 Perceived impacts of climate change and communities resilient to the variations in quality and quantity of water

Both closed and open questionnaires were used to collect information about key water resilience issues and identify potential opportunities for intervention. The study collected information on how communities, NGO's and government are prepared towards adaptation, coping strategies to water fluctuations, declining water quality, and potential coping/adaptation strategies. Key informants and focus group discussions were used to collect the information on adaptation/coping strategies to water fluctuations, water quality, and potential coping/adaptation strategies. Rainfall data for 30 years (1987 – 2017) were also collected from TMA depository, in order to assess the rainfall variability and change over time.

3.3 Data Analyses

3.3.1 Historical access, quantity, and water quality

Computation of mean distance from households to water sources as well as mean time spent collecting water was done onsite. Amount of water collected was computed as the mean number of 20-litre buckets per day per household. The information enabled comparative assessment between villages (Rickards *et al.,* 2012).

3.3.2 Measurements for quality of water

Escherichia coli, total coliform, pH, total dissolved solids and temperature were used as indices for quality of both households and water sources. Subsequently, One-way Students T-test was used to test whether the quality of water from water source differed significantly from EWURA standard whereas repeated ANOVA was used to test whether there were any significant differences in water quality within and between villages. Also, separate ANOVA (*i.e.* TukeyHSD multiple comparisons of means) was performed to identify villages with statistical differences for the indices that showed significant differences. Using the same water quality indices, paired T test was used to test whether the quality of water from water sources differed significantly from those of households. Moreover, Pearson correlation was used to discriminate related and unrelated water quality variables. All analyses were conducted via R Statistical Package, version 3.4.3. (Rickards *et al*., 2012).

3.3.3 Efforts invested and progress reached towards accessibility and management of sufficient and quality water supply

Paired T-test was used to investigate whether there were any significant differences between the current distance walked by communities to water sources and the distance to be travelled after materialization of the project. Time taken to collect water could not be compared as project water sources are not yet functional.

3.3.4 Perceived impacts of climate change and communities resilient to the variations in quality and quantity of water

Likert scale was used to clarify the most prominent perceived impact on climate change and the counter strategy the communities are putting in place. Data on rainfall for 30 years were used to explain the trend over the years (Rickards *et al.,* 2012).

CHAPTER FOUR

4.0 RESULTS

4.1 Historical Access to Water Sources and Water Quantity and Quality

4.1.1 Access to water sources and water quantity

Evaluations indicated that all five villages were still using their traditional water sources with an exception of one sub-village namely, Barabarani in Misalai village whose community members use water tape network. As result, households in the sub-village walk a return trip (distance to and from the water point) of an average distance less than 50 m (11 to 79 m), and on average collect 5 buckets (20 litres) of water per day, each bucket demanding an average of 6 minutes (time to and from water point plus time used in water collection; n = 30 minutes for the 5 buckets in a day). The communities in the rest of the villages move an average distance of 171.7 m (return trip) to collect a bucket of water, and each household is able to collect an average of 11 buckets per day, spending 20-minutes per bucket during rainy season (n = 220 minutes), and more time i.e. 34 minutes per bucket during dry season (n = 374 minutes). Therefore, 3.7-6.2 hours are spent daily in water collection.

4.1.2 Water quality

The level of *E. coli* in water samples from various water sources and households were significantly higher than EWURA value ($t = 16.33$; $df = 160$; $p = 0.000$) as the water samples had an average of 60.6/100 ml compared to EWEURA standard, which is 0/100 ml. Similarly, total coliform in samples from the same water sources and households were significantly higher than the EWURA standard ($t = 23.65$; $df = 162$; $p = 0.000$) with the water samples attaining an average of 109/100 ml compared to EWURA values, 0-3/100 ml. Moreover, the pH values for 49% of the household water samples was below 6.5

(Figure 2). Likewise, pH for 62% of water samples from water sources fell below the standard (Appendix 1).

