Microbial water quality monitoring of raw and treated water sources in Harare and the effect of gender in disaster management due to water related disasters.

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By

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ABSTRACT

Background - Microbial water quality monitoring is essential to the provision of potable water for domestic use. Unsafe water sources increase the risk of waterborne diseases. There is a need to raise awareness of legislature that supports management of water related disasters. Gender, education, health, and economic vulnerability contribute to the success of disaster management. Aim – This study aimed to investigate the microbial water quality of treated water in the Harare area. The study also researched the microbial water quality monitoring practices in Zimbabwe and how these contribute to the management of water borne diseases. The impact of gender, marriage, education, and disease in disaster management practices in Zimbabwe and South Africa was analysed. Method - Literature review was conducted on microbial water quality monitoring practices in Zimbabwe and legislature that supports disaster management. Practices of disaster management in Zimbabwe, and South Africa were investigated and compared. The perspective of the Harare community on the quality of their potable water was investigated through the use of a questionnaire and water quality testing was conducted using hydrogen sulphide test and R2A based heterotrophic plate count. Raw water supplying Manyame River and tap water in Harare households were assessed for microbial quality. Results and Discussion - Raw water sources were found to be contaminated by faecal matter. Household water sources had no faecal contamination, but tested positive for heterotrophic bacteria. The CFU/ml quantities obtained ranged from 1- 452 CFU/ml for all samples. The WHO guidelines for domestic water sources recommend that domestic water should have no coliforms/100 ml sample. Disaster management protocols were available in disaster prone areas such as the Matabeleland South Province. No guidelines were in place for monitoring microbial water quality as a disaster prevention method. Conclusion - The current state of treated water supplied by the Morton Jaffray Treatment Plant was found to be suitable for domestic use, but not sufficient to meet the Harare population's needs. The need to push for legislature supporting microbial water quality monitoring was recognised. Initiating public / private partnerships in water distribution and water quality monitoring in Zimbabwe was encouraged.

Key words: Microbial water quality; faecal contamination; H_2S strip test; R2A agar test; public health, gender, disaster management.

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LIST OF ACRONYMS

AFDB – Africa Development Bank

Aus AID – Australian Agency for International Development

BRICS – Brazil, India, China, and South Africa

CBD – Central Business District

CDC – Centres for Disease Control

CIDA – Canada International Development Agency

CFR – Case Fatality Rate

CFU – Colony Forming Units

CPA – Civil Protection Act

CZI – Confederation of Zimbabwe Industries

DCPC – District Civil Protection Committee

DFID – Department For International Development

DII – Death Inequality Index

DRDR – Disaster Related Death Rate

DRR – Disaster Risk Reduction

EA – Education Act

EII – Enrolment Inequality Index

EMA – Environmental Management Agency

FAO – Food and Agriculture Organisation

G-20 – *Group of key advanced and emerging market economies. Consists of Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, Turkey, South Africa, United Kingdom, United States, and the European Union (IMF, 2016).

G-24 – *Group of 24 countries which sits to coordinate emerging markets and developing countries on international monetary and development finance issues. Consists of Algeria,

Argentina, Brazil, Democratic Republic of Congo, Cote d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Guatemala, India, Islamic Republic of Iran, Lebanon, Mexico, Nigeria, Pakistan, Peru, Philippines, South Africa, Sri Lanka, Syrian Arab Republic, Trinidad and Tobago, and Venezuela (IMF, 2016).

GDR – Death rate from a given cause for male or female citizens per hundred thousand citizens

GPS – Global Positioning System

HDI – Human Development Index

HIV/AIDS – Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome

HPC – Heterotrophic Plate Count

ICDDR, B – International Centre for Diarrhoeal Disease Research, Bangladesh

ICDS – Inter Censual Demographic Survey

ICT – Information and Communication Technologies

IDDP – Integrated Drylands Development Programme

IDSR – Integrated Disease Surveillance and Response

ILO – International Labour Organization

ISDR – International Strategy for Disaster Reduction

JMP – Joint Monitoring Programme

LEABI – Life Expectancy At Birth Inequality index

LFCLS – Labour Force and Child Labour Survey

LGR and UD – Local Government, Rural and Urban Development

LRII – Literacy Rate Inequality Index

MDG – Millennium Development Goal

MEDR – Death rates from medical and surgical errors

MF – Membrane Filtration technique

MIMS – Multiple Indicator Monitoring Survey

MoHCW – Ministry of Health and Child Welfare

MPN – Most Probable Number

MPDA – Zimbabwe Manpower Planning and Development Act

MSD – Meteorological Services Department

MT – Multiple Tube

NCPC – National Civil Protection Committee

NDRMA – Namibia Disaster Risk Management Act

NDRRS – Botswana National Risk Reduction Strategy

NGO – Non-Governmental Organizations

NGWA – The Ground Water Association

NPoDM – Botswana National Policy on Disaster Management

OHCHR – Office of the High Commissioner for Human Rights

PMI – Purchasing Managers Index

POTRAZ – Postal and Telecommunication Regulatory Authority

PSHDR – Death due to intentional self harm

PSI – Population Services International

PWD – People with Disabilities

RTA – Road Traffic Accidents

SADC – Southern Africa Development Committee

SAZ – Standards Authority of Zimbabwe

SDG – Sustainable Development Goals

SEI Index – Secondary Education Inequality Index

SEJDR – Death Rate from the sequel of external injuries

SIDA – Swedish International Development Cooperative Agency

SMEs – Small to Medium Scale Enterprises

SOP – Standard Operating Procedures

SSA – Statistics South Africa

TDR – Total Death Rate

TUDR – Total Death Rate from unnatural causes

TEI – Tertiary Education Inequality Index

UDDR – Undetermined cause and/or intent death rate

UEI – Unemployment Inequality Index

UN – United Nations

UNDP – United Nations Development Programme

UNICEF – United Nations Children's Emergency Fund

UNIDSR – United Nations Integrated Disease Surveillance Reporting

VOIP – Voice-Over Internet Protocol

WASH – Water And Sanitation Hygiene

WGEKN – Women and Gender Equity Knowledge Network

WHO AFRO – World Health Organisation African Regional Office

WHO – World Health Organisation

WOIS – Water Observation and Information System

WOP – Water Operators Partnerships

ZAMCOM – Zambezi Watercourse Commission

ZDHS – Zimbabwe Demographic Health Survey

ZIMSTAT – Zimbabwe Central Statistical Office

ZINWA – Zimbabwe National Water Authority

PREFACE

I would like to acknowledge the Beit Trust, Carnegie Trust and the Rhodes University Scholarship Committee for providing me with funding for this research. I also want to acknowledge my research supervisors, Doctor R. Tandlich and Professor C.S. Srinivas, for their unwavering dedication and commitment to this research. Lastly, I want to express gratitude to my whole family and to my partner, Reginald Ivor Mudehwe, for their continued patience and encouragement whilst I completed this project.

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Publications

Tandlich, R., Luyt, C. D., Wisch, M. H., Madikizela, P., Chirenda, T. G., Pyle, D. M. (2014). Stakeholder participation and sustainable disaster management planning in South Africa. Published in the peer reviewed proceedings from the 1st International Conference on Information and Communication Technologies for Disaster Management paper number 109; 24- 25 March 2014

Chirenda, T. G., Srinivas, C. S., Tandlich, R. (2015). Microbial water quality of treated water and raw water sources in the Harare area, Zimbabwe. (Online) Available at www.ajol.info/inedx.php/wsa/article/view/124959

1 CHAPTER 1

1.1 LITERATURE REVIEW

This chapter seeks to illustrate the importance of access to water that is safe for domestic use. It will also identify guidelines used to determine that a water source is safe for domestic use, according to the Standard Guidelines for domestic water quality in Zimbabwe, and how this compares to the quality of water available for domestic use in the Harare area. The link between shortages of clean potable water in domestic settings and public health will also be investigated. Existing literature will be used to identify the risk that a water source which does not meet the standards for microbial quality of water poses to public health. Microbial water quality monitoring projects previously conducted in Zimbabwe will be analysed, as they form part of the necessary research on environmental and public health. The impact of high microbial loads on potable water sources will also be investigated through the use of prior research in microbial water quality monitoring. The chapter will also provide background information on disaster management in Zimbabwe, and will consider how this has developed over time in response to disasters experienced in the country. It will also seek to address waterborne disease outbreaks as a biological hazard, and to gain insight into the disaster management procedures and legislation addressing waterborne disease outbreaks in the Zimbabwean community. Finally, information on the assessment of microbial risk in other countries will be used to contextualise the prevailing conditions in Zimbabwe, with particular attention paid to the protocols in place for managing disasters as a result of waterborne disease outbreaks.

1.2 Water availability and access to potable water sources

Water is an indispensable human requirement and is critical for development (WHO, 2003; WHO/UNICEF 2013). It forms the basis for domestic services, agricultural and industrial endeavours, and, more importantly, sanitation health. The human right to water is "the right of everyone to sufficient, safe, acceptable and physically accessible and affordable water for personal and domestic use" (WHO, 2003; UN, 2015a; WHO, 2015). The quantity of water available to each person must meet basic human needs in terms of drinking, bathing, cleaning, cooking, and sanitation, and the World Health Organisation (WHO) sets this volume at approximately 50-100 litres per person (WHO, 2003; WHO, 2015). The minimum quality of

household water is dependent on its specific use: drinking water must be safe for consumption, whereas lower standards may be set for water for sanitation (Gleick, 1999; UN, 2015).

In 2002, the United Nations Committee on Economic, Social and Cultural Rights adopted its General Comment No. 15 on the right to water, defined as "the right of everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic use" (OHCHR, 2010). Sufficient quantities of safe water have been the most difficult to achieve. In some regions, sufficient quantities of water are available, but they are not safe for domestic use (NGWA, 2015). In other regions, safe potable water sources are available, but cannot accommodate the populations there. Even though ~70 % of the earth is covered with water, 97 % of this is salt water and ~2 % is glacial water, which means that only ~1 % is freshwater available for potable use (NGWA, 2015). Surface water is the most accessible source for human consumption, which includes livestock production, industry, and domestic purposes, and these uses result in contamination (OHCHR, 2010). According to the United Nations' guidelines for domestic water, safe drinking water is "free from micro-organisms, chemical substances and radiological hazards that constitute a threat to a person's health." (UN, 2015). Table 1.1 below shows the guidelines for domestic water sources according to the World Health Organisation (WHO, 1997). These are the same guidelines used in the Government Analytical Laboratory for the Determination of Microbial Quality of Water in Zimbabwe (Personal communication, 2012).

1.2.1 Table 1.1 Guidelines for Drinking Water Quality 1997

Indicator Organism	**Guideline value (Colony Forming Units/ millilitre) CFU/100 ml**
Faecal coliforms	0
Treated water entering the distribution system Total coliforms	0
Treated water in the distribution system Total coliforms	0

Worldwide, substantial differences are observed in the presence and levels of contamination between countries, between urban and rural regions, and between water source types (Bain et al., 2012). These differences occur due to the varying distribution of bacterial and viral pathogens that cause diseases (Bain et al., 2012). This is why the WHO designs a guideline from which countries may adapt and rewrite their own water quality guidelines, taking their various differences in dominant pathogens for their regions into account (WHO, 2015). Each country is therefore advised by the WHO to investigate and identify the pathogens commonly found in their region, to assist in disease surveillance and pathogen monitoring (WHO, 2015). In spite of the various ranges of water quality allowed for the different applications of domestic water, it is still difficult for most countries to come up with their own country specific guidelines which suit their countries' microbial patterns.

