

# Climate Variability Impacts, Diseases and Human Health: The Case of Morogoro Municipalities, Tanzania

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## Abstract

This study assesses the impacts of climate variability in water quality and its subsequent effects to human health through diseases in Morogoro Municipality. It assessed the standard/quality of drinking water and how it is affected by the impacts of climate variability in the study area. Primary data were obtained through interview and questionnaire covering two hospitals namely Nunge and Saint Thomas Hospital, whereby each hospital provided 75 respondents through questionnaires to make the total of 150 respondents in the study area. These primary data were supported by secondary data which were collected from TMA and MORUWASA. Quantitative data were edited, coded and analyzed using statistical package for social science (SPSS version 16 and Microsoft Excel Sheet. Qualitative data were analyzed through content analysis, summarized and presented in the text. The analyzed data were presented into tables and graphs. The findings of the results show that the climate of Morogoro municipal is varying, then quality of drinking water is not good and people are much affected by water borne diseases. However, climate change and its variability has played both direct and indirect role for water deterioration, though there are other factors which bring to synergetic effects to climate change, like population density, human activities and economic factor which make human health more vulnerable to climate change impacts.

**Key Words:** Climate variability, Water quality, Human health.

## INTRODUCTION

### Background Information

Climate variability has numerous negative effects on the stock of fresh water. On the other hand deteriorated fresh water increases the incidence of waterborne disease due to increased temperature and reduced precipitation (IPCC, 2001). Domestic water treatment plants may be susceptible to climate change leading to human health risks. For example, droughts may cause problems with increased concentrations of effluent pathogens and overwhelm water treatment plants; aging water treatment plants are particularly at risk. Urbanization of coastal regions may lead to additional nutrient, chemical, and pathogen loading in runoff (ibid).

Findings from different research show that there is a close link between climate and the occurrence of disease dangerous to human health due to contamination of water, air and food. In short, the main effect of affected water is water born disease. Some of the effect may lie ahead if they increase in a very extreme extent. With increase in temperature and change in

rain pattern the situation can lead to water born diseases such as cholera and diarrheal caused by organism such as giardia and salmonella (IPCC, 2001).

People in Morogoro municipality mainly use tap water from Mindu Dam (Paavola, 2006). The availability of tap water has significant public health benefits, because specific chemical compounds are often added to tap water during the treatment process to adjust the pH or remove contaminants, as well as chlorine to kill biological toxins. Tap water remains susceptible to biological or chemical contamination due to the event of contamination which deemed dangerous to public health. Government officials typically issue an advisory regarding water consumption. In the case of biological contamination, residents are usually advised to boil water before consumption or to use bottled water as an alternative. In the case of chemical contamination, residents may be advised to refrain from consuming tap water entirely until the matter is resolved (Lee, 2009). The problem is that not all people treat water at their home. Also, not exactly that water is well treated from the source. Even though, climate seemed to interfere with the quality of water; sometimes lead to contamination in the pipe during transportation or in tanks where water is stored.

### **Problem Statement**

It has been said that the climate is not promising due to its irregularity. Also, this seems that its irregularity has played a great role in the deterioration of water quality which in turn may lead to increase in the spread of water born disease. Furthermore, the increase in temperature and precipitation may cause the emergence of more disease in regions that did not previously host disease or disease carrier" (IPCC, 2007). In the tropical region where contamination due to temperature and rainfall, eruption of diseases like typhoid, cholera and meningitis can easily happen. These diseases have pronounced negative impacts to both family and community level (IPCC 2007). However, it can be difficult to explore to what extent does deterioration of water quality due to climate change has affected human health in Morogoro district (ibid). Therefore, assessment of climate change impacts to deterioration of water quality is more significant to avoid the eruption of diseases due to contamination.

### **Objectives**

#### ***General objective***

The main objective of this study is to assess the impacts of climate variability to water quality and subsequently the affect to human health in Morogoro municipality.

#### ***Specific objectives***

Specific objectives are:

- i. To assess the quality of drinking water in the study area.
- ii. To assess the impact of climate variability to water quality in the study area.
- iii. To determine the effect of polluted water to human health in the study area.

### **Research Questions**

- i. What is the quality of drinking water taken by the people of Morogoro municipal?
- ii. What is the relationship between climate variability and water quality?
- iii. To what extent deterioration of water quality has affected human health?

### **Problem Justification**

Water is an essential ingredient to economic growth and a basic need to human life (Mwanza, 2004). Safe and clean water creates a good condition to the development of economy and poverty reduction to the poor. This is because safe and clean water can ensure good health status of the people (UN, 2005). Hence, the population can remain healthy and energetic

enough to participate well in the production. Improving the quality of drinking water is an essential pre-condition to the attainment of other Millennium Development Goals. Health and environmental or income targets cannot be achieved unless action is taken to address water problems. Makule (1997) asserted that with water scarcity due to climate variability, lower quantities and qualities of water are consumed by people. This attributes to waterborne diseases as sanitation becomes low. A sick society cannot contribute towards economic growth or poverty alleviation. Time and resources will be used in taking care of the sick. Long distance to water sources occupies and consumes the time of those involved that could be used for other productive activities.