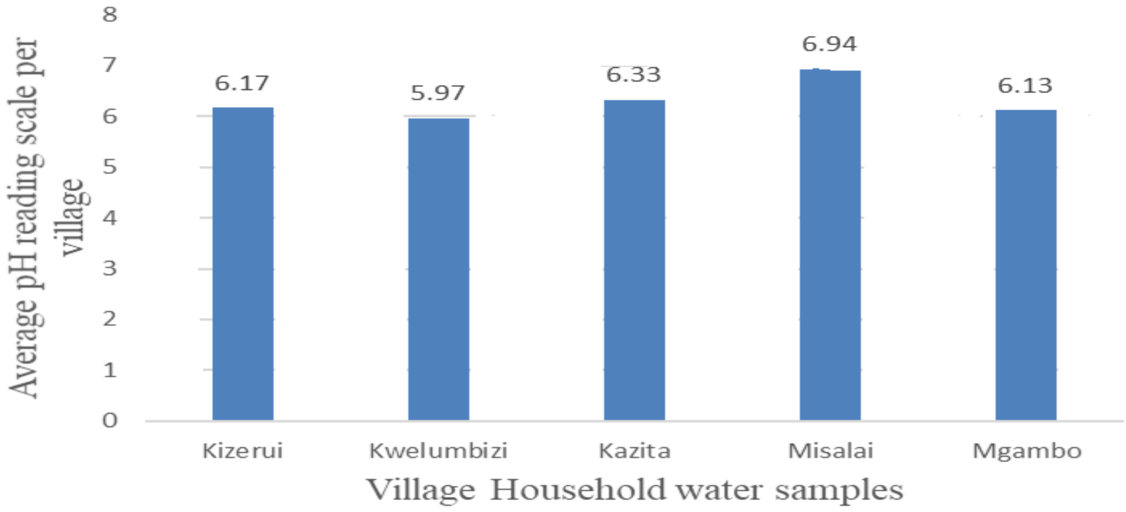

Figure 2: A bar chart indicating the average pH values for water samples for each village. EWURA water standard (Tanzania standard) for people's consumption pH values ranges from 6.5 – 8.5.

Temperature and total dissolved solids for water samples from the water sources were in agreement with the EWURA standards, which means they fell within 20-35^{O}C and 100 mg/L for total dissolved solids, respectively (Appendices 2, 3 and 4).

In order to see if there was any significant difference between household and water sources in terms of water quality, One-way ANOVA analysis was conducted, but no significant statistical difference was observed for *Escherichia coli* and total coliform within villages, but differed significantly between villages (Table 1). Also, pH, TDS and temperature differed significantly both within villages and between villages (Table 1).

Table 1: Repeated ANOVA table indicating the parameters tested and their values.

Parameter tested	Within villages			Between villages		
	F	df	p-value	F	df	p-value
E. coli	1.160	160	0.174	21.410	160	0.000
Total coliform	1.168	160	0.163	10.396	160	0.002
pH	5.789	160	0.000	56.096	160	0.000
TDS	2.528	160	0.000	7.913	160	0.006
Temperature	2.788	160	0.000	206.807	160	0.000

TDS = Total dissolved solids

Additionally, Tukey multiple comparisons of means was used to identify the between village sources of variation in household water quality (Table 2). *E. coli* differed significantly between Kwelumbizi, Kazita, Mgambo and Misalai against Kizerui.

Table 2: Variation of water quality between villages

Villages	*E. coli*	Total coliform	Temperature	pH	TDS
Kizerui-Kazita	p=0.000	p=0.003	p>0.05	p=0.04	p=0.03
Kwelumbizi-Kazita	p>0.05	p>0.05	p>0.05	p=0.000	p>0.05
Mgambo-Kazita	p>0.05	p>0.05	p>0.05	p=0.000	p>0.05
Misalai-Kazita	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05
Kwelumbizi-Kizerui	p=0.000	p=0.000	p>0.05	p>0.05	p>0.05
Mgambo-Kizerui	p=0.000	p>0.05	p>0.05	p>0.05	p=0.000
Misalai-Kizerui	p=0.000	p=0.005	p=0.04	p>0.05	p=0.000
Mgambo-Kwelumbizi	p>0.05	p=0.02	P=0.05	p>0.05	p=0.000
Misalai-Kwelumbizi	p>0.05	p>0.05	p=0.003	p>0.05	p=0.000
Misalai-Mgambo	p>0.05	p>0.05	p=0.01	p=0.03	p>0.05

Also, multiple linear regression analysis indicated a positive correlation between *Escherichia coli* and Total coliforms; TDS and pH; and TDS and *Escherichia coli*, but negative correlation between pH and temperature. In this case any rise of Total coliform caused the rise of *Escherichia coli* while any rise of temperature caused the fall of pH values. Also, an increase in total dissolved substances caused the fall in pH while the rise of Total dissolved substances caused the increase in *Escherichia coli*. However, there was no correlation between temperature and growth of either *Escherichia coli* or Total coliform (Table 3).

Table 3: Correlation analysis between parameters measured within households (all villages pooled together

Parameters tested		Statistic		
Parameter 1	Parameter 2	R	P-value	Significance
Escherichia coli	Total coliforms	0.72	0.0001	***
pH	Temperature	-0.35	0.0001	***
TDS	pH	0.17	0.01	**
TDS	*Escherichia coli*	0.21	0.001	***
Temperature	*Escherichia coli*	0.051	>0.05	N.S
Temperature	Total coliforms	0.077	>0.05	N.S

*** significantly different (P < 0.001), ** significantly differently (P < 0.01) and N.S not significantly different (P > 0.05).

According to the results, 98.8% of respondents did not treat their drinking water. Moreover, 69.4% of respondents had perception that the government/water service providers were responsible for ensuring good quality of water while only 30.6% were of opinion that the issue of water quality was household responsibility.

4.2 Efforts and Progress Towards Accessibility and Management of Water Quality

The study revealed several efforts that have been invested towards ensuring accessibility of high quality and sufficient quantity of water. The efforts include provision of water at the closest range and maintaining quality of water both at the source and household as presented in section 4.2.1 and 4.2.2.