To be termed acceptable, water should be aesthetically appealing in terms of colour, smell, and taste to each individual using it for domestic purposes (UN, 2015). Access to the water source should also be within a reasonable distance. A water source has to be within 1000 metres (m) of a household and collection time from such a source should not exceed 30 minutes (min). For water to be affordable to all, the UN suggests that water costs should not exceed 3 % of a household's income (UN, 2015). In developing countries where unemployment rates are high, and the contrast between the rich and the poor is stark, access to potable water represents a major challenge to most households (Matenga, 2016).

Countries are required by the WHO to ensure that everyone has access to a sufficient amount of safe drinking water for personal and domestic uses (WHO, 2015). They are also obliged to progressively ensure access to adequate sanitation as a fundamental element of human dignity and privacy, and also to protect the quality of drinking water supplies and resources (OHCHR, 2010; WHO, 2015). The obligation to ensure access to safe drinking water for domestic purposes was also addressed by the Millennium Development Goals (MDGs). MDG target 7c aimed to halve the percentage of the world's population without sustainable access to safe drinking water and basic sanitation by 2015 (WHO/ UNICEF, 2013; UN, 2013). This target was met five years ahead of schedule (UNDP, 2015). Between 1990 and 2012, 2.3 billion people gained access to improved drinking water sources (UNDP, 2015). Over a quarter of the world's population gained access to improved sanitation since 1990; however, 48 million people still remained without

access to an improved source of drinking water (UNDP, 2015). The Joint Monitoring Programme (JMP) for Water Supply and Sanitation of WHO/UNICEF cautioned that achievement of this goal took neither the quality nor microbial safety or sanitary status of the water into account (WHO/ UNICEF, 2013; Bain et al., 2014). The JMP for Water Supply and Sanitation of WHO/UNICEF categorized a drinking water source as improved if, by nature of its construction or through active intervention, it was protected from outside contamination, in particular from contamination with faecal matter (WHO/UNICEF, 2013). Improved source types included piped water into dwellings, yards or plots, standpipes, boreholes, and protected dug well or spring water and rainwater (Bain et al., 2014). In 2015, new Sustainable Development Goals were set to fulfil that which had not been achieved in the past 15 years under the Millennium Development Goals (UN, 2015b). Goal 6 of the Sustainable Development Goals (SDG) aims to 'Ensure availability and sustainable management of water and sanitation for all' (UN, 2015b). SDG Target 6.3 aims to 'improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally by 2030' (UN, 2015b). By increasing recycling and water reuse, the need for microbial water quality monitoring becomes imperative.

1.3 Water treatment, water delivery and microbial water quality monitoring practices in Zimbabwe.

Most of the Zimbabwean urban population has been without running water for over 5 years and were only re-included in water reticulation systems in 2011 (Health matters, 2011). This implies that certain iron water supply pipelines have been laying dormant and accumulating bacterial contaminants and rust. WHO statistics indicate that in 1990, 71 % of the rural population and 100 % of the urban population had access to improved drinking water sources in Zimbabwe, compared to 69 % rural and 97 % of the urban population in 2011 (WHO, 2013). This change was not too significant from a statistical point of view and could not have increased beyond the 100 % service mark reached in 1990. Yet as the population grew, access to safe and adequate quantities of water reduced, as did access to proper sanitation (Schwan, 2016; Matenga, 2016). This background has informed the current investigation into the microbial quality of water in Harare and, eventually, the rest of Zimbabwe.

The Environmental Management Agency of Zimbabwe advertises that it has facilities, on which water quality may be tested, for a fee (EMA, 2016). Their website provides an array of microbes for which water can be tested. During this research, there was no evidence obtained, through interviews, of individuals who had made use of this facility to determine microbial load in their domestic water sources. This was mostly as a result of their ignorance of this facility, while others dismissed it as probably expensive before attempting to contact EMA for further information. Total coliforms, faecal coliforms, faecal streptococci as well as agar plate counts at 22 ^{0}C and 37 ^{0}C were listed on the website as some of the microbiological test procedures provided (EMA, 2016).

According to research on the City of Harare website and interviews conducted at the Harare Municipality laboratories, neither hydrogen sulphide nor R2A tests were included in the test procedures currently conducted in Zimbabwe at Municipal level, or at the Harare City Laboratory. Since water quality monitoring procedures are carried out at a Municipal level (Harare City), Ministry level (Government Analysts Laboratory) or by private companies (Zimbabwe National Water Authority - ZINWA), a publicly available reference guide has been unavailable. According to data provided by interviews with laboratory technicians at the Harare City offices, studies are conducted to determine faecal contamination and levels of metal ions, but access to these records for research purposes is not possible. The continued difficulty to deliver safe water for public consumption reflects badly on ZINWA, and this in turn reflects badly on the operations of Zimbabwe's Ministry of Health and the Ministry of Local Government, Public Works and National Housing. The situation is compounded if these records are to be used for studies published outside the country, due to sensitivity of such information, especially if it is misinterpreted. Instead, most of the data available is specific to certain districts, showing results from microbial water quality monitoring as carried out by individuals as part of their dissertations or independent studies conducted by lecturers on the more renowned and heavily contaminated Lake Chivero. The absence of these microbial water quality monitoring records on the public domain resulted in the reliance on other studies conducted by previous researchers as reference guides to this research.

Currently, ZINWA is mandated to provide potable water to the City of Harare (City of Harare, 2016). ZINWA was founded by the Water Act of 1998 to manage bulk water planning and supply (Water Act, 2002). It provides technical support to catchment councils so that they can provide water services to their respective municipalities (Water Act, 2002). It also supervises the provision of safe drinking water to residents in Harare after processing at the Morton Jaffray Plant (City of Harare, 2016). Harare is in the Manyame Catchment area, which is one of seven catchment areas in Zimbabwe, including the Save, Runde, Mzingwane, Gwayi, Sanyati, and Mazowe catchment areas (City of Harare, 2016). Each catchment area provides water to a particular geographical location, with assistance from the town or rural councils contained therein.

The following data provides insight into how microbial water quality monitoring has been carried out in different regions across Zimbabwe. A study by Munyebvu (2011) focused on assessing the variations in groundwater quality in protected and unprotected water sources in a few wards of the Murewa district. In Zimbabwe, there are ten provinces, which are divided into districts, and these districts are further divided into wards for statistical purposes (ZIMSTAT, 2012). The study by Munyebvu indicated that there was a significant difference in coliform levels between protected (1.57 CFU/100 ml) and unprotected water sources (120.83 CFU/100 ml) i.e. boreholes vs. wells and rivers respectively. Protected wells were defined by Munyebvu as "those with brick work lining, heavy concrete slab and in-built or housed lifting device such as rope and washer, well head protection" while unprotected wells were "those with unlined walls, with opening on the surface without proper well head protection and mobile water abstraction device" (Munyebvu, 2011). Munyebvu's study was conducted during the rainy season and it provided valuable input into the coliform counts prevailing in both protected and unprotected water sources in the rainy season, specifically February and March.

Another study by Zvidzai et al. focused on monitoring microbial water quality in rural areas in the Mount Darwin district in Zimbabwe (Zvidzai et al., 2007). Results indicated that the protected wells, swamp area shallow wells, boreholes, and deep wells were contaminated by a minimum of 23 CFU/100 ml to a maximum of 469 CFU/100 ml coliforms (Zvidzai et al. 2007). Both studies provided useful data, but were carried out in a singular time frame, which made it

difficult for comparison across seasons. This brought about the need for more microbial water quality studies which show continuity across seasons while tracing the water quality profile from raw water sources up to the end user. The resources available to this study allowed for the determination of microbial water quality from the raw sources, to the end user on the Manyame Catchment area, but on a small scale.

1.4 Epidemiological surveying of communicable and waterborne diseases in Zimbabwe

The determination of microbial water quality helps in the prevention of water related illnesses and their management once infection has occurred. One of the major signs of water related illness is diarrhoea, and it is aggravating when not managed correctly (WHO/ UNCEF, 2013). Diarrhoea illness resulting from waterborne diseases is one of the major causes of childhood mortality, after tuberculosis and pneumonia (WHO, 2013b). In 2013, Zimbabwean national statistics estimated pneumonia to be the highest cause (21 %) of mortality in children in the age group 1-59 months (WHO, 2013b). HIV/AIDS recorded the second highest rate, with 17 %, followed by diarrhoeal disease with 16 % (WHO, 2013b). In the same year, 13 % of children below 5 years of age had developed diarrhoea in the two weeks preceding the Zimbabwe health statistics survey, compared to 10 % who presented with fever symptoms and 58 % who had anaemia at the same time (WHO, 2013b). Diarrhoea results in major dehydration in affected infants, which makes it difficult to treat them. They end up dying from complete organ failure because their bodies fail to metabolise their medications (WHO, 2013a). Despite this knowledge of the major causes of childhood mortality, it is very difficult to control diarrhoea in either adults or children. Climate, environment, behaviour, and concurrent diseases, such as HIV/AIDS, are all interdependent pathways that determine pathogen transmission (WHO, 2013b). Zimbabwean statistics have shown that most hospitals are understaffed, as a result of the migration of qualified health care personnel to Western countries in search of better working conditions (Chikanda, 2005). When a disease outbreak occurs, it becomes difficult to gather the necessary human resources for a full epidemiology study and complete management of the disease (Chikanda, 2005; AFDB, 2007). Increased access to medical resources and sufficient training and retention of the labour force could therefore improve diarrhoea disease management (FMSP, 2009). Health surveillance data quality can be improved through collaboration between the Zimbabwean

Disease Control Centres and the Integrated Disease Surveillance and Response (IDSR) strategy, under the World Health Organisation African Regional Office (WHO AFRO) (Kasolo et al., 2013).

In 2011, WHO AFRO and the Centres for Disease Control (CDC) trained epidemiology health care workers and district health management teams in Uganda to implement updated IDSR guidelines. By December 2011, Zimbabwe was one of the countries that had implemented training on IDSR (Kasolo et al., 2013). Using records provided by the IDSR team, it was found that perennial Cholera epidemics, exacerbated in urban areas by breakdown of sewerage and water supply and treatment systems, and worsened by declining water and sanitation coverage in rural areas, have resulted in the loss of over 4.6 % of lives out of a total of over 98 000 cases by the end of June 2009 in Zimbabwe (WHO, 2010; Morof et. al., 2013). Access to health services was limited, prolonging the course of the Cholera outbreak (WHO, 2010; Morof et. al., 2013). During the Cholera epidemic of 2008, a specialist team in the area of diarrhoeal disease was deployed to Zimbabwe from Bangladesh to assist in controlling the effects of the outbreak. The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) team, documented important aspects of the outbreak (Ahmed et. al., 2011).