Therefore, this study has determined to what extent does human health been affected by the change of water quality due to climate variability in Morogoro municipality and provided some measure like simple techniques of treating water at home, such as chlorination, filters, and solar disinfection, and storing it in safe containers could save a huge number of lives each year. This is in line with the UN millennium development goals (MDG), such as to reduce by half the proportion of people without access to safe drinking water and eradication of extreme poverty (UN, 2008). It is also reflecting PRSP (URT, 2000), that elimination of poverty will not be done without ensuring every person with access to clean and safe drinking water.

## LITERATURE REVIEW

### Climate

If the earth's climate were to become more erratic, it could have more implications to human beings. A change in the hydrological cycle could mean that an area which depends strongly on rainfall for agriculture could start to see differences in the duration and intensity of seasons, and farmers would have to plan how to overcome the repercussions of floods or droughts. Water quality will also be affected by the change of weather patterns. When water levels are low, as in a drought; pollutants become more concentrated. During flood, sediments and others pollutants can wash out into the drinking water sources (Sufford, 2007).

### Water Quality

Water quality is the physical, chemical and biological characteristics of water (Makule, 1997). It is a measure of the condition of water relative to the requirements of one or more biotic species and/or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be used (IPCC, 2007). The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water (ibid). The raw or treated water is analyzed by testing their physical, chemical and bacteriological characteristics: Physical Characteristics of water to be determined are turbidity, color, temperature taste and odour. Chemical Characteristics of water are pH, acidity, alkalinity, total hardness, chloride, sulfates, iron, solids, and nitrate (UN, 2008). The bacteriological characteristic of bacterial examination of water is very important, since it indicates the degree of pollution. The polluted Water through sewage contains one or more species of disease producing pathogenic bacteria. Pathogenic organisms cause water borne diseases, and many non pathogenic bacteria such as Ecoli, a member of coliform group, also live in the intestinal tract of human beings. Coliform itself is not a harmful group but it has more resistance to adverse condition than any other group. So, if it is ensured to minimize the number of coliforms, the harmful species will be less. Hence, coliform group serves as an indicator of contamination of water with sewage and presence of pathogens. About 1.1 billion people lack access to an improved drinking water supply, 88% of the 4 billion annual cases of diarrheal disease are attributed to unsafe water and inadequate sanitation and hygiene, and 1.8 million people die from diarrheal diseases each year (WHO, 2007). The WHO estimates that

94% of these diarrheal cases are preventable through modifications of the environment, including access to safe water.

### **Safe Water**

Safe water means water that will not harm living organism especially human being if comes in contact with it. The most common use of this term applies to drinking water, but it could also apply to water for swimming or other uses. To be safe, the water must have sufficiently low concentrations of harmful contaminants to avoid sickening people who use it. The list of harmful contaminants includes disease-causing microbes such as bacteria, viruses, and protozoan's. Defining safe water becomes a matter of risk assessment, in which you consider the chance of illness or injury from drinking water, in comparison to the risk of illness or injury from the many other hazards (EPA, 2003).

National Health Policy 1990, emphasize the need for adequate supply of water and basic sanitation to minimize water born and water related diseases, which are among the major health problem in this country, and reorganize that the health of individual, the family and the community at large depending on the availability of safe water supply, basic sanitation and improved hygiene practices.

Everyone needs safe water to drink, and people often have questions regarding the quality of water from their well or public utility. Due to the deterioration of water quality water born disease has become a major problem. Worldwide 1.2 billion people do not have access to clean and safe drinking water, and 2.4 billion people lack sanitation (Alumn, 2008). Every year, 5 million people die of waterborne diseases (ibid).

### **Water Born Diseases**

Water-borne diseases are infectious diseases spread primarily through contaminated water. Though these diseases are spread either directly or through flies or filth, water is the chief medium for spread of these diseases and hence they are termed as water-borne diseases. Infectious diseases caused by pathogenic bacteria, viruses and protozoan parasites are among the most common and widespread health risk of drinking water. People are introduced to these microorganisms through contaminated drinking water, water drops, aerosols and washing or bathing. Some waterborne pathogenic microorganisms spread by water can cause severe, life-threatening diseases. Examples are typhoid fever, cholera and Hepatitis A or E. Other microorganisms induce less dangerous diseases. Often, diarrhea is the main symptom. People with low resistance, mainly elderly people and young children are vulnerable to these diseases as well (Alumn, 2008).