4.2.1 Provision of water at the closest range

As communities were moving relatively long distances across gorges, ONGAWA and TFCG had introduced a piped water project to supply eight villages so as to reduce the walking distance and time spent collecting water. In the course of the project implementation, representatives from households spent 16 hours per week hence 64 hours per month for a period of eight months (n = 512 hours) working on voluntary basis towards making water available at the closest range possible. This time was used for digging tunnels, gathering building materials such as stones, sand and gravel at construction sites, and building the infrastructures. Through paired T-test analysis, the study indicated that the project water provision would significantly reduce the distance communities move for water collection ($t = 3.2938$, $df = 169.96$, p-value = 0.001 at 95 percent confidence interval) from 171.65 m to 116 m free from difficulty terrain.

4.2.2 Maintaining quality of water both at sources and in households

Environmental education on protection of water sources has been conducted, and this has resulted to a reduced number of people misusing the water sources by washing their utensils, washing clothes or bathing within or around water sources.

Figure 3: People washing utensils and clothes at the water source

A law that restricts destructive human activities such as agriculture and animal grazing within a 60 m zone from an edge of a water body (e.g. river, well, spring, lake and ocean) has been introduced to communities. Training on the necessity of maintaining the 60 m zone for water protection has also been done and implemented.

So far there is an appreciable response on protection of river banks or water sources by avoiding the 60 m on either side of a water body. Furthermore, seminars have been conducted by TFCG and ONGAWA, and working groups towards maintaining the water quality have been formed. Bylaws restricting communities to wash close to their water source to avoid pollution of water, and mandatory tree planting along water sources/water courses have been enacted.

4.3 Perceived Impacts of Climate Change and Community Resilience to Variations in Water Quality and Quantity

From the questionnaire, when asked about the impacts of climate change, majority admitted that climate change has caused water fluctuation (increase/decrease) of water in rivers and dams while other impacts such as water scarcity and drying up of water sources; water fluctuations and waterborne diseases and water scarcity and waterborne diseases together represented opinions by 35.1% of respondents (Table 4).

Table 4: Response to the question on perceived impacts of climate change

S/N	Perceived impacts	Frequency	Percentage
1	Water fluctuations	92	54.8
2	Water scarcity and drying up of sources	21	12.5
3	Water fluctuations and waterborne diseases	30	17.9
4	Water scarcity and waterborne diseases	8	4.7
5	I do not know	17	10.1

Data from Tanzania Meteorological Agency, showed that rainfall has been varying between years in terms of quantity (Figure 4) hence communities experiencing different rain intensity, though on average it appears to have increased by 43.7mm in 30 years' time.

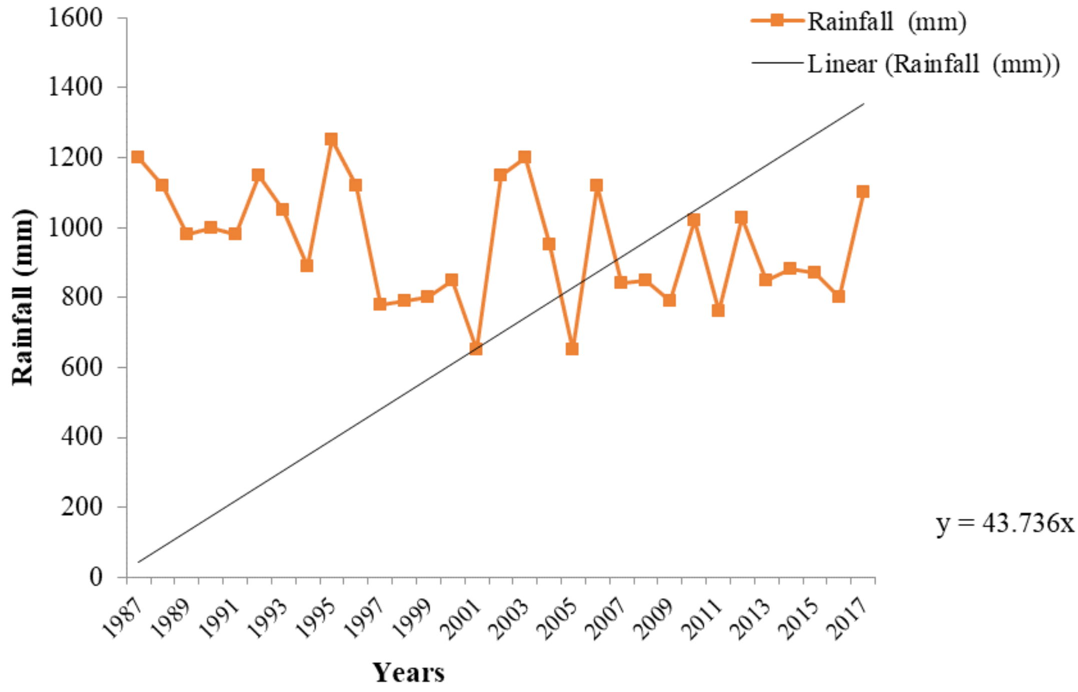

Figure 4: Rainfall pattern for the past 30 years.