The Crude Case Fatality Rate (CFR) was 5.3 % and over two thirds of these deaths occurred in communities with no access to treatment facilities (Ahmed et. al, 2011). According to the United Nations, the CFR is supposed to be less than 1 % in a disease outbreak that is quickly contained (Zimbabwe Country Analysis Report, 2010; WHO, 2016). In Zimbabwe; Masvingo, Manicaland, Mashonaland West, Mashonaland East, Midlands, and Matabeleland North had the highest recorded CFR of >5 % (Ahmed et. al., 2011). The ICDDR, B team observed the contamination of water sources, regardless of their uses, and a breakdown in sanitation systems all across the affected areas in Harare (Ahmed et. al., 2011). This exacerbated the rate of spread of diarrhoea and prolonged the Cholera outbreak. During this epidemic, five water samples were collected from boreholes and wells to detect the contamination profile in Harare (Ahmed et. al., 2011). All five sources indicated faecal contamination, with 26 CFU/100 ml in borehole and well samples, while tap water samples had a total coliform count of 79 CFU/100 ml. The residual chlorine content found in treated water was 0.06 mg/litre, well below the 0.5-0.2 mg/litre guideline level

in treated water (Ahmed et. al., 2011). These results identified the threat to public health through contaminated water sources. The WHO provided assistance through provision of clean drinking water and learning materials on how to better improve water quality during this outbreak (Ahmed et. al, 2011).

1.5 The impact of the economic status of Zimbabwe in the management of waterborne diseases.

As human development keeps improving in some parts of the country, so does the annual rate of internal migration. Statistical data from the 2012 census indicated that there was significant internal migration of people from their provinces of birth to, mostly, urban areas in Zimbabwe (ZIMSTAT, 2012). The largest net gainer of population was Harare (21 %), followed by Bulawayo (19 %) (ZIMSTAT, 2012). Meanwhile, Masvingo experienced the largest relative loss (-14 %) followed by Manicaland (-12 %) (ZIMSTAT, 2012). Harare is capital city, followed by Bulawayo, which is one of the major cities in Zimbabwe. Masvingo is a city in the Masvingo province, while Manicaland province hails Mutare as its provincial capital. Industrial development in Zimbabwe has mainly been concentrated in the major cities, Harare, and Bulawayo (Chikanda, 2005). Since 2000, there has been a general decline in industrial development in the country (Chikanda, 2005). Regardless of this information, people keep migrating from rural locations to urban centres in search of economic opportunities. The mass internal migration by the population of Zimbabwe to urban areas results in city councils being unable to provide adequate sanitation, as most of the water systems and sewer treatment sites were designed in the 1970s for the White population.

However, even after placing the main focus on these two cities, most of the industries have been shut down due to the volatile economic situation driven by politics, which investors tend to avoid (Matenga, 2016). Unavailability of standard sewage systems and water supplies resulted in the construction of temporary structures (City of Harare, 2016). Increases in urban populations have resulted in growing water demands by cities, industry, and agriculture, affecting sanitation in overpopulated and newly allocated areas of residential settlement (City of Harare, 2016). As a

result of this increase in demand, there have been shortages in treated water supply to most urban populations such as Harare, Bulawayo, Gweru and Mutare etc. (Chigonda, 2010; Manzungu and Mabiza, 2004).

The main sources of water in Zimbabwe were tap water, boreholes, rivers, dams, and rainwater (Nhapi, 2009; Chigonda, 2010). Most of the rural population had been receiving water from wells, rivers, and dams, while the urban population was reliant on tap water. There was also an increase in the number of boreholes and water tanks found among the urban population (Manzungu and Mabiza, 2004). This resulted from the shortage of sufficient water supplied to the neighbourhoods, industries, and town offices requiring potable water for domestic purposes. However, despite the supplementation of domestic water sources, municipal water itself was suspected as a vehicle in the transmission of gastro-enteric diseases (Nhapi, 2009). In 1995, treated drinking water was estimated to be responsible for 35 % of household gastro-enteric infections in Zimbabwe (WHO, 1997).

Most of the waterborne disease outbreaks recorded in Zimbabwe occurred in densely populated areas in towns and in rural areas (Bepete, 2014). Households that used communal water sources for domestic purposes were therefore at the highest risk of contracting diarrhoeal disease if their water source became contaminated (Bepete, 2014).

1.6 Cholera, Typhoid and Rotavirus outbreaks and their management in Zimbabwe

There are over 1.7 billion cases of diarrhoea recorded annually (WHO, 2013). In developing countries, children under 5 years old experience, on average, three episodes of diarrhoea every year (WHO, 2013). Zimbabwe experienced several Cholera outbreaks since the early 1970s, occurring in 5-10 year cycles. Cholera is now an annual occurrence with cases being reported in both rural and urban areas since 1998 (UNDP, 2015). Previous outbreaks were relatively quickly contained by emergency approaches supported by a functioning health delivery system (UNDP, 2015). However, since 2000, outbreaks of Typhoid and Cholera were occurring more frequently, with less efficient response systems available to eliminate the threat (UNDP, 2015). In 2014, a total of 328 people across the country died from diarrhoea linked to the consumption of contaminated tap water (Kavhu, S., 2014). There were 0.2 % deaths in the 34 967 cases of

diarrhoea recorded in January 2014 alone (Kavhu, S., 2014). According to a study published by Manzungu et al. (2012) for Zimbabwe, the Harare City Health Department revealed that the proportion of water samples that failed to meet World Health Organisation (WHO) standards rose from about 8 % in 2001 to about 20 % by 2005 in the city (Manzungu and Chioreso, 2012). The incidence of water-related illnesses, such as diarrhoea, increased as a consequence (Manzungu and Chioreso, 2012). Weekly diarrhoea cases rose from 200 cases in 2004 to about 800 cases in 2008 (Manzungu and Chioreso, 2012). Case fatalities were reported to be high in low income suburbs than in the high income suburbs as high income households could afford health care services and alternative potable water supplies (Manzungu and Chioreso, 2012).

The Cholera outbreaks in 2008 and 2009 affected 6 000 people, with more than 2 % deaths recorded. Between August 2008 and June 2009, a total of 98 592 reported cases and 4.3 % deaths, were mainly experienced in the Budiriro area (WHO, 2009; UNDP, 2015). This arose due to erratic water supplies, uncontrolled sewage intrusions or seepages into the potable water supply, uncollected refuse, and unplanned settlements (Nhapi, 2009). Budiriro and Beatrice Road Infectious Diseases hospitals were established as Treatment Centres to help deal with this outbreak (City of Harare, 2013). Cholera patients were transported to these centres for management and treatment. Statistics from the WHO indicated that there were 60 055 reported cases of Cholera with 4.88 % deaths in 2008 alone (WHO, 2013). In 2009, these numbers rose to 68 153 reported cases, with 3.97 % reported deaths (WHO, 2013). A decade earlier, in 1998, there were 995 cases with 4.42 % reported deaths due to Cholera (WHO, 2013). Another Cholera outbreak in 2010 affected 123 people and caused 3.3 % deaths in Kadoma City.

Between February and May 2010, Zimbabwe experienced a nationwide Typhoid outbreak. There were 448 cases and ~2 % deaths reported from Typhoid disease, mainly from Mabvuku and Tafara, two of Harare's high-density suburbs (AHO, 2015). In October 2011, a Typhoid outbreak occurred in Dzivarasekwa, Warren Park, Kuwadzana, Mufakose, Marlbereign, and in the peri-urban area of Granary (City of Harare, 2013). Causes of this outbreak were found to be microbial contaminated shallow wells in the area, lack of provision of adequate potable water, and poor sanitation (Chaminuka and Nyatsanza, 2008; WHO, 2013). Proper hygiene education and sanitation were provided to the areas worst affected. Severe cases were referred to designated

Infectious Diseases hospitals. Staff at these hospitals were trained by the ICDDR, B team to manage symptoms of Typhoid and Cholera, using the necessary antibiotics for each condition, the extent to which to conduct intravenous infusions, and the salt and sugar solution rehydration method, so that patients referred to these facilities received better health care (Ahmed et. al., 2011). Some cases were never reported due to their long distance from health care facilities, rendering the full impact of this biological hazard, partially documented by local health authorities (Ahmed et. al., 2011). Published reports on the Typhoid and Cholera outbreaks at this time were mainly produced by visiting diarrhoeal disease specialists or International Organisations with manpower in Zimbabwe (WHO, 2013; Ahmed et. al., 2011). The lack of internal country reporting availability for public use increased cynicism toward the Ministry of Health's ability to handle the crisis (Chaminuka and Nyatsanza, 2008). This is an area that would benefit from public interaction of Epidemiology and disease surveillance teams with Zimbabwean citizens. In early November 2011, 30 to 50 new cases were reported daily, and the total case count surpassed 1 500 by February 2012 (Tomasulo, 2012). The outbreak was traced back to chicken and fish contaminated by *Salmonella typhii* sold by street vendors in open-air markets (Tomasulo, 2012). The Ministry of Health and Child Welfare reported another Typhoid outbreak in August 2014 which killed nine people, while 370 new cases were reported in Harare, Mutare, and Chegutu (Relief web, 2015). All of these cases were also purported to have arisen as a result of poor sanitation and water supply services, especially in the high density suburbs of Harare (Tomasulo, 2012).

There have been capacity building exercises with hospital staff annually, arranged by the Ministry of Health, but the outcomes of these exercises have focused on planning, rather than on reviewing implementation (MoHCW 2009 and 2011). However, none of these measures have been intended to cater for water quality disasters. Interventions in Zimbabwe have mainly been developed for disease control and not disease prevention, perhaps due to a shortage of manpower and financing. This led to exercises such as microbial water quality monitoring, receiving minimal attention. This study observed that the Typhoid and Cholera guidelines were developed after the serious Cholera outbreaks experienced in Zimbabwe in 2008-9, and the Typhoid fever outbreaks experienced in the Mabvuku and Tafara area of Harare in 2010 (MoHCW 2009 and 2011). These guidelines were used in the establishment of Treatment Centres, and in trying to

contain the epidemic, but the challenges experienced existed due to limited manpower, limited drug supplies, and limited access to laboratories equipped for detection procedures for problem microbes (MoHCW 2009 and 2011). These guidelines made it possible to maximise on available resources to assist as many people as possible, but, ultimately, the CFR reported indicated signs of weakness in the Epidemic Preparedness Response Protocols, specifically on the part of the health care professionals involved (Ahmed et al., 2011).

Rotavirus is another serious diarrhoea causing organism. Rotavirus is a major cause of severe gastroenteritis and accounts for up to 20 % of deaths in children below the age of 5 years old (WHO, 2007). Rotavirus infection was detected in 41 % of hospitalisations in Africa, 45 % of hospitalisations in South East Asia and the Western Pacific, 40 % in the Eastern Mediterranean and Europe, and 34 % in the Americas in the standardised surveillance conducted between 2001 and 2008 (Payne, 2009). A Rotavirus Surveillance Report by the CDC indicated that there were 527 000 global deaths due to Rotavirus infection in 2004 (CDC, 2006). About 85 % of these deaths were said to have occurred in Sub-Saharan Africa and South Asia (CDC, 2006). From 2006, most countries started implementing Rotavirus vaccination in their immunisation programmes (Payne, 2009). A trial demonstration project was planned for two districts in 2012 and 2013 for Rotavirus and Human Papilloma Virus (ZEPI, 2014). Some infants who received their vaccines at paediatricians' rooms, however, were receiving the Rotavirus vaccine from six weeks of age (Personal communication, 2015).