### **Morogoro Town Water Supply**

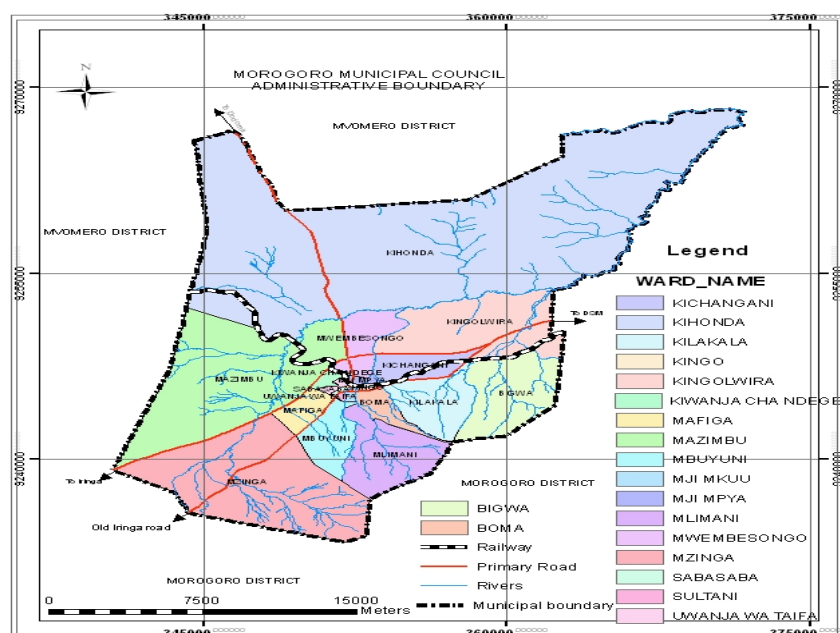
Morogoro town is served by two gravity fed water supply systems which have two sources. These are Morogoro and Ngerengere rivers and treated at Mambogo and Mafiga water station respectively. Ngerengere river collected from Mindu dam then pumped to Mafiga before distribution. During the dry season the levels of the two sources of water goes drastically down. This makes the supply of adequate water to be a problem. Yet the town is growing fast and industries are demanding an increasing supply of water. At 65% Coverage residents of the town rely to a significant extent on unsafe open water systems wherever they can be found. This is particularly so during the dry seasons (Moloch, 1997)

## CHAPTER THREE RESEARCH METHODOLOGY

### Study Area Description

#### Location

Morogoro Region is one of the 24 regions in Tanzania Mainland. The region lies between latitude 5° 58" and 10° 0" to the south of the Equator and longitude 35° 25" and 35° 30" to the east. It is bordered by seven other regions namely Arusha and Tanga regions to the north, the Coast Region to the east, Dodoma and Iringa to the west, and Ruvuma and Lindi to the south. It occupies a total of 72,939 square kilometers which is approximately 8.2% of the total area of Tanzania mainland. Morogoro municipality is located about 190 km west of Dar es Salaam, it is situated on the lower slopes of the Uluguru Mountain sand covers an area of 260 km<sup>2</sup>. Research will be carried in two hospitals found in different wards in Morogoro municipal. The hospitals are STH and Nunge found in Kilakala and Mjimpya ward respectively.



**Figure1: Morogoro Municipal Map**  
Source: Field Data Survey (2012)

#### Climate

The annual rainfall ranges from 600mm in low lands to 1200mm in highland plateau. However, there are areas which experience exceptional droughts (with less than 600mm of rainfall and these areas are in Gairo and Mamboya divisions in the North of Kilosa District and Ngerengere Division in the East of Morogoro Rural District). The mean annual temperatures vary with altitude from the valley bottom to the mountain top. The average annual temperature varies between 18°C on the mountains to 30°C in river valleys. In most parts of the region, the average temperatures are almost uniform at 25°C. In general the hot season runs from July to September.

### ***Population***

According to the 2002 population and housing census, Morogoro region had a total population of 1,753,362 male being 873,245 and female 880,117 with total of 385,269 households (URT, 2006).

### ***Socio-economic activities***

The economy of the region is dominated by agriculture and the allied activities. The major activities include: Small Scale farming (food and cash crops production subsistence farming) cattle keeping, plantations and estates (sisal, sugar). However, there is growth of small capital intensive urban sector whose main activities include: Manufacturing and provision of services - offices, hotels, petty trading etc. However, agriculture is the major economic activity in the region. It engages about 80- 90 percent of the region's labor force. Agriculture involves both small and large scale farmers. Large scale farms are the Kilombero and Mtibwa sugar estates. Sisal estates are large scale paddy farms in Dakawa, Morogoro Rural District, and Mgeta in Kilombero District and Kilangali in Kilosa.

### ***Transport and communication***

The region has a total road network of 3,742 km. Out of these total 55 km are trunk roads, 961 km regional roads, 1,043 km district roads and 1,179 km feeder roads. See Table III.1. The trunk and regional roads are in good shape, although they still need some maintenance. District and feeder roads are in a poor state. The Postal service in Morogoro region boasts of 10 regular post offices and 21 other postal agencies with a total of 6,625 letter boxes. The telephone service has the installed capacity of 4,010,103 service lines out of which 3,169 have been taken up. There are also 102 Fax lines, 35 Telex lines and 8 e-mail lines in operation.

### ***Research Design***

Both primary and secondary data were collected and cross sectional involving both qualitative and quantitative data. Participant Observation, Questionnaire and Key informant interview were used to collect data so as to get enough, relevant and useful information to achieve the objectives of this study.