However, when communities were asked about whether they were practicing or there were any strategies in place to reverse/fight against climate change particularly rainfall variability, majority of respondents asserted "**yes**" while other substantial groups of respondents either had no idea about existence of such strategies or had their answer being "**no**" (Table 5).

Table 5: Communities response to whether there were any strategies in place to combat climate change

S/N	Are there any strategies	Frequency	Percentage
1	Yes	74	44.3
2	No	35	21.0
3	I don't know	58	34.7

But, when asked about the efforts made by individuals or households in ensuring that sufficient water is available, majority of respondents seemed to be taking no efforts at all, even though small number use the following strategies; additional utensils, tree planting along water bodies and shifting from one source to another in search of water were being practiced (Table 6).

Table 6: Adaptation/copying strategy employed by communities in ensuring that household have sufficient water in the face of climate change

S/N	Strategies	Frequency	Percentage
1	Tree planting	30	17.8
2	Alternative source	6	3.6
3	Use of additional utensils	28	16.7
4.	Nothing	104	61.9

When also asked about useful strategies in place towards fighting climate change in the eve of protecting their water sources, majority of respondents reported that they were planting trees while about one third of respondents were inactive as far as the matter was concern (Table 7).

Table 7: Strategies employed by communities in water protection at water sources

S/N	Strategies	Frequency	Percentage
1	Tree planting	105	62.5
2	Creating 60 m buffer zone	11	6.5
4	Doing nothing	52	31.0

The study also collected information on why it was difficult for the community to prevent unnecessary water loss. Half of the respondents reported low knowledge on prevention of water loss as the prime reason for the villages' loss of water while the percentage of respondents that expressed concern over climate change and loss of water through wearing pipes together constituted 32.8% of respondents (Table 8).

Table 8: The reasons behind community failure to prevent unnecessary water loss

S/N	Why was it difficult to prevent unnecessary water loss	Frequency	Percentage
1	Low level of community's education	85	50.5
2	Wearing of pipes	28	16.7
3	Climate change	27	16.1
4	I don't know	28	16.7

Through this study, communities proposed strategies thought to be helpful in solving the water crisis. These were: strengthening education and environments conservation, which was reported by majority of respondents whereas other positive proposals together accounted for 49.4% of respondents along with minority who appeared to have no idea on what should be done towards solution to the problem (Table 9).

Table 9: Strategies proposed by communities for solving the water crisis

S/N	Strategies	Frequency	Percentage
1	Strengthen education and	73	43.5

	environmental protection		
2	Alternative water sources	66	39.3
3	Repairing pipes	17	10.1
4	I don’t know	12	7.1

CHAPTER FIVE

5.0 DISCUSSION

5.1 Historical Access, Quantity and Quality of Water from Their Sources

5.1.1 Historical access to water resources and water quantity

The study indicated that, only households in the sub-village with tape water network (Barabarani in Misalai village) have been able to shorten walking distance to an average of 42 m per return trip and therefore able to collect an average of 5 buckets of water in 30 minutes per day. This is contrary to their colleagues in the other sub-villages in Misalai village and the other four villages who are still collecting water from wells and rivers at an average distance of 171.7 m per return trip, leading to collection of an average of 11 buckets of water in 3.7 and 6.2 hours per day in wet and dry season, respectively. If the communities with tape water network had decided to collect 11 buckets per day like their counterparts (without tape water network), that would mean 66 minutes per day, which is equivalent to 30% and 17.6% of the time spent by their counterparts during wet and dry season, respectively. The higher time spent by communities lacking tape water network is attributable to the difficulty terrain and the fluctuating water level, which worsens in the dry season hence more time spent waiting for one person to fill-up her bucket before another one can take her turn.

Studies done in Dodoma by FAO (2009) indicated that people walked 2 to 5 km for water collection during dry seasons. Nevertheless, communities in Morogoro rural are moving relatively shorter distance, an average of 700 m and Mtwara, an average of 1.2 km during dry seasons (URT, 2012) compared to their colleagues in Dodoma. The case is not different from other countries or places in Africa as UN World Water (2009) evaluated that in Africa 340 million Africans were still in need of access to safe drinking water and people move an average of 3 to 6 km for water collection choirs.

This is also backed by the fact that Africa has abundant water resources that are not evenly distributed across the continent, and rainfall patterns are becoming increasingly unpredictable due to climate change (Perlman, 2014). The growth of human population, deforestation, and an increase in agricultural production has also accelerated to freshwater shortages in the area (Tanzania Water and Sanitation, 2009). The water requirement for agriculture, homestead, and industries are larger than the annual recharge. These together with prolonged draughts have always caused people to move longer distances and sometimes use less water for their household choirs.