Kadoma City experienced a Rotavirus outbreak in 2007 which resulted in the mortality of 34 children (Maponga et. al., 2013). A total of 1091 cases of watery diarrhoea were reported between September and November 2011 in Kadoma. Of these, 994 (91 %) were residents of Kadoma City and 552 (51 %) were female. Six hundred and ninety three (64 %) were children below 5 years of age. The incidence rate of diarrhoea among children less than 5 years old was 548 per 10 000 people, whilst for children above 5 years old, the incidence rate was 50 per 10 000 people. The causative organisms that were isolated (*Rotavirus*, *Salmonella spp.*, *Shigella spp.*, and *Escherichia coli*) fit into the average incubation period of 3 to 5 days, which fit the profile of faecal contamination (Maponga et al., 2013; WHO, 2014). Even though the statistics of Rotavirus infection in Zimbabwe showed high mortality rates, they accounted for less than 1 % of Rotavirus related deaths in Sub-Saharan Africa (WHO, 2013). In Zimbabwe, Rotavirus

vaccination was included in the National Immunisation schedule in 2014, but has not been fully implemented in public hospitals.

The high incidence of diarrhoea illness calls for efforts to develop preventive measures in the spread of disease-causing microorganisms through water sources in Zimbabwe. Biological hazards such as Cholera, Typhoid, HIV/AIDS and malaria have defined parameters for assessment and management, which are set by the Ministry of Health (MoHCW, 2011). These protocols were adapted from the Hyogo Framework and the WHO Integrated Disease Surveillance and Response (IDSR) principles (UNIDSR, 2014). Typhoid guidelines provided information on epidemiology, mode of transmission, susceptibility, clinical diagnosis, laboratory analysis necessary for the confirmation of typhoid infection, and the necessary control measures (MoHCW, 2011). They also provided guidelines on how to carry out standard case investigations and control methods (MoHCW, 2011). Other information available included handling of typhoid carriers, safety considerations, and possible drug therapy (MoHCW, 2011). The protocol for the management of Cholera included the early detection of Cholera outbreaks, prevention measures against a Cholera epidemic through ensuring a safe water supply, and protocols on environmental sanitation (MoHCW, 2009). It also contained information on how to make and implement an Epidemic Preparedness Response Plan, which included information on training in case management of Cholera affected patients, and surveillance and case reporting (MoHCW, 2009). These guidelines also provided information on hand washing and chlorination procedures of water sources, as ways to prevent further spread of a Cholera epidemic (MoHCW, 2009). These are some of the areas included in Cholera and Typhoid management, but there was a lot more relevant information available from these documents to assist in managing these epidemics.

Due to the continually fluctuating economic situation in the country, disease outbreaks now occur more frequently than before, and the burden of managing them is prioritised before prevention, which leaves a gap in disaster mitigation and relief programmes for water borne diseases.

1.7 Indicator organisms used for water quality monitoring

Identification and quantification of microbes, which are also known as indicators, assists water quality monitors in determining whether the presence of a specific microbe is detrimental to the health of a community or to the end user of the water source (Köster et. al., 2007). The small quantity of each organism found in the water sample brings about the need to concentrate/multiply, detect, and enumerate the bacteria present in a supplied water sample (Köster et. al., 2007; Sutton, 2010). Bacteria can be concentrated using a membrane filtration technique, viruses through an adsorption/elution technique, and protozoa through the cartridge filtration method (Köster et. al., 2007). In the membrane filtration technique, a water sample is filtered, and the filter is subsequently placed on a growth medium suitable for the proliferation of the required microbe (Köster et. al., 2007; Clarke, 1953). In the pour plate technique, volumes of 1 ml of a water sample are poured onto an agar plate and allowed to grow. The spread plate technique utilizes volumes of about 0.1 ml to 0.2 ml spread and allowed to grow on an agar plate (Köster et. al., 2007). Large volume liquids require dilution of up to ten times and these are poured through membrane filters and enumerated on filter paper. Filter papers of approximately 47 mm in diameter are then incubated on a solid medium or on pads soaked in liquid medium or enrichment broth (Köster et. al., 2007). Liquid techniques may also be used for the detection of target microorganisms, in a presence/absence test, in addition to quantitative procedures, as seen in the hydrogen sulphide test. A positive result would then necessitate the membrane filtration technique to determine the contamination levels by quantifying the bacteria.

Each technique has its advantage over the others. Membrane filtration technique is more flexible in terms of the volume of the sample used, increasing its precision (Sutton, 2010). Chemicals and solid particles adsorbed onto the surface of the filter from the sample may, however, interfere with the growth of the target organism, especially if they interfere with the nutrient broth used for culturing the microbes (Sutton, 2010, Clarke, 1953).

If testing treated water samples, quantitative procedures such as membrane filtration or pour plate techniques may help in detecting whether a microbial load exceeds the stipulated maximum level for the specific organism (Sutton, 2010). Most probable number (MPN) presence/absence tests, the pour plate and spread plate techniques are relatively inexpensive in terms of media and labour (Köster et. al., 2007). Using the spread plate technique, however, makes it easier to differentiate colonies. MPN requires tenfold dilution and works well if there is particulate matter

that interferes with plate count enumeration methods (Sutton, 2010). It also requires more space for incubation since at least three dilutions per tube are made, to increase the level of accuracy of the procedure (Sutton, 2010). MPN is a semi-quantitative procedure that shows turbidity in the incubated test tubes as an indicator of the presence of microbes (Sutton, 2010). It also helps in the identification of microbes occurring in small quantities, such as those less than 25 CFU/ ml, e.g. *Salmonella spp*. This procedure, however, requires many steps and more time and skill to carry out, but the results are more precise, at a 95 % Confidence Interval (Köster et. al., 2007; Sutton, 2010). Another example of qualitative tests is the hydrogen sulphide test. Most bacteria produce hydrogen sulphide using peptone or cysteine as the source of sulphur (Clarke, 1953). The method for the hydrogen sulphide test depends on the source of sulphur and on what metal salts are used to indicate hydrogen sulphide production. This study was conducted using the hydrogen sulphide test in its modified form developed by Catherine Luyt et al. (Luyt et al., 2011). Some of the media for pour plate technique and spread plate technique include R2A and McConkey agars.

Other methods are now available for the detection of microbes in water. Chromogenic media based detection methods provide either qualitative results in a 100 ml sample, or quantitative results in a proprietary tray that separates the sample into a series of test wells and provides a MPN/100 ml (Köster et. al., 2007). This procedure yields results within 24 hours (h) and has been used to enumerate *E. coli*, Enterococci and Coliform bacteria. Examples of the media include Enterolert®, Colisure®, Chromocult®, Microsure® and m-ColiBlue®.

The ease of procedure, sensitivity, and precision for the required microbes was considered in the selection process of the methods used in this research. Hydrogen sulphide testing and R2A agar were selected to concentrate, identify, and enumerate bacteria.

Microbial water quality monitoring involves the assessment of water samples for indicator organisms associated with certain diseases (WHO, 1997). In this assessment, researchers monitor the threshold acceptable in water samples and, when this threshold is exceeded, implement measures to reduce the microbial load, either by adding more chemicals in the purification process, or completely changing the purification method (Neumann, 2005). Some of the indicator organisms in question include *E. Coli, S. typhii* and *Campylobacter spp.* Microbial water quality monitoring provides valuable information for assessing source protection needs,

sanitary surveys, setting treatment levels, determining treatment efficiencies, and understanding the epidemiological characteristics of outbreaks, all of which are valuable for protecting public health (Medema et al., 2004; Neumann, 2005). The monitoring of the microbial quality of water is therefore an essential tool in maintaining human health.

In most cases, optimization of water treatment processes is most challenging when the quality of raw water coming into a treatment plant is poor due to inadequate sewage treatment (Medema et. al, 2004). In Zimbabwe, raw sewage is discharged into Lake Chivero, which pours into the Manyame River, the source of raw water for the Morton Jaffray Treatment Plant (City of Harare, 2016). Increasing quantities of raw sewage into Manyame River increases the need for Harare City to purchase chemicals to treat water at the Treatment Plant (City of Harare, 2016). The situation is aggravated when treatment chemicals are limited for the required population, or when the cost of treating water gradually increases due to an increase in leakages in the reticulation system, reducing the volume that reaches reservoirs scattered all across Harare (Medema et. al., 2004; City of Harare, 2016). Shortages in treatment chemicals reduce the quantity of water available for distribution, and this in turn affects the pipelines which transport treated water, making them a possible harbour for pathogens (Gogo, 2015).

Provision of safe drinking water requires a holistic approach, which includes a detailed knowledge of microbial threats from the treatment source to the tap inside a household (Medema et al., 2004; Neumann, 2005). Microbial water quality monitoring along the supply chain therefore becomes a necessary and very important assignment. The primary function of using bacterial indicator organisms and microbial water quality monitoring for water quality analysis is to help assess the overall public health risk. The provision of contaminated potable water to households increases this public health risk to the community (Gogo, 2015).

E. coli, thermotolerant coliform bacteria, coliform organisms, and faecal *streptococci* have been used as indicator organisms for microbial contamination of water sources. *E.coli* grows at 44.5 ± 0.2 ^{0}C on complex media and it ferments lactose and mannitol, producing acid and gas. It is abundant in human and animal faeces, attaining concentrations of up to 10^{9} per gram (Neumann, 2005; Luyt et. al., 2012). It may be found in sewage, treatment effluents, and all natural water

and soils that have been subject to recent faecal contamination, either from human, animal, or agricultural activities. The presence of *E. coli* in treated water would indicate treatment inefficiency (Neumann, 2005).

Thermotolerant coliforms are able to ferment lactose between 44 and 45 ^{0}C, and their concentrations in contaminated water are usually directly related to that of *E. Coli* (Todar, 2012). They originate from organically enriched water and their growth indicates the presence of bacterial nutrients (Todar, 2012). Thermotolerant coliforms are readily detected and have a secondary role to play as indicators of the efficiency of water treatment processes in removing faecal bacteria (Todar, 2012). Not all thermotolerant coliforms may be used as indicators of faecal contamination: *Klebsiella spp* may be found on plant material, surface water, soil, and plants (Podschun and Ullmann, 1998). Their other habitat is the mucosal membrane of humans, horses, and swine which they colonise (Podschun and Ullmann, 1998). Identification tests will therefore need to be carried out to differentiate between the various coliforms. These may also be used to assess the treatment necessary for waters of different quality (Podschun and Ullmann, 1998).

Coliform organisms (total coliforms) are fairly easy to detect and enumerate. They grow in the presence of bile salts or other surface acting agents with similar growth inhibiting properties (Rompre, 2002). They can be found in faeces, nutrient rich (Nitrogen and Phosphorus) waters, soil, or decaying plant material (Rompre, 2002). They may also be found in relatively good quality drinking water, where they could also multiply. Their presence in drinking water indicates inadequate treatment, post-treatment contamination, or a high concentration of nutrients (Nitrogen, Phosphorus) (Todar, 2012). They may be used as additional indicators of treatment efficiency and may be used for the routine control of recently repaired or newly installed systems (Todar, 2012). In microbial water quality monitoring, there should be no Colony Forming Units (CFU) / 100 ml sample of water, while no E. coli is expected in a domestic water source (WHO, 1997). Since total coliforms are process indicators, they may not be ideal for routine monitoring of water sources that have not been treated using the chlorination process (FAO, 2016).