Primary data were collected using structured closed questionnaires to probe the link between climate variability and water quality in affecting human health. Sources of information were patients who have already attended in the hospital. Also, doctors and nurses in the hospital were interviewed in order to cross-check the data.

The secondary information was collected from TMA, MORUWASA and STH. Furthermore, literatures and documentary searches from SNAL, SMC and Morogoro Regional Library were consulted to get a more detailed and well researched in formations.

### ***Data collection tools***

Data were obtained through the use of questionnaires, key informant interviews. These tools were supported by secondary data collected through extensive review of public documents that included climate, water quality and human health.

### ***Sample size***

Data were collected purposively from two hospitals found in different wards which were Nunge at Mjimpya ward owned by the government and STH at Kilakala ward owned by private organization. In each ward 75 patients was interviewed which make the total of 150 respondents.

### **Sampling procedure**

Multistage sampling was used to collect data of patients from hospitals. Two hospitals were selected purposively. A total of 75 respondents were randomly selected in each hospital making a total of 150 respondents. Data were collected for five days where 30 respondents were interviewed per day.

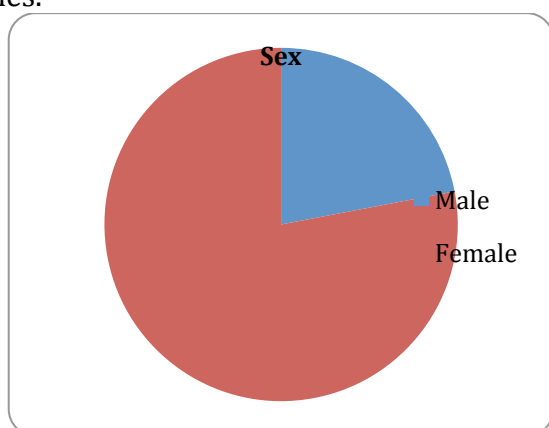
### **Data Analysis and Presentation**

Data were analysed at Sokoine University of Agriculture. Quantitative data were coded and analyzed by Statistical Package for Social Science (SPSS) version 16, and Microsoft Excel Sheet. Qualitative data were analyzed by content analysis, summarized and presented in the text. Microsoft Excel Sheet was used for analysis of secondary data. The results were presented into graphs, tables, figures and charts.

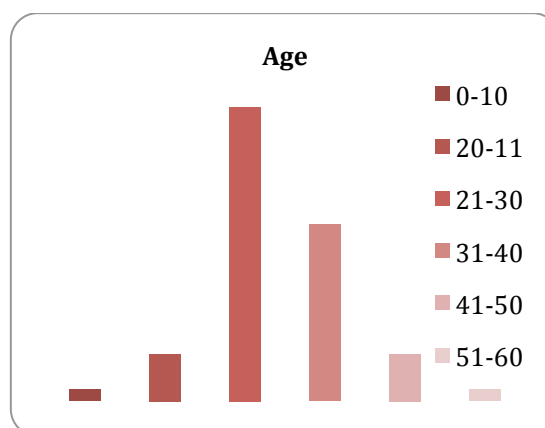
## **RESULTS AND DISCUSSION**

### **Introduction**

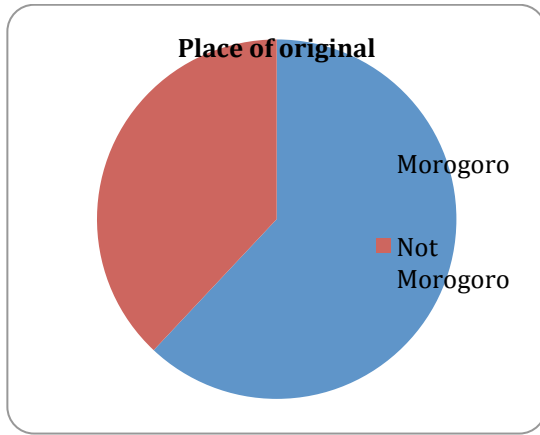
This chapter present and discuss the results of the assessment on climate variability to water quality and how the polluted water affects human health in Morogoro municipality. The results from Figures 1- 4 show the proportions of respondents in terms of age, sex, level of education and place of origin. These figures show that about 33 respondents or (22%) were females while 117 respondents or 78% were males. The percent of male response was low while that of female was high this implies that women are more vulnerable than men as they are found sick (patient) in hospitals. In term of originality, the results show that about 62% of respondents have born and live in Morogoro and 38% are not born in Morogoro. In term of age, the respondents had the age ranging from 10 to 58 years, the majority (50%) range from 21 to 30 years. Furthermore, the majority respondents have primary education comprising 62%. Those with secondary education constitutes 28%, those with post secondary education were 6% while informal education forms 4%. This shows that, the majority respondents were not educated to secondary or post secondary education due number of reasons including poverty as most of the people are from poor families that failed to take them for further studies.