5.1.2 Water quality

From the study, it was observed that water from various water sources were not safe for drinking as *E. Coli* and Total coliform did not meet the EWURA standards. The presence of *E. coli* and total coliform could be due to the fact that many of the water sources were open hence vulnerable to human, livestock and wild animals' contaminations. According to Chapin et *al*. (2014), presence of any animal fecal can influence the growth of coliform. Therefore, the presence of these bacteria is a marker that reflects the possibility of cholera, typhoid fever, and bacillary dysentery, suggesting a potential public health risk (FDA, 2015; EPA, 2012). Coliform testing has been used to indicate the hygienic condition of water for centuries (Wolfe *et al.,* 2014; Trmˇci´c *et al.,* 2016, Wagner *et al*., 2006; Czuba *et.al*., 2011).

Based on significant difference in the infestation of *Escherichia coli* and Total coliform between water used in household and water sources, all studied villages of Muheza were basically using unsafe drinking water given that 98% of respondents reported absence of any premeasures such as boiling. Therefore, there is a need to strengthen the efforts towards provision of education and controlling the bacteria in all the villages. Coliform bacteria, like other bacteria, can usually be killed by boiling water or by treating it with chlorine (Arneson *et al.,* 2012).

The pH for households and water sources differed significantly within and between village and their readings fell below 6.5 (4.5 to 6.5). This suggests that communities were utilizing acidic water (Osmond *et al.,* 1995; EPA, 2014). The difference in pH between water sources and household is directly related to air saturation (EPA, 2014) since water molecules respond differently with physical environmental conditions (Constant, 2010).

However, the difference in pH levels between sources might be attributed to the difference in algae concentrations. Through observation, it was seen that some water sources had more algae concentrations than others. Photosynthesis by algae and plants uses hydrogen hence increasing pH levels and therefore the more the algae the higher the pH and vice versa (ADEM Water Quality Branch, 2013; Earth Science Communications Team, 2013). Pollutions also affect pH (Langland and Cronin, 2003; Chesapeake Bay Program, 2012). This is demonstrated by results of four studied villages namely, Kazita, Kwelumbizi, Mgambo and Misalai, which had big tea estates in which both pesticides and fertilizers were used. The effluents from these estates to water sources in these village could be responsible for the significant difference in pH observed between water source within and between villages. Experiences from elsewhere indicate that results of human activities such as agricultural runoff containing fertilizers and pesticide, wastewater discharge and industrial runoff may lower pH levels in water sources (EPA, 2014; Perlman, 2014).

Extreme pH levels usually increase the solubility of elements and compounds, making toxic chemicals more “mobile” and increasing the risk of absorption by aquatic life (Perlman, 2014). Also, acidic water is an indication of the presence of heavy metals including zinc, iron, lead and copper, hence the presence of these metals have severe impacts when are positioned to the body (Perlman, 2014). Therefore, there is a need to try working hard for this problem in the area. UNESCO (2015) report indicated that water quality degradation translates directly into environmental, social and economic problems. Therefore, when speaking of community development clean water should often be of the highest priority.

5.2 Efforts and Progress towards Accessibility and Management of Water Quality

Through this study it was observed that communities in collaboration with TFCG and ONGAWA worked towards solving the water crisis. There were also subsequent efforts by governments and other development actors to enhance access to water and improve sanitation. The Government of Tanzania through village participation, TFCG and ONGAWA have established a partnership to contribute to the achievement of clean water and sanitation in the area. The goal is to deal with this central cause of poverty and sickness for 42,000 people – especially children and women. If project will materialize the water distance is expected to be reduced from171 m to 116 m.

Similar efforts have been invested in different parts of Tanzania by water sector (ADB, 2010) though, much effort is needed to safeguard the catchments across the studied villages for continued flow of water to many downstream villages in Handen and Korogwe Districts as well as the Tanga Municipal itself. Therefore, failure to maintain water in the catchment area, where the studied village are located may cause severe water shortage to the communities downstream. TFCG and ONGAWA have involved different stakeholders, although, there is a misconception by communities-they believe that all financial issues concerning water provisioning is a government/institutional responsibility hence threatening the sustainability of water infrastructural management. The sustainability will only be achieved if all stakeholders will have sufficient capacity and incentive to do their role (Harvey and Reed, 2004). Harvey and Reed (2004) suggest that if services are to be sustainable, national and local government institutions are the most important stakeholders for coordination, and need to have sufficient capacity at all levels to deliver services.

Other efforts by TFCG and ONGAWA in attempt to ensure sustainable water flow in the project area included holding a multi-stakeholder workshop on solving water related problems. Participants of the workshop were local government officials, districts water management team and environmental organizations. Among results of the workshop was formation of various groups with different aims such as provision of education on safe and clean water for better health, and well-being of women and girls with a slogan "reduce a burden to a woman". Other outcome of the workshop was an effort to increasing awareness about the government by law, which requires a 60 m buffer zone on each side of any water source, planting trees that are water-friendly to the environment and training on construction and use of the best toilet facilities, aiming at improving the quality of water resources and ecosystems (WHO, 2004).