Heterotrophs require organic carbon for growth, and they include bacteria, yeasts, and moulds (WHO, 2003). Heterotrophic plate count procedures generally require temperatures of 20 - 40 ^{0}C, incubation times from a few hours to a few weeks, and varying nutrient conditions (WHO,

2003). The R2A based heterotrophic plate count procedure employed here required temperature conditions of 22- 28 ^{0}C and a growth period of 5-7 days, without need of an incubator. This was ideal for the field research in Zimbabwe, far removed from the laboratories and incubators at Rhodes University, South Africa.

1.8 Challenges in water quality monitoring

In Zimbabwe, water quality monitoring is not conducted with hydrogen sulphide testing or R2A based heterotrophic plate count. Given the economic instability in the country, these low cost tools for water quality monitoring are ideal. The hydrogen sulphide test, as modified by Luyt et al., is a low cost tool ideal for settings with low incomes (Luyt et. al., 2011). The low cost of this method permits regular water quality monitoring, which can then assist in accurate record keeping of the water quality in households (Luyt et. al., 2011). Irregular measurements of water quality tend to overestimate safety, and so a good strategy would be to combine sanitary status with water quality measurements (Bain et al., 2012). In those communities with access to sanitation, measurements of water quality help to determine the risk of contamination of water sources as a result of sanitation practices.

While there is concern regarding the potential for post-collection contamination of water, other comparative studies suggest that source water quality is still more significant than water storage practices in determining water quality and diarrhoeal disease incidence (Alexander and Blackburn, 2013). The burden of water-related disease varies according to context and is highest in low-income settings, where diarrhoea remains a leading cause of mortality in children under five years old (Liu et al., 2012). Microbial water quality monitoring therefore needs to be carried out at household, reservoir, and at source level. Previous research in Zimbabwe has been conducted on water quality determinations in areas near Lake Chivero. There have been studies in other areas outside of Harare, but they have all been conducted for educational purposes in undergraduate or postgraduate studies. Continuity of this data has been the main limiting factor because once the researchers finish their undergraduate programmes, they have gone on to work in Environmental health organisations or similar. However, they have not produced follow up research on the microbial water quality monitoring projects which they previously conducted, and neither has there been a trend in water quality reporting from year to year, even from academic institutions, for specific water sources in Zimbabwe.

The economic instability which is affecting the country since the year 2000 impacted significantly on socio-economic development (The Financial Gazette, 2014). Zimbabwe resorted to using foreign currency to trade locally since the Zimbabwean dollar had lost its value (The Financial Gazette, 2014). High percentages of inflation, coupled with high unemployment indices, placed a strain on the industrial sector and many employees were laid off (The Financial Gazette, 2014). Since the reduction of industrial production, manmade disasters in the industrial sector have been recorded as minimal (ZIMSTAT, 2013). Manufacturing industries in Zimbabwe reduced production when ownership changed from foreign investors to local business operators (The Financial Gazette, 2014). This reduction had not been anticipated and it resulted in the liquidation of many industrial organizations through auction in order to meet the salary demands and retirement packages of employees.

Those manufacturers that remained in operation experienced inconsistent power supply, limited human resources, a lack of raw materials, and an overall inconsistency in the quality of processed goods (The Financial Gazette, 2014). Reduced confidence in the manufacturing industry is inimical to its continuation, since customer satisfaction and confidence in the products translate into increased demand. In any manufacturing company it is necessary that throughout production processes, a set of Standard Operating Procedures (SOPs) is followed, to ensure that products meet the standards stipulated for local supply and export, as determined by the Standards Authority of Zimbabwe. Due to the problems mentioned above, the country therefore continued to function with a manufacturing industry that was operating below capacity, while the prices of its products continued to rise in order to meet production costs (The Financial Gazette, 2014).

The Confederation of Zimbabwe Industries (CZI) released statistics in 2014 indicating the industrial status of the country. The Purchasing Managers Index (PMI) stood at 43.5 %, which indicated an economic decline (The Financial Gazette, 2014). PMI is a diffusion index that is used to evaluate new orders, inventory levels, production, supplier deliveries, and employee conditions. Production stabilized at 50 % while all other indicators showed a decline (The Financial Gazette, 2014). A PMI under 50 % indicates that the manufacturing sector is contracting, while anything above 50 % indicates growth and expansion of the industry (The Financial Gazette, 2014). The country's industrial capacity utilization level continued to decline

since 2011 due to unavailability of working capital. This was declared by the President of the Confederation for Zimbabwean Industries (The Financial Gazette, 2014). This resulted in people preferring to purchase manufactured goods from neighbouring countries, which were of better quality and were more reasonably priced, encouraging cross-border trade (FMSP, 2009). Cross-border trading opened doors to violence in the form of xenophobia, human smuggling and trafficking, and gender based violence to vulnerable women travelling long distances alone (FMSP, 2009). The children left behind when the parents went in search of economic sustenance became vulnerable to violence and disasters as they were ill prepared to handle them (FMSP, 2009).

The reduction in formal employment also reduced taxes available for the city's development. Shortages in water supply led communities to seek alternative water sources to cater for their domestic needs (Health matters, 2011). Meanwhile, in the Harare Municipality, it became less important to monitor water quality outside the Treatment Plant, as there were limited funds to purchase the necessary chemicals for treatment of raw water (Chaminuka and Nyatsanza, 2013). As such, microbial water quality monitoring was now being conducted at Water Treatment Plants, Harare City laboratories, and some private water quality testing laboratories (Bepete, 2014). In other parts of the country, the mandate to provide piped water was divided between ZINWA and the towns' specific municipalities. In Mutare, Pungwe River, which supplied Mutare City with water, supplied only the city and not the Mutasa Rural villages located along the river banks (Chiketo, 2015). The piped water system was designed to supply both the town and villages, but this was not happening in 2015 (Chiketo, 2015). In Gweru, water shortages were predicted, with the main water source, Gwenoro River, at 46 % holding capacity and the supplementary Amapongokwe River at 60 % holding capacity and they were decreasing rapidly as at March 2016 (Chadenga, 2016). Gweru City council blamed its shortfalls on erratic ZESA availability to power the piped water distribution system. It anticipated more disruptions in the water supply network due to a loss of 13 tonnes of copper cables to vandalism and theft at the ZETDC department (Chadenga, 2016). In Bulawayo, the holding capacity of the dams also decreased rapidly, with the main rivers, Insiza and Mtshabezi, holding 58 % and 70 % of their respective capacities as at March 2016 (Ndhlovu, 2016). The Bulawayo City council therefore tightened its daily water supplies, and restricted low density areas from 750 litres to 550 litres per day, hotels, hospitals and clinics to 90 % of their usual supply, and police stations, army

barracks, and prisons to 60 % of their usual allocation (Ndhlovu, 2016). The reduction in funding available for water treatment, as well as the reduced water levels in dams, all impacted on the provision of treated water available for human consumption. This reduction in volume in turn resulted in the use of alternative water sources to Municipal supplies, and the main concern became accessing adequate quantities of water required for each family's use. Shortage of treatment chemicals and foreclosure of industries increased the cost of acquiring treatment chemicals, and the cost of maintaining the old treatment plants, and more focus was placed on addressing this crisis first, before addressing water quality monitoring.

Another challenge affecting water treatment and distribution was drought. Zimbabwe experienced the effects of El Nino from 2012 to 2014 (The Zimbabwe Mail, 2016). This led to drought conditions and the drying up of groundwater sources used for agriculture, and resulted in crop failure after the lack of rainfall (The Zimbabwe Mail, 2016). The main rivers that supplied most of Zimbabwe's catchment areas were now operating below capacity, and this resulted in rationing of water supplies and exacerbated water shortages for those receiving piped water (Ndhlovu, 2016; Chadenga, 2016 and The Zimbabwe Mail, 2016). According to a 2012 World Bank Report, dam levels were expected to fall by up to 50 % by 2080 due to the effects of climate change in Africa (The Zimbabwe Mail, 2016).

In order to assist in the provision of alternative water sources, boreholes were constructed by the Municipality or Non-Governmental Organisations (NGOs) for communities at focal points (Kavhu, 2014). Boreholes were also constructed at individual households, but they also supplied a portion of the neighbourhood due to the absence of tap water (Kavhu, 2014; Kawadza, 2016). Without knowledge of the imminent hazard of using a common unprotected water source, residents ran the risk of spreading contamination rapidly in the event of an outbreak of Typhoid or Cholera (Kavhu, 2014; Kawadza, 2016). This also limited the ability to implement disaster preparedness plans in disaster prone areas, since the necessary resources for management of a disaster became more difficult to acquire for each community (Kavhu, 2014; Kawadza, 2016). Scarcity of information and the scarcity of water treatment chemicals increased the community's susceptibility to waterborne disease outbreaks and other water related disasters (Kavhu, 2014; Kawadza, 2016).

Microbial water quality monitoring requires skilled staff, water quality testing kits, record keeping staff, medical resources to counter contamination, and financial resources to pay the staff conducting these studies. Without adequate financing, water quality testing becomes a complicated task. As a result, it is fair to assume that the economic situation in the country was a contributing factor as to why periodic microbial water quality monitoring was not being carried out.

1.9 Legal framework for disaster risk reduction

Given that the economy is not conducive to periodic microbial water quality testing, this study investigated the Legislature in place which could support water quality monitoring if all the necessary resources were available. The following information was extracted from the Government of Zimbabwe's parliamentary website, which provides a list of Acts of Parliament. The Zimbabwean Government committed to ensure disaster risk reduction to its population since the early 1980s (Betera, 2011). In 1989, the Civil Protection Act (CPA) (Number 5 of 1989) was designed to cater for disaster preparedness, in response to natural and man-made disasters. The mandate of this Act was "to establish a Civil Protection organisation and provide for the operation of Civil Protection services in times of disaster; to provide for establishment of a fund to finance Civil Protection; and to provide for matters connected with or incidental to the foregoing" (CPA Chapter 10:06). The CPA had been updated with a more recent version through the Statutory Instrument 22 of 2001. According to the Civil Protection Act, the Director of Civil Protection, assigned to the post by the Minister of Local Government, Rural and Urban Development, is responsible for executing this Act (CPA Chapter 10:06 section 3 part 1). The Director is responsible for the establishment of Civil Protection organisations in Civil Protection areas, directing personnel and material services for this Act, and for promoting research into matters relating to Civil Protection and disseminating such information (CPA Chapter 10:06 section 3 part 2a-2h).

The CPA then dictated that there shall be a National Civic Protection Committee (NCPC) with the Director sitting as the chairman, and consisting of other members as follows: Secretary for Health; Commissioner of Police; Commanders of the various branches of the Defence Forces; Secretary General of the Zimbabwe Red Cross Society; Director of Prisons; Director of Civil

Aviation; a representative of the fire brigades; and three other members appointed by the Minister for their expertise in matters of Civil Protection (CPA Chapter 10:06 Section 4 part 2a-2i). The Department of Civil Protection is managed under the leadership of the Ministry of Local Government, Public Works and National Housing. The head office is run by the department head, called the Director, and seven other staff members (MLG 2016). The requirements of the Civil Protection Act in terms of staffing and the implementation of disaster management programmes were not observed. Records on how the requirements of the Civil Protection Act are being implemented, as well as on the progress of the enactment of the Disaster Management Bill, were unavailable.