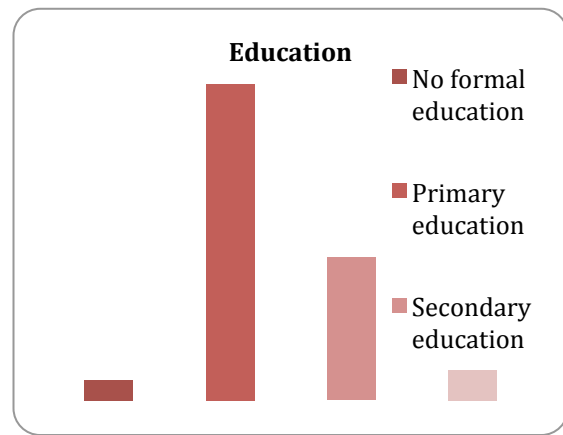
**Figure 1: Sex of Respondents**  
Source: Field Survey Data (2012)



**Figure 2: Age of Respondents**  
Source: Field Survey Data (2012)



**Figure 3: Origin of respondents**  
Source: Field Survey Data (2012)



**Figure 4: Educational level of respondents**  
Source: Field Survey Data (2012)

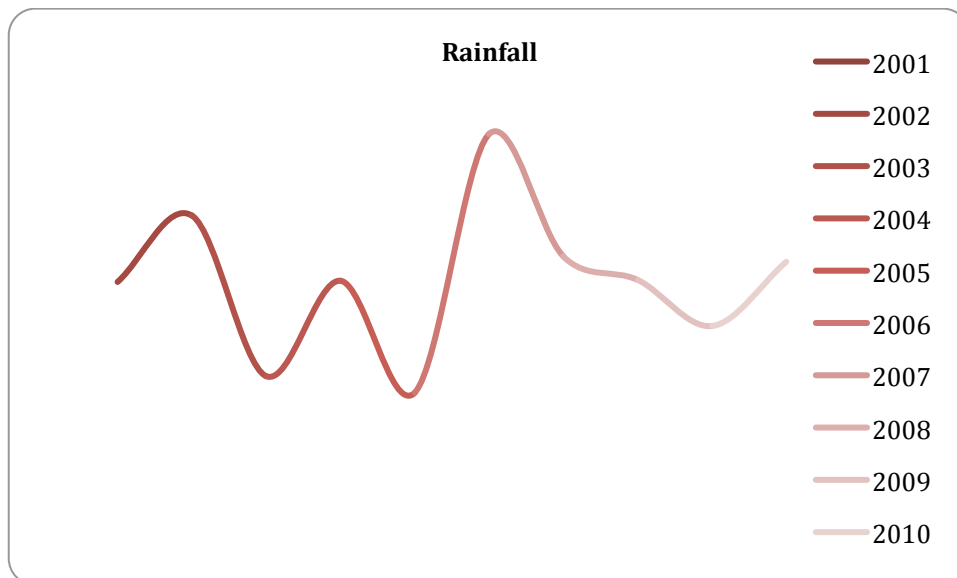
**Climate Variability and Water Quality**

**Perception on Rainfall**

The study show that 3% of respondents said that rainfall is increasing, 46% said it is decreasing, 40% said that it is fluctuating and 8% said they do not know about the trend of rainfall as shown in Table 1 below.

**Table 1; Respondents Perception on Trend of Rainfall**

Parameter	Distribution	Percentage (%)
Rainfall	Increasing	6
	Decreasing	46
	Fluctuating	40
	Do not know	8
	<b>Total</b>	<b>100</b>



**Figure 5: Trend of rainfall from 2000 to 2012**  
Source: TMA (2012)

The findings presented in both Table 1 and Figure 5 shows that the trend of rainfall is highly variable at the decreasing trend. However, people from TMA (Figure 5) above shows that the trend of rainfall is fluctuating. In the years 2003 and 2005 there was very low average rain per



year which is 41.2 and 37.3 respectively, while 2007 was having high average rainfall of 98.5 per year while 2001,2004,2008 and 2010 were having rainfall ranging from 63.5 to 69.6. 4.2.2. This implies that the rainfall pattern varies. The variation of rainfall has impacts to socio-economic livelihoods of the people especially health and poverty.