5.3 Perceived Impacts of Climate Change and Community Resilience to the Variations in Water Quality and Quantity

Through this study it was found that all communities perceived to witness issues concerning climate change. They have witnessed it through water fluctuations and emergence of new diseases such as Malaria. Communities were able to tell how occurrence of extreme weather events such as drought and floods affects their life. Though climate change impacts are felt globally their impact have affected communities differently (IPCC, 2001).

In the study area, water volume has been declining from season to season and year to year, and communities have acted differently. On the temporal terms, communities add utensils or change the water source. On the permanent terms, communities do plant trees, avoid cultivating along or around water sources and groups have been formed to ensure communities get the necessary education for water protection. Sadly, however, a fraction of communities considers climate change as a natural phenomenon that comes and go on its own. Such perception may undermine the efforts if allowed to spread.

Studies indicate that extreme variability in water resources and significant decreased instream-flow is the major threats across sub-Saharan African countries (Saloua *et al*., 2012) and the variation has been one of the major limiting factors of economic growth (Yahaya *et al*., 2014). The same forces have been facing African countries as they are unaware of the resilience and adoption; despite the opportunities they are having (UNDP, 2010; ADF, 2005).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the study conducted on the access and quantity of water in Muheza district, the following conclusions were made;

i) Communities in the study area are still walking a long distance, and are still using either natural wells or rivers which are dearly demanded by the downstream villages. Water volume in sources do fluctuate heavily during dry seasons, and hence causing the rise in water demand which has also affected the lower villages which do not get water at all during dry seasons. Therefore, it is important to embark more efforts to provide water to these villages at the same time find a better way to protect water sources in order to serve both the studied villages and the villages downstream.

ii) Water collected were of very poor quality due to *E. coli*, total coliform and pH did not match with the stated Tanzania standard for communities' consumption. Given that the studied villages were upstream, this scenario indicates that communities downstream are might be vulnerable to diseases such as cholera, typhoid and other water borne related diseases. Therefore, there is a need to make sure water points are treated collectively and communities are given education on water safety. Also, there is a need to conduct another study to find out how much are the communities affected by coliform, also how does acidic water affect their health as the pH was lower than the standard.

iii) Climate is perceived to have played a significant role on variation of water quality and quantity in the area. Despite communities adopting different strategies to curb both temporary and permanent water scarcity; there is a need to add more efforts on community education, tree planting projects, latrine management and provision of tap water as part of ecosystem and water management protection tactic.

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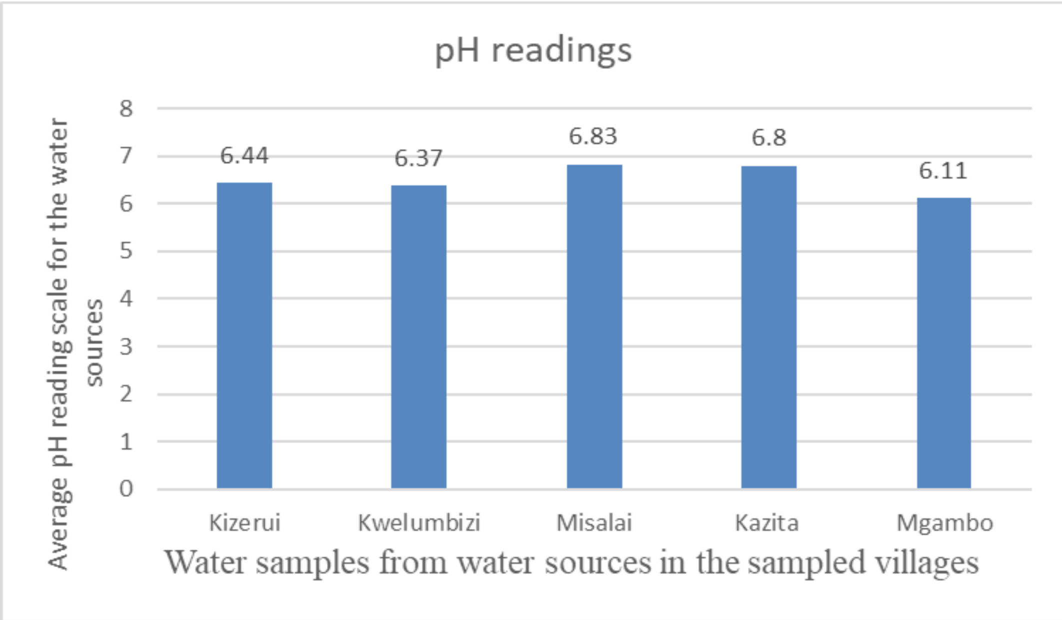
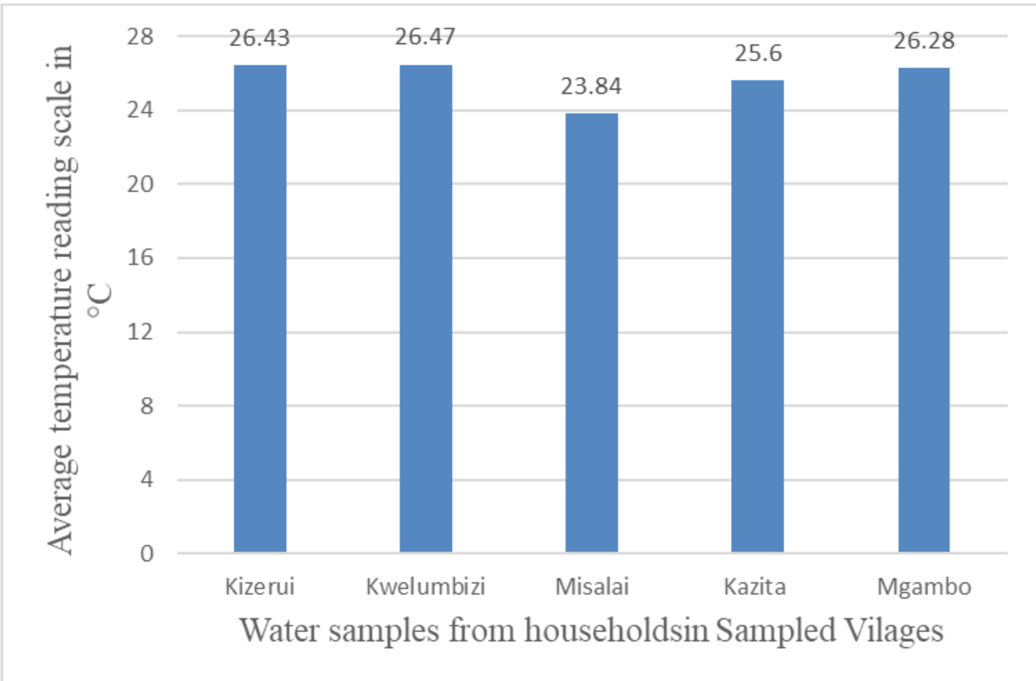
APPENDICES