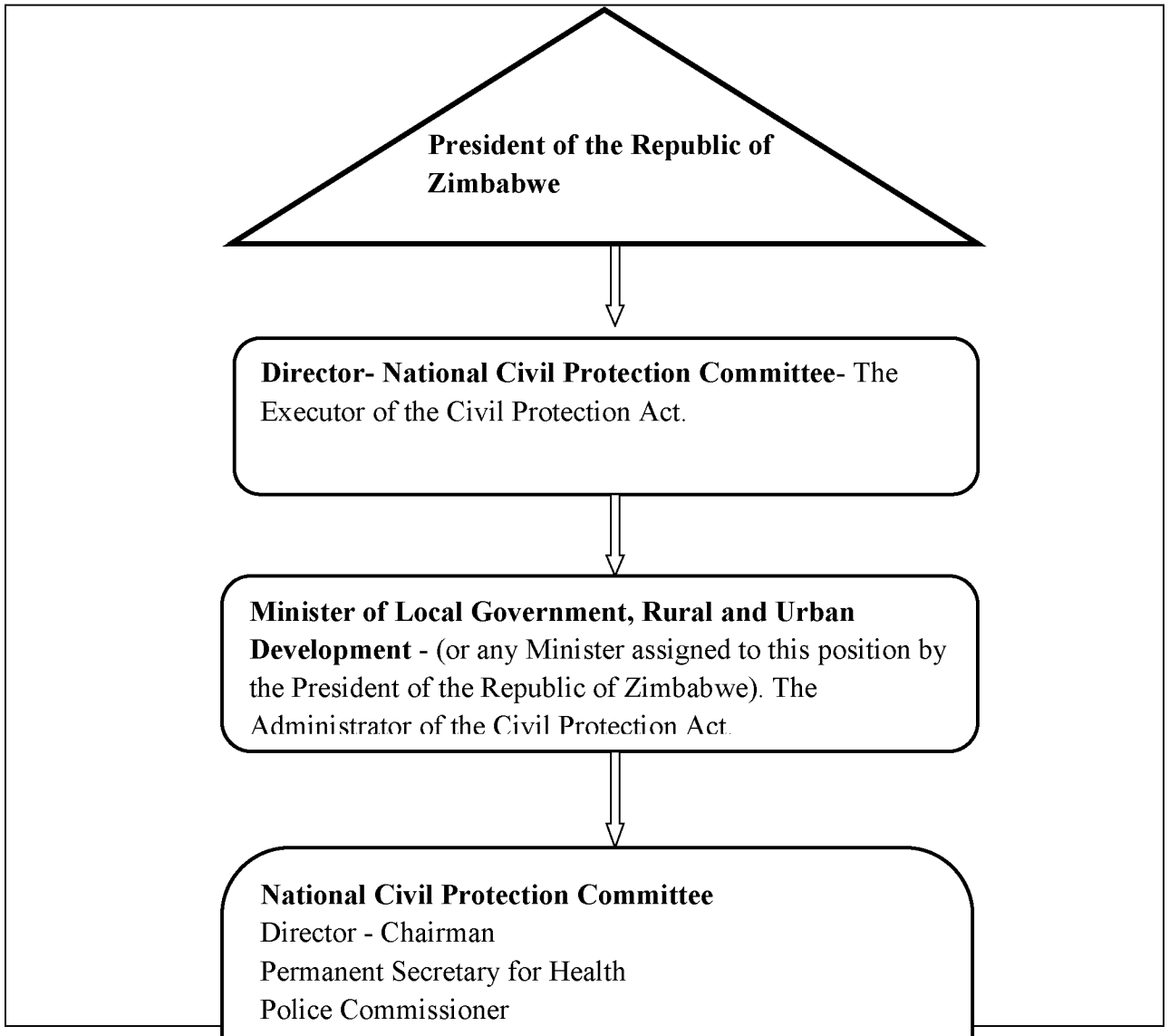
When necessary, the NCPC is permitted to establish subcommittees that execute its functions (CPA Chapter 10:06 section 6 part 1). The Director may also appoint planning committees to prepare plans in terms of any aspect of Civil Protection in any Civil Protection Province, or in any Civil Protection Area (CPA Chapter 10:06 section 9). Provincial Civil Protection officers and their assistants may be appointed by the Minister through the statutory instrument or on the advice of the Director (CPA Chapter 10:06 section 14 part 1 and part 2). They are responsible for coordinating the planning of Civil Protection measures, training personnel, and advising and assisting area Civil Protection officers in the execution of their duties (CPA Chapter 10:06 section 13). In the context of water borne diseases, the Director and staff of Epidemiology and Disease Control in the Ministry of Health would train health personnel. As shown by the reports published through the Ministry of Health, the training of technical staff and sourcing of the material required for managing a disaster is recorded when carried out (MoHCW, 2009 and 2011). For example, the Typhoid and Cholera outbreaks occurring from 2008 to 2011 resulted in revision of the guidelines, the allocation of resources to treatment facilities, and the sourcing of external experts to assist in managing these two epidemics (MoHCW, 2009 and 2011).

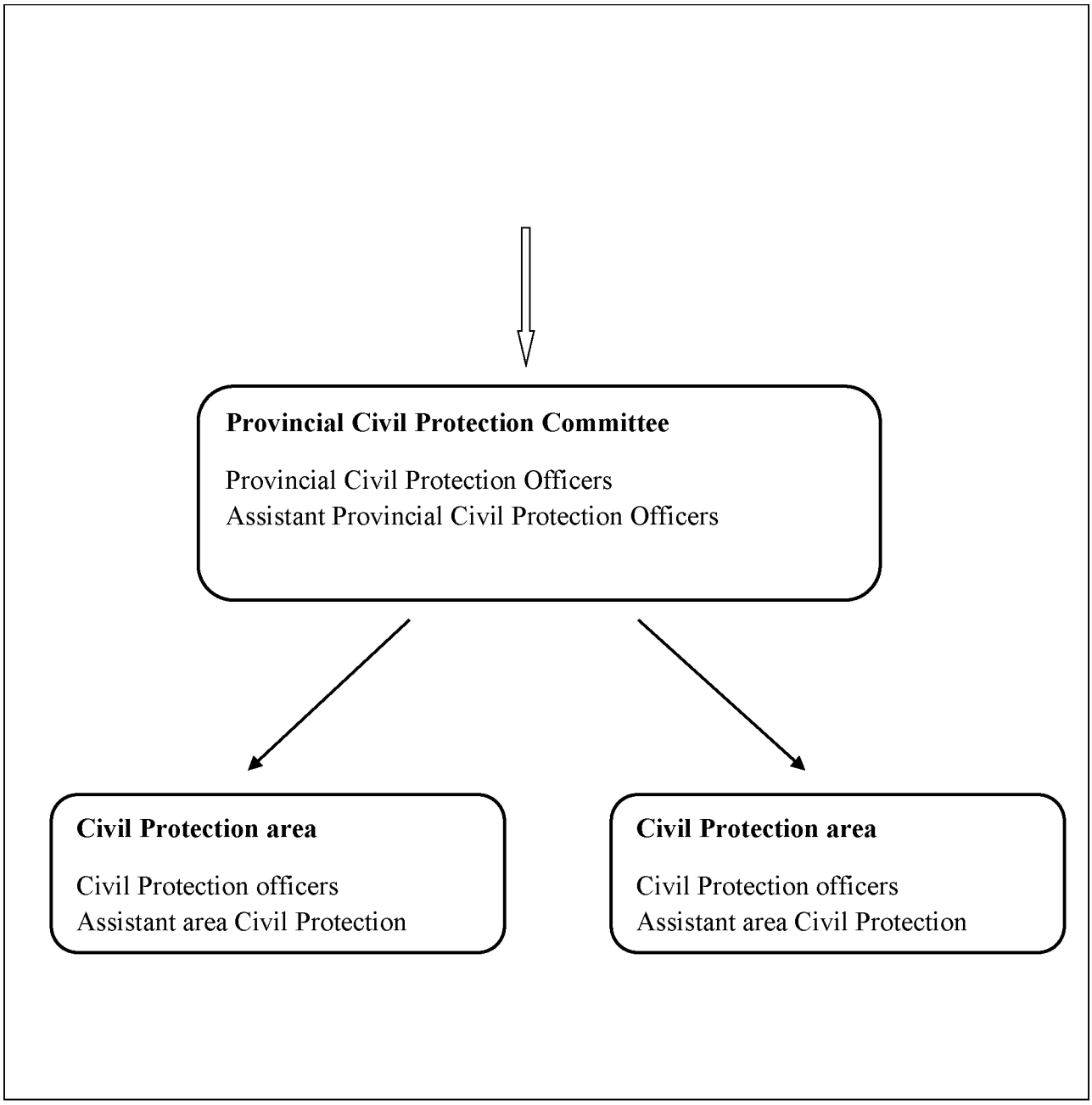
Volunteers are also welcomed to serve in the Civil Protection organisation by applying to the area Civil Protection officer concerned (CPA Chapter 10:06 Section 20 part 1). Volunteer duties include performing any duties connected with Civil Protection in the Civil Protection area, and to comply with any reasonable instructions from the area Civil Protection officer (CPA Chapter 10:06 section 20 part 3). In Zimbabwe, volunteers to disaster preparedness programmes have

been observed mainly through the Red Cross Society and Action Aid organisations, rather than directly through the Department of Civil Protection in the Ministry of Local Government.

The Civil Protection Act states that "every citizen of Zimbabwe should assist where possible to avert or limit the effect of a disaster" (Civil Protection Act Chapter 10:06). The Central Government initiates disaster preparedness programmes through the relevant ministries, with local administration taking the responsibility for implementing and maintaining their effectiveness (Civil Protection Act Chapter 10:06).

The following diagram represents the various sectors represented in the Civil Protection System of Zimbabwe.





1.9.1 Figure 1.1: The structure of the Civil Protection System in Zimbabwe

The Civil Protection system in Zimbabwe is not a separate Ministry, but a department within the Ministry of Local Government, Public Works and National Housing (GoZ, 2016). It receives its core strategies from the Minister of Local Government and reports its activities to that minister (GoZ, 2016; Civil Protection Act Chapter 10:06). The Department of Civil Protection in Zimbabwe does not benefit from a dedicated team of specialists in various sectors that need

attention, such as microbial water quality monitoring, statisticians, nurses, doctors, or civil engineers, to mention but a few. Instead, it operates on a staff contingent of eight to carry out the activities that in other countries require more than five departments and department heads, with subcommittees (GoZ, 2016). Disaster risk management requires representation at national, provincial, district and local authority level to establish tangible results in the face of disasters. Networks need to be set up which continually provide feedback and updates on how best to manage disasters in the different Ministries that take part in disaster management. By way of example, microbiologists involved in determining water quality after a flood disaster need to provide their data to pathology laboratories, which would then provide their microbial culture sensitivity test results to the Ministry of health. This would ensure efficient distribution of medical resources to disaster struck communities. In the same circumstance of a flooding disaster, local authorities would be the best source of information for community leaders on disaster preparedness, and if they constantly interact on the same platform as the health care workers attending to disaster struck areas, they reduce the burden of grassroots education of communities on their health counterparts, and assist their communities in gaining resilience in the face of disasters. Civil Protection is considered as a subject area in Zimbabwe that can be addressed as and when needed, in cases of crisis, rather than as a functioning Ministry that carries out tasks in flood and drought disaster management, waterborne disease prevention, and general improvement of social preparedness for disasters (GoZ, 2016). The Director of Civil Protection in Zimbabwe is responsible for providing annual assessments in those areas which have been focused on in disaster management, and each year provides a progress report. One of these areas is the satellite generated flood management programme started in 2002 (Nyamukondiwa, 2016). The framework is informed by previous flood experiences such as the Tokwe- Mukosi floods of 2014 (Nyamukondiwa, 2016). The framework is based on a geo-database which uses modern technology to understand flood risk, mitigation and preparedness (Nyamukondiwa, 2016).