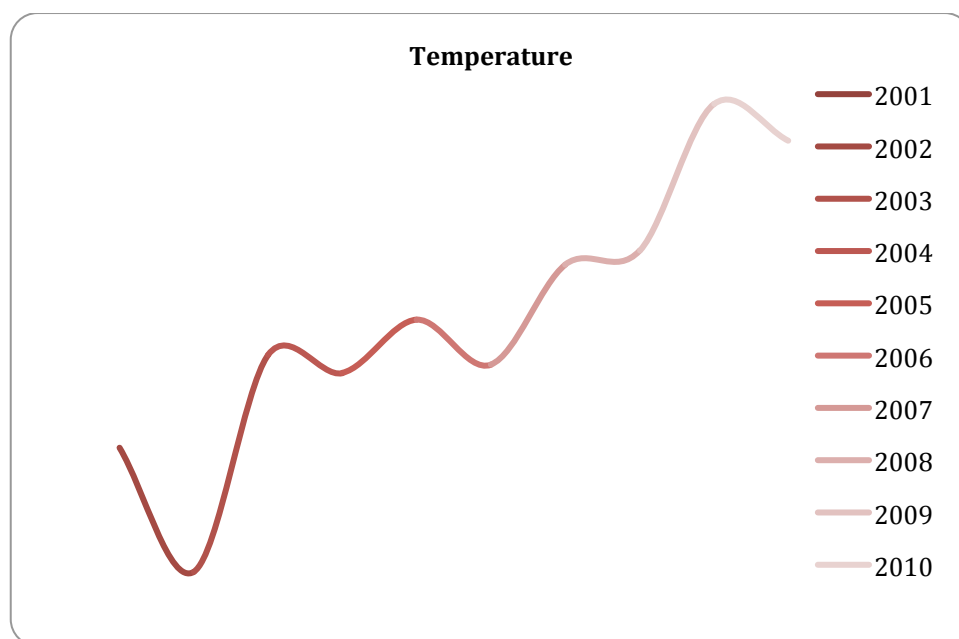
### Temperature

The study findings from Table 2 below show that 50% of the respondents said that temperature is increasing, 18% said it is decreasing, 20% said that it is fluctuating and 8% said they do not know.

**Table 2: Respondent Perception on Climatic Condition**

Parameter	Distribution	Percentage (%)
Temperature	Increasing	50
	Decreasing	18
	Fluctuating	20
	Do not know	12
	<b>Total</b>	<b>100</b>

Source: Field Data Survey (2012)



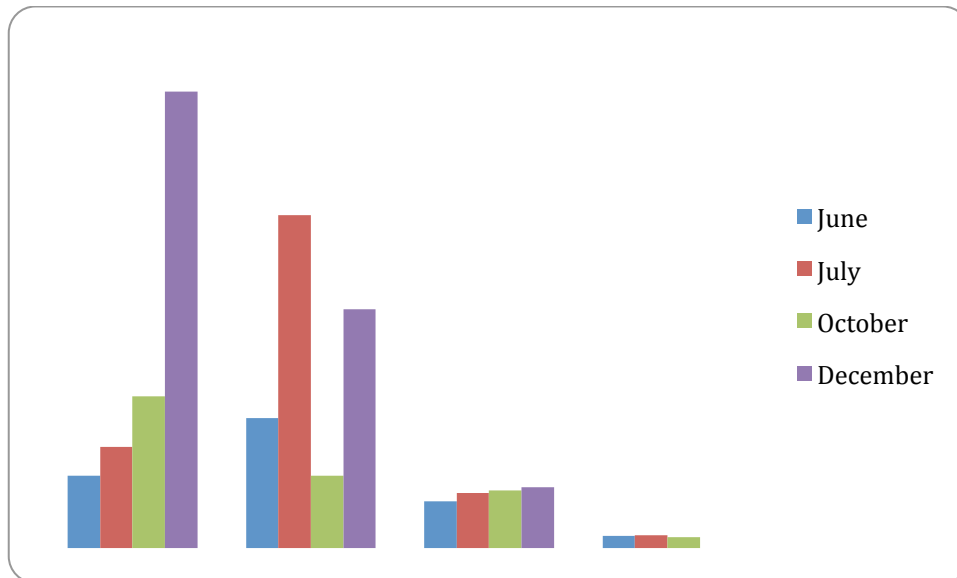
**Figure 6: Trend of temperature from 2000 to 2012**  
Source: TMA (2012)

The result findings from both the study area (respondents) and TMA; show that the trend of temperature is increasing in the study area. The average temperature per year showed to increase from 21.78 0c in 2002 to 25.10c in 2009. These variations imply that climate of Morogoro municipal is not static; it varies referred as climate variability. This variation has lead to eruption of diseases of water born diseases especially cholera and typhoid as a number of patients have been found and admitted to the two hospitals in the study area suffering from those diseases.

### Water quality

From the study findings, 88% of the respondents said that the color of water during rainy season is not clear (not clean) and 12% said it is clear. Also about 92% said that the color of

water in summer is clear (clean) and the rest said it is not clear (not clean). Then the results from analyzed data from MORUWASA as seen in Figure 7 below shows that pH, color, NO<sub>3</sub> and turbidity are varying depending on the season of the year, but fecal coliform showed to be zero. It implies that the changes in these water parameters can be due to variability in climate that regardless the water treatment the parameters are varying. These results give evidences that, water in the study area is not readily safe unless are treated by the user (boiling).