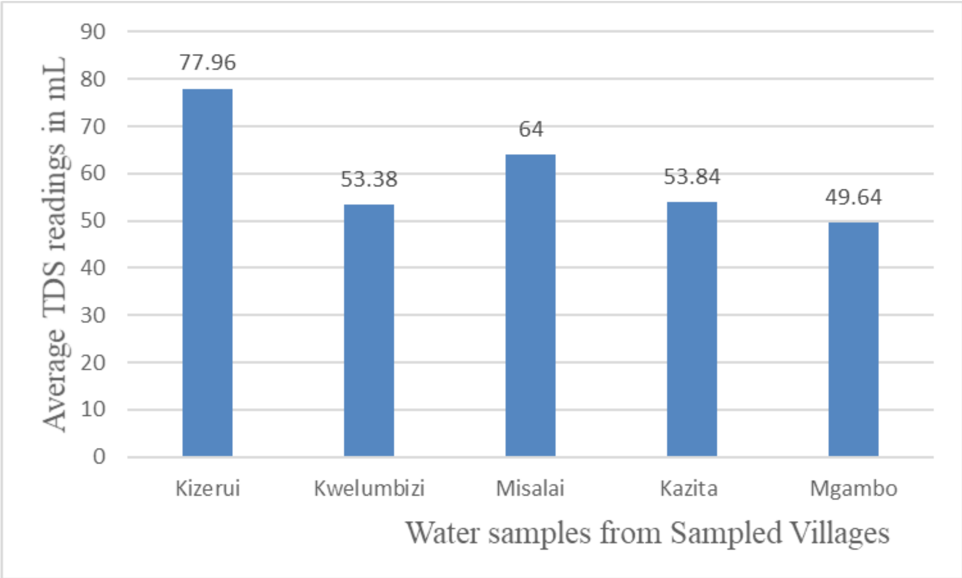
Appendix 1: pH readings on water sources



Appendix 2: Average temperature reading from households



Appendix 3: TDS in water samples from households in Sampled Villages



Appendix 4: General household questionnaire

Demographic Characteristics

1 Name… ……………………………ID no.………………………………….
2 Gender……………………………………………………………………….
3 Age of respondent…………………………………………………………
4 Education level…………………………………………………………...
5 Family size…………………………………………………….………...

Water Accessibility and Availability

6 Where do you collect your water?
7 Distance from household to the water source……………….……………………
8 Is the same source used for all household activities? Yes……….or No………...
9 If no why?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

10 Where is the other source distance …………………………………………
11 Are you using the same source throughout the year? Yes…on No…..
12 If No, why do you think is the reason?..
13 Is this situation of not having enough water common to the area for years?.....Yes or No……
14 If no what do you think is the reason for having less water

……………………………………………………………………………………

……………………………………………………………………………………

15 Is there any year where the source of water dried up No……or yes………………..
16 If yes what do you think was the reason for the source to dry……………………………………………………………………………

17 How much water do you use per day in terms of buckets?..

....