For the sake of comparison, this study also considered the Civil Protection systems in Namibia, Mozambique, and Botswana. In Namibia, the Disaster Risk Management Act (NDRMA) was signed into effect in 2012, and its mandate was "to provide for the establishment of institutions for disaster risk management. It also sought to provide for integrated and coordinated disaster management approach that focuses on reducing the risk of disasters, mitigating the severity of

disasters, emergency preparedness, rapid and effective response to disasters and post disaster recovery. Finally, it was also set up to provide for the declaration of national, regional and local disasters and provides for the establishment of the National Disaster Management Risk Fund" (NDRMA, 2012).

In the provisions of this Act, the Prime Minister is responsible for the administration of the Act, which includes initiation, formulation and development of policies on all matters pertaining to disaster risk management; and advising the President, Cabinet, and disaster institutions on matters regarding disaster risk management (NRDMA 2012 Section 2 part 1a-1c). In Zimbabwe, the Director of Civil Protection reports to the Ministry of Local Government, not to the President, unless there is a state of emergency, during which information is communicated to the Ministry, and that information is forwarded to the President immediately.

There are many committees responsible for disaster risk management in Namibia, and these are subdivided as follows: The National Disaster Risk Management Committee; the Directorate: Disaster Risk Management; the Namibia Vulnerability Assessment Committee; the Regional Disaster Risk Management Committee; the Constituency Disaster Risk Management Committee; Local Authorities Disaster Risk Management Committee; and the Settlement Disaster Risk Management Committee. Some of these committees mirror those found in Zimbabwe, with the exception of the Namibia Vulnerability Assessment Committee. Even though these committees are enforced by the Civil Protection Act, their functions are not visible to the public, and their performance is not well documented.

The Namibia Vulnerability Assessment Committee focuses on collecting vulnerability information of a society to pending disasters once they are identified (NRDMA 2012 Section 13 part 2a). It also collects information on the prevailing food security status and tracking indicators, in order to provide early warning on pending disasters, and to guide rural development strategies (NRDMA 2012 Section 13 part 2a). It informs on issues of poverty reduction and social safety net programming. This committee also analyses the outcomes of a disaster on livelihoods and the coping mechanisms after a disaster (NRDMA 2012 Section 13 part 2b). It stores and records Vulnerability Assessment information, and trains regional officials on Vulnerability Assessment and Monitoring Early Warning Information (NRDMA 2012 Section 13 part 2b-h).

A report on the Integrated Dry lands Development Programme (IDDP) was published in 2011 (UNDP, 2011). This programme was launched by the Namibian Government and the United Nations Development Programme. The IDDP addresses issues such as mainstreaming dry land problems into national policy and developmental frameworks, reducing the vulnerability of communities to economic, socio-cultural, and environmental challenges, as well as improving local governance of natural resources (UNDP, 2011). This programme focused on management of disaster risks such as flooding and droughts in Namibia. Activities carried out involved capacity building for disaster risk management and climate change in target dry land communities. Communities in the Ondobe Constituency of Namibia provided the following outcomes of this project (UNDP, 2011): Mobilisation and sensitisation of stakeholders was carried out to bring together members of the Community Development Centres, the Disaster Risk Management Committee, and the Ministry of Agriculture, Water and Forestry. Capacity building tools were developed at community level for disaster risk management and climate change (UNDP, 2011). These were converted into the vernacular for further local use. Community awareness was raised in the communities that participated, the problems they face were used to develop capacity building tools for training, and to develop measures for the disasters affecting them (UNDP, 2011). Measures taken to build capacity for disaster management included relocating communities to higher ground, embarking on practises that reduce the negative effect of disasters, and transmitting this information to other members of the communities (UNDP, 2011). There were also collaborations formed in the area of climate change and disaster risk management, such as those between the Constituency Development Committee and the Ohangwena Regional Council, which were already established in disaster risk management (UNDP, 2011). In Zimbabwe, this could be incorporated into communities as well, making vulnerable groups participants in disaster management programmes. Records show that this area has been dominated by Non-Governmental and humanitarian organisations that focus on specific areas of vulnerability, and that these equip communities in ways to reduce their disaster vulnerability (WHO/UNICEF 2013; WASH Atlas, 2008-9).

The Namibian Disaster Management Act was designed in such a way that accommodates the use of tracking indicators, early warning information, previous methods used in addressing disasters, and new recommendations to be used in case such a disaster occurs again. In terms of waterborne diseases, this means that Namibian disaster management teams are able to refer to

previous disasters and how they were managed when responding to new disasters. This specific aspect of the Namibian Disaster Management Act is one that should be incorporated into the Zimbabwean setting, so that draft guidelines for disaster management are not repeated, focus areas for disaster management are specified and widened to include neglected subject areas, and progress markers are established, with future targets set in a transparent and progressive manner. This kind of system would ensure that for every disaster management effort financed either by the Government, or by humanitarian aid, there are clear accountability records that indicate the use of finances, so that organisations and Government do not repeatedly fund non-performing disaster management projects.

The Botswana National Policy on Disaster Management was formulated in 1996 and has been augmented by the introduction of the National Disaster Risk Management Plan of 2009 (NDRRS, 2013). The country also has the National Disaster Risk Reduction Strategy (NDRRS) for 2013-2018 as a guide and framework for Disaster Risk Reduction implementation (NDRRS, 2013).

The National Policy on Disaster Management deals with mitigation, preparedness, response, and recovery, as well as development in Botswana (NPoDM, 1996). In this setting, disaster mitigation refers to the plans, strategies, and actions to reduce the population's vulnerability to future disaster (NPoDM, 1996). Disaster preparedness involves the plans, procedures and actions taken to ensure effective responses to future disaster strikes (NPoDM, 1996). Response refers to the actual operations taken immediately after a disaster to provide assistance and support to stricken populations (NPoDM, 1996). Recovery refers to the actions taken after providing first aid for the survival of disaster stricken communities (NPoDM, 1996). It also includes mitigation to allow for better protection in the future. The responsibility for national disaster preparedness rests with the office of the President, and the coordinator of disaster management is the Deputy Permanent Secretary in the office of the President (NPoDM, 1996). Despite this elaborate system of planning, the Namibian Government was found wanting when an audit was conducted by the auditor general's office (EMU Namibia, 2008). Mapping for all disaster areas, which was meant to have been conducted, had not been done. Training of staff, which was planned to take place over 10 national training courses, was only conducted six times, which included two repeats of prior sessions and two workshops (EMU Namibia, 2008). Meetings were only conducted during

times of disaster, and not between disasters, indicating limited disaster preparedness. There were no records of activities hosted by the Regional Emergency Management Units, which could have been assessed to measure their effectiveness (EMU Namibia, 2008). This audit therefore showed that many of the preventative measures of disaster preparedness had not been conducted, which limited the effectiveness of the Emergency Management Unit. More remedial effort on decreasing the impact of disasters which had already occurred was observed. The audit of the financial aspect of the Emergency Management Unit found neither the operational budget for the Emergency Management Unit or an account of expenditure of the National Emergency Disaster Fund (EMU Namibia, 2008). Total expenditure by the National Emergency Disaster Fund for each year between 2002 and 2007 were available in the records, however. A total expenditure of N$ 272 673 127 was recorded, in the absence of an expenditure breakdown (EMU Namibia, 2008). It seems that even with the office of disaster preparedness being directly funded and managed by the Office of the Prime Minister, similar problems to those found in Zimbabwe were experienced, which included funding being available for disaster management processes but not for disaster preparedness processes.

Mozambique has a very active disaster management protocol for flooding (SADC, 2015). Its flood reduction initiative is overseen by the National Institute for Disaster Management (INGC) in Maputo (SADC, 2015). The INGC coordinates disaster relief initiatives and disseminates information to the public on the relevant preventative measures. The INGC identified places that were prone to floods from which to remove people and established over 60 resettlement areas for relocated communities (SADC, 2015). They trained one individual from each community to receive information directly from the INGC, which in turn receives its information from the SADC Regional Platform for Disaster Risk Reduction (SADC, 2015). Mozambique is downstream of many catchment areas and so benefits greatly from up to date information of what is happening in other catchment areas. The Zambezi Watercourse Commission (ZAMCOM) monitors water movement along Zambezi River for countries hinged to this watercourse, which include Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe (SADC, 2015). The ZAMCOM also tracks the extent of flooding with use of satellite images from the Water Observation and Information System (WOIS), and informs countries on the Zambezi river basin on happenings. If heavy rains are experienced in Angola, Mozambique has several months to prepare for eventual floods, which allows them to

move people to higher safe ground before flooding occurs (SADC, 2015). With Mozambique actively promoting river awareness through its disaster programme, the number of deaths directly attributed to floods is significantly reduced (SADC, 2015). The Mozambique Government works with Non-Governmental Organisations operating in rural communities to establish early warning mechanisms for flood disasters (IFRC, 2007). In 2007, Cyclone Favio was experienced in Mozambique. Red Cross Society community volunteers worked with community members to improve disaster preparedness, distributed radios, and ensured access to the Government cyclone early warning system (IFRC, 2007). Emergency response kits as well as Government endorsed warning mechanisms to show the proximity of the cyclones were distributed. Eighteen communities in the Inhambane and Zambezia Provinces benefited from this collaboration with the Red Cross Society volunteers, and were better prepared to handle Cyclone Favio than were communities where information materials, training, and High Frequency radios had not been distributed for use in disaster preparedness training (IFRC, 2007). Local disaster management committee members also assisted the Mozambique Red Cross teams to assess the cyclone damage after the disaster and to conduct a needs assessment. Community ownership of the training they received ensured successful management of the effects of Cyclone Favio, and resulted in training programmes being extended to other communities which had not been included in the initial pilots conducted in the Sofala province (IFRC, 2007). There are many NGOs that target various areas of disaster management in Zimbabwe. NGOs have established relationships and channels of communication with community leaders while promoting resilience and disaster preparedness. Collaborating with these NGOs would assist in making use of existing mechanisms to prepare the country for disasters, the most serious one at the moment being drought. Water quality management and distribution from improved sources could also be done using existing channels, promoting sustainable inputs, rather than by seeking immediate assistance for disasters that have already occurred.

These countries provided a good framework for what Zimbabwe was lacking in its disaster risk reduction planning. There have been efforts to build resilience in previously affected disaster areas, but there is still a need to provide mitigating measures for those areas currently unaffected. There are people who are settled in the line of pending disasters, such as river basins, who would benefit from the allocation of resettlement areas. Community awareness programmes and the identification of focal persons in each community, who become responsible for community

awareness programmes, would also help to improve the disaster risk management system in Zimbabwe.