**Figure 7: Water Quality Data**  
Source: MORUWASA (2012)

However from the research done by SUA in Department of Veterinary Microbiology and Parasitology and Department of Food Science and Technology looking the quality of drinking from different sources in Morogoro municipal including Sabasaba, Kiwanja cha ndege, Kichangani and Mjimpya public taps respectively, showed that faecal coliforms, *Escherichia coli*, faecal streptococci and *Clostridium perfringens* for a period of 6 months. Chlorinated pipe borne water were found contaminated with microorganisms in the order of  $3.8 \times 10^1$  to  $4.95 \times 10^3$ ,  $3.2 \times 10^1$  to  $4.5 \times 10^3$ ,  $10^1$  to  $6.4 \times 10^1$  and  $1.2 \times 10^1$  to  $25 \times 10^2$  in 100 ml of water respectively (Msangi, et al, 1991). This implies that either there was mistake in experiment done by the MORUWASA people or water is well treated from the source but the problems are in water pipes. These findings indicate that there is a need for further treatment of water before consumption in order to avoid potential health hazards.

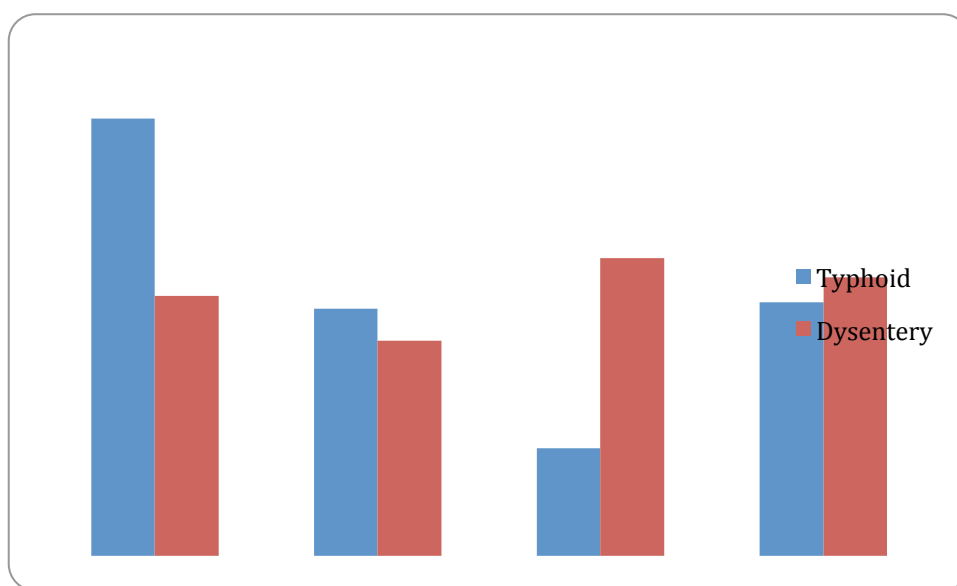
### Human Health

This study shows that 86% of the respondents suffered from water born diseases, 32% suffered from typhoid, 40% suffered from Diarrhea and 14% suffered from dysentery. Apart from water born disease Malaria is a vector born disease 14% of respondents were suffering from malaria as presented in Table 3 below. One of the clinical doctor at STH said "Malaria is one among the diseases which are due to climate change but the government has provide a great support in it, in such a way that its vulnerability has decreased compared to typhoid and other gastroenteritis".

**Table 3: Respondents Health Conditions**

	<b>Distribution</b>	<b>Percentage (%)</b>
Disease	Typhoid	32
	Diarrhea	40
	Dysentery	14
	Malaria	14
	<b>Total</b>	<b>100</b>
Symptoms	Stomachache	80
	Headache	18
	Nausea	2
	<b>Total</b>	<b>100</b>

Source: Field Data Survey (2012)

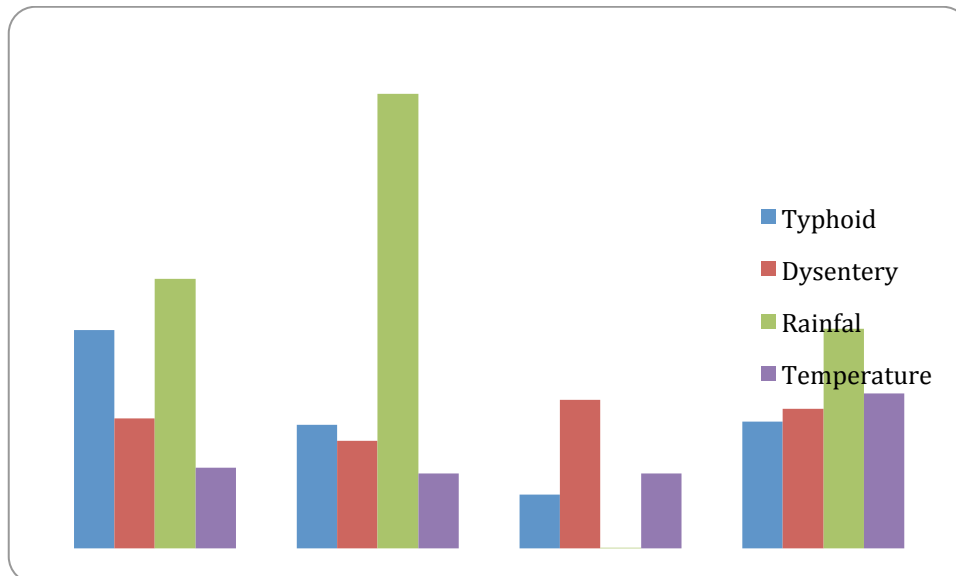


**Figure 8: Typhoid and Dysentery Data**  
Source: STH (2012)

The results from Figure 8 above shows that most of the people (80% of the respondents) who were suffering; the main symptoms was stomachache. To assess the potential risk of deterioration of water quality to human health the adaptation of climate variability to water quality were considered.