18 How much water is enough for your daily use……………………………………..
19 Do you believe that the water you are using is of good standard? .Yes ....or No............
20 If no do you treat your drinking water?..
21 Are you confident that your water source is suitable for drinking? Yes…… or No……
22 If Yes Why………………………………………..
23 If no why………………………………………………………………

24 Where, do you think,the water of the highest quality is found?...
....
Why……………………………………………………………………………………
25 In your opinion, who should be responsible for water quality control?

Strategies and Progress towards Accessibility and Management of Water

26 Do you think there is any water variation between seasons Yes………… No…………?
27 If Yes, how do you deal with water scarcity during the season where you have less water…………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
28 Do you remember any year where you had less or no rain at all? Yes……………… No…………….
29 if Yes, what do you think was the reason for not having rain?..................................
30 What did you do to make sure the problem never repeats...?
31 Do you believeinn climate change and their associated impacts? Yes..................or No...
32 If yes, what are the impacts of climate change…………………………………………………………………………
……………………………………………………………………………………….
33 What are you doing to make sure we can reduce the impact of climate change on our area?...
34 What are the strategies in place that are made to make sure you have enough water all the year?
a) Short-termm strategies
………………………………………………………………………………..
………………………………………………………………………………..
………………………………………………………………………………
b) Long-termm strategies
………………………………………………………………………………
………………………………………………………………………………
………………………………………………………………………………

Which strategies do you think works well and will definitely make sure we have enough waterthroughh out the year?
………………………………………………………………………………
………………………………………………………………………………
………………………………………………………………………………

35 What is your opinion on how we can make sure we have enough water and everything goes as smooth as it used to be before?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

What is the potential gap/obstacle towards making sure you have enough water?

Is the community resilient to the variations in quality and quantity of water resources?

36 Do you know anything about climate change?..

37 Has the climate change affected the availability (volume) and quality of water………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
……………………………………………………………………………………

38 What do you as the household do to make sure you have enough water despite the prevailing condition…………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

Are there any measures that you are doing to make sure you are assisting in water management and maintenance for your future and the future of your kids to have enough water?...
....
....

What do you think is the prime obstacle that makes everything hard especially on making sure we have enough water for all year around?..
....
....

Water Quality Testing Information

As part of the surve,y we are also looking at the quality of household drinking water we would like to perform some simple water quality test using samples of your usual drinking water. Can I have some the water from your drinking utensils?

Yes, permission is given

No, permission is not given

Day/Month/Year of conducting test:……………………………………………………..

Household number………………………………………………………………………..

Source of water for drinking…………………………………………………………..

Source of water for other household activities if different …………………………….

Appendix 5: Water quality information and the corresponding procedures for information gathering

Using the water provided by the respondent, take a sterile 1 ml syringe and add 1 ml of water to compact dry plate. Label the household number on the tube.

Bacteria Measurement

i) Total coliforms ……………………………………………………….

ii) *Escherichia coli* (*E. coli*)…………………………………………….

Hours taken………………………………………………………………………

Using the water provided by the respondent, take 20 ml microbiological testing kit and fill up to mark

Bacteria Measurement ……………………………………………………….

Measurement of chemical parameters

i) pH

Measurement of Physical parameters

i) Total dissolved solids

ii) Temperature

Fill, label and store inIceboxx 100 mL sterilized bottle from the selected household for duplicate coliform testing in the laboratory.

Label household number……………………………………………………….

Bottles filled

Bottleslabeledd (Write the label written on the sample bottles)

Bottle sample preserved

Record the time of sample collection: Hour: Minutes ___ ___ : ___ ___

Water Source

Water source number……………………………………………………….

Using the water from the source, take a sterile 1 mL syringe and add 1 mL of water to compact dry plate. Label the household number on the tube

Bacteria Measurement

iii) Total coliforms ……………………………………………………….

iv) *Escherichia coli* (*E. coli*) …………………………………………….

Hours taken………………………………………………………………………

Using the water from the source, take 100 ml microbiological testing kit and fill up to mark Bacteria Measurement ……………………………………………………….

Measurement of chemical parameters

ii) Ph Measurement of Physical parameters

iii) Total dissolved solids

iv) Temperature

Fill, label and store in ice box 100 mL sterilized bottle from the water sources for duplicate total coliform testing in the laboratory.

Label water source number……………………………………………………….

Bottles filled

Bottles (Write the label written on the sample bottles)

Bottle sample preserved

Appendix 6: Key informants and focus group questions

1. Do you have enough water that will sustain you daily life throughout the year and for the coming years?
2. What do you think is the reason for having less water in the recent years, especially during dry seasons?
3. Do you think there is climate change, why?
4. Do you think there is any strategy that is being put in place that will reverse your problem?

   Short term strategies……

   Long term strategies….
5. What do you consider to be the best strategies that would help in solving/reducing the fierceness of the problem?
6. Do you think there are any other strategies that would suit in solving the problem but are not put into actions?
7. In your opinion, who should be working hard to solve this problem and why?
8. Do you think you communities understand the problem of climate change and their impact on our water resources?
9. In your opinion, what adaptation strategies should be developed by communities prone to climate change? Why do you think so…...?
10. What should you do to save you water sources and quality for the future?