The Civil Protection Unit in Zimbabwe has tried to build resilience in the face of disasters. Early warning signs and mitigation measures have been put in place by the Civil Protection Unit to individually cater for each of these disasters. Warnings of impending droughts; floods; tropical cyclones; thunderstorms and lightning; hailstorms; storms; and earthquake predictions are provided by the Meteorological Services Department. There is evidence of the implementation of Civil Protection measures in water related disasters through the relevant Ministry of Health, which publishes reports of the management of diseases and training of technical staff on new guidelines for a specific epidemic (MoHCW, 2009 and 2011). Using protocols set by the Civil Protection Unit of Zimbabwe, Bulilima District was able to establish its own set of disaster protocols in the case of a flooding disaster. Bulilima District is located in the Matabeleland South province of Zimbabwe and does not have an urban area within its bounds (ZIMSTAT 2012c). The Matabeleland South province is also one of those most affected by floods and cyclones. As a result of their vulnerability, disaster management training was conducted in some districts in the province, such as Mangwe and Bulilima (Bulilima, 2008 and Mangwe, 2008). Emphasis was placed on natural disasters and manmade disasters, with capacity building for preparedness being recommended (Bulilima, 2008 and Mangwe, 2008). Health related hazards were addressed briefly as being caused by 'ignoring primary environmental health care, which were considered critical in developing good personal hygiene' (Bulilima, 2008). Health improvement techniques, such as awareness campaigns, water and sanitation programmes, and drug and vaccine mobilisation, were recommended (Bulilima, 2008 and Mangwe, 2008).

The development of these disaster preparedness plans was made possible through the participation of various stakeholders such as local authorities, traditional leaders, Government representatives, and NGOs (Mangwe, 2008). There is, however, no record of where these recommendations have been implemented, with most of the disaster relief information being obtained from the UN, NGOs, and the local press, which covers humanitarian aid activities. There is no protocol in place for infectious disease or microbial water quality monitoring post- or pre-disaster in any of the designated Civil Protection areas. The unstable economic situation in

Zimbabwe makes it even more difficult to push the agenda for microbial water quality monitoring.

Despite efforts to bolster measures against natural disasters, more resources were mobilized towards the restoration of destroyed communities in terms of access to healthcare, education, and treatment of the resulting diseases, than to ensuring the microbial safety of water sources (Ahmed et al., 2011; Betera, 2011). This may be due to the fact that there was no continuity in determining microbial water quality, which made it difficult to obtain a quantitative analysis of the effects of contaminated water in relation to public health. The same goes for health related disasters. It was easier to determine the quantity of resources that were mobilized for treatment of patients in an epidemic than the quantity used in disease surveillance and waterborne disease prevention (MoHCW, 2009 and 2011). This is common in developing countries, as the availability of qualified staff to carry out preventative measures is limited. In a country like Zimbabwe, for example, there are many areas that need an allocation of the national budget, which include education, health (specifically maternal and child health), and salaries of civil servants, to mention only a few. If the area of focus does not present as a crisis, such as is the case with disaster preparedness, it does not receive due attention. When a disaster occurs, the most recent example being the drought and national water shortage, funds are immediately allocated to rectify the disaster. In some circumstances, the disaster is readily rectified, but in others, it takes many months to control, as is the case in Typhoid or Cholera outbreaks, and preventive measures for these disasters therefore become a more financially viable process to consider. Since most disaster preparedness and prevention guidelines are established after the disaster has stricken those communities which have not previously experienced such disasters become vulnerable to future disasters. The limited disaster preparedness mechanisms in Zimbabwe provide a short trail to follow when trying to quantitatively analyse the impact of natural disaster, whether health related or due to other causes.

The water samples tested in this research indicated fluctuations in water quality as the rainy season gave way to winter. In the past five years from 2011- 2015 Zimbabwe has been afflicted by flash floods and concurrent drought in the flood plains (MSD, 2015). In February 2000, Zimbabwe was struck by Cyclone Eline. There were four main provinces affected by Cyclone Eline, with a population estimate of 500 000 directly affected by the impact of the floods

(Reliefweb, 2000). Manicaland, Matabeleland South, Masvingo, and Midlands Provinces received the bulk of the rains, and reports provided by the Civil Protection Unit calculated that over 20 000 individuals had been left homeless (Betera, 2011). The UN disaster management team coordinated donor activities and distribution of food resources to avoid duplication of donor activities by volunteer organisations that were involved in assisting the affected communities (Reliefweb, 2000). Maternal health aid, vaccination kits, water and sanitation needs, and education requirements were evaluated (Reliefweb, 2000). Strategies to overcome these crises and the necessary budgets were developed. Co-ordination and management of the flood disaster relief programme was coordinated by the UN disaster management team, with the local Civil Protection team again being sidelined for lack of adequate training to coordinate disaster relief and mitigation measures (Reliefweb, 2000). Whilst the provision of material assistance in the face of a disaster is welcome, it should not occur as a result of the lack of qualified personnel. If we consider that some of the employees in these international organisations are citizens of Zimbabwe, the Ministry of Local Government should be encouraged to do better in terms of retaining the services of these disaster management practitioners in Zimbabwe.

1.10 Statement of the problem

Millennium Development Goal Target 7c aimed to half the population living without access to safe drinking water and basic sanitation by 2015 (UN, 2015b). This target was achieved worldwide five years ahead of schedule. Between 1990 and 2015, 2.6 billion people gained access to improved drinking water. More than 2.1 billion people worldwide gained access to improved sanitation (UN, 2015b). Despite this progress, 2.4 billion people were still using unimproved sanitation, and 946 million people still practiced open defecation (UN, 2015b).

Sustainable Development Goal 6 aims to ensure access to water and sanitation for all (UN, 2016). Statistics on the United Nations website showed that at least 1.8 billion people globally used a water source that had faecal contamination, and at least 663 million did not have access to improved drinking water sources (UN, 2015c and UN, 2016). Floods and other water related disasters accounted for 70 % of all deaths related to natural disasters (UN, 2015c). Water scarcity, poor water quality, and inadequate sanitation negatively impacted on food security,

livelihood choices, and increases disaster vulnerability (UN, 2015c and UN, 2016). Zimbabwe experienced all three of these problems as of 2016, and failure to address these crises will worsen poverty, hunger, and the burden of disease in the country.

The microbial water quality of drinking water in Harare was noted to be deteriorating since early 2000 (UNDP, 2015; Chirenda et al., 2015). The current economic situation makes it challenging to nearly impossible to maintain operations of an efficient public health system in Zimbabwe. This increases the vulnerability of the population to waterborne diseases. A health system is that which includes the resources, actors, and institutions related to the provision, regulation, and financing of health actions (WHO, 2015). A health action is any set of activities whose primary intent is to improve or to maintain health. All health systems should achieve the following goals: health, responsiveness, and fairness in financing of health actions (WHO, 2015). An effective health system should increase the responsiveness of a health system to the legitimate expectations of the public for their non-health improving interactions with such a system (WHO, 2015). Responsiveness caters toward persons in terms of their dignity, confidentiality, and client orientation. Fairness in financing necessitates different amounts being paid for health care between the rich and the poor, with the poor being expected to pay less than the rich, since the rich have more disposable income (WHO, 2015). The public health system, however, is suffering due to shortages of qualified staff, medicinal resources, and basic needs, such as running water (Chadenga, 2016). In a country like Zimbabwe, undergoing economic fluctuations, it is imperative that measures be in place to prepare for both natural and manmade disasters due to poor water and sanitation health (Chirenda et al. 2015). It is also necessary to assess the effect of other variables such as gender, education, marriage, and disease etc. when designing disaster risk management plans in Zimbabwe.

The objectives of this study were:

1) To identify guidelines used to determine that a water source is safe for domestic use, according to the Standard Guidelines for domestic water quality in Zimbabwe, and how this compares to the quality of water available for domestic use in the Harare area.
2) To use existing literature to identify the risk a water source that does not meet the standards for microbial quality of water poses to public health.

3) To address waterborne disease outbreaks as a biological hazard, and to gain insight into the disaster management procedures and legislation addressing waterborne disease outbreaks in the Zimbabwean community, using literature review.
4) To investigate the impact of concurrent diseases, gender, education, and marriage in the management of waterborne diseases in Zimbabwe and South Africa.
5) To assess the impact of engaging various stakeholders in addressing the problems of microbial water quality and water availability in Zimbabwe, and comparing these to the South African setting.
6) To determine the microbial water quality of raw water, treated water, and alternative water sources in the Manyame Catchment area, which provides water to Harare.
7) To recommend evidence based strategies that will help to improve the availability of safe potable water sources that have recommended microbial water quality levels.

2 CHAPTER TWO

2.1 PRELIMINARY ASSESSMENT OF THE GENDER ASPECTS OF DISASTER VULNERABILITY AND LOSS OF HUMAN LIFE IN SOUTH AFRICA.

2.2 INTRODUCTION

This chapter is going to assess gender related aspects of disaster vulnerability in South Africa. Disaster management in South Africa is more developed than that in other African countries. It has been modified to include partnerships with Institutes of Higher education in disaster management. The impact of these institutions on South Africa's disaster management will therefore also be analysed. Community engagement is one of the responsibilities of higher education in addition to research and teaching (Kagisano, 2010). There have been discussions which explore community engagement as a form of social responsiveness, and how continued provision of knowledge through established research activities increases engagement of researchers with the community (Kagisano, 2010). Community engagement in the Higher Education sector will therefore be explored along these lines. The impact of gender and education in the management of waterborne diseases in South Africa, and how these can be addressed to create a sustainable disaster management approach will be considered. In order to

quantify the impact of these factors, inequality indices will be developed based on gender for education, economic empowerment, and economic development. The results from these calculations will then be used to compare for the same parameters in the Zimbabwean setting in Chapter Three and to identify areas that need adjustment in Zimbabwe. The United Nations Human Development Report of 2015 will also be used to provide comparative data on human development between Zimbabwe and South Africa from 1990 to 2014.

2.3 Community engagement in tertiary institutions

There has been increased focus on the engagement with surrounding communities by Tertiary Institutions in a bid to mould qualified professionals who are socially conscious and are prepared for the market. After South Africa's transition from apartheid to a democratic Government, President Nelson Mandela established the National Commission on Higher Education (NCHE) (South Africa, 1997). This commission was designed to redress past inequalities, meet new national needs, and respond to new realities and opportunities for the New South Africa. The South African Government and stakeholders included in developing the White Paper on Higher Education of 1997 recognised that Higher Education Institutions play a crucial role in social, cultural, and economic development of modern societies (South Africa, 1997). Previously, higher education institutions were based on the assumption that teaching in higher education is an individual process best encouraged by explicit teaching, outside of the surrounding community (Hodgkinson-Williams et al., 2008). Wenger is one of the writers who have opposed this system by encouraging the concept of communities of practice, defined as 'groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly' (Wenger, 2004). This definition provides a concept for how social engagement of higher education with communities improves learning and knowledge (Hodgkinson-Williams et al., 2008). Higher Education Institutions influence development and reconstruction of broken communities by stimulating and mobilising the creative and intellectual energies of its students and those around them. Section 1.12 of the White Paper encourages Higher Education Institutions to prepare students for reconstruction and development by providing high level skills training (South Africa, 1997). This involves the development of professional and knowledgeable workers with globally recognised skills who are aware of their social responsibility to national development and social transformation. Section 1.20 addresses the principle of development, which states that conditions must be provided to transform the higher education system so that it

contributes to the common good of society through the production, acquisition, and application of knowledge. In turn, this increases human capacity and provides lifelong learning opportunities (South Africa, 1997). This means that the White Paper encourages constant interaction between students and their communities while they attain their Higher