### **Human Health and Climate Change**

Data from STH and TMA (Figure 9 below) when combined to compare graphically the relationship existing between diseases associated with water born diseases and climate variability in year 2010 where the results show that the average rainfall from June and August were approximately zero and temperature was low compared to other months, the rate of dysentery were high and typhoid were low compared to others months and the rate of typhoid was higher between January and March when temperature and rainfall were moderate.



**Figure 9: Data of Rainfall, Temperature, Dysentery and Malaria**  
**Source: STH and TMA (2012)**

This shows that there is relationship between the amount of rainfall and temperature to typhoid and dysentery pathogens. Mr. Peter, a doctor from STH said “The rate of water born diseases is high due to climate variability even though other factors like environmental pollution and agriculture activities are considered”.

In connection to that, a doctor from Nunge hospital said “pastoralism near water sources and deforestation are among the factor for deterioration of water quality affecting human health and measure taken are like planting tree surrounding water sources, educating the community on the importance of treating water from the individual level”

Furthermore, Mr. Edger, a student from Muhimbili said “typhoid and dysentery are heard much in rain seasons because it’s when most of waste are taken to the water body through run off even though typhoid can also be cause by poor prepared food because typhoid is both water and food born disease”

In general the results show that climate change and variability has contributed in water quality deterioration. During rainy season agricultural wastes are taken with water as runoff and deposited to the water body. Which deteriorate water quality as a result affecting the human health through diseases.

## CONCLUSION AND RECOMMENDATIONS

### Conclusion

The findings show that the climate of Morogoro municipal is varying, quality of drinking water is poor and people are much affected by water borne diseases. Water quality has been affected by climate change and variability in term of its appearance (physical condition) plus biological and its chemical condition. This in turn has affected human health as water has been contaminated. This imply that climate change and variability indirectly play part in water deterioration even though there are other factors which bring to synergetic effects to climate change, like population density, human activities such as pastoralism and other economic factors. This is to say that there is a great link between climate change and variability, water quality and human health and cannot be separated but thought how to combat them. Among the ways to combat climate change and variability is to be able to adapt change and in order to

ensure good health water should be re treated in house hold level to reduce the risk of diseases.

## Recommendations

- Water should be well treated before being supplied and during seasons which makes water more vulnerable to pollution and cause human health problems; there is a need to take all recommendation precaution to reduce impacts.
- Pipe line supplying water to different households should be regularly monitored.
- The government should put effort in ensuring good water supply and action should be taken when found distributed water is not safe either due to poor treatment or irregularity of pipe line monitoring.
- Government also should assist the health sectors by reducing cost for the treatment of these diseases example typhoid.
- Lastly every person should take precaution that is, treating water before consuming in household level.

## References

- Alumn, B. (2008). Water treatment solution. Technical University of Delft, Netherlands.
- IPCC (2001). Impacts, Adaptation, and Vulnerability. Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.
- IPCC (2007). Climate Change 2007 Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of IPCC. Cambridge: Cambridge University Press.
- Jones-Lee, A., & Lee, G. F. (2009). Water Quality Evaluation in Domestic Water Supply.
- Makule, D. (1997). Implications of Water and Sanitation to Poverty Alleviation. A paper presented in the National Workshop, 22-23 May 1997. Dar-es-salaam, Tanzania
- Massachusetts water resources authority .<http://www.mwra.com/04water/2004/water.htm>
- Miller k, et al. (2002). Effects of changing climate on weather and human activities. University Science Books Sausalito, California.
- Mwanza, D.D. (2004). Water Utility Partnership for Capacity Building in Africa. Available at <http://www.springerlink.com> [site visited on 24/01/2012].
- Malocho, N. (1997). Minister of State Planning and Parastatal Sector Reform Paavola J. (2006). Livelihoods, vulnerability and adaptation to climate change in the Morogoro Region of Tanzania, Centre for Social and Economic Research on the Global Environment (CSERGE), Univ. of E. Anglia, UK Working Paper, and pp. 9-16.
- Roberge, P. (1999), Handbook of Corrosion Engineering (1st Ed.). McGraw-Hill Professional.
- URT (2000). Poverty Reduction Strategy Paper. Government printer. Dar es Salaam
- URT (2006). Tanzania National Census 2002: Analytical Report. Government printer, Dar es Salaam.
- Water and climate change. [w.w.w climate./topic/water.html](http://www.climate.gov/04water/2004/water.htm). Retrieved 22:10 on December 26, 2011.
- WHO (2007). Guideline for drinking water, Geneva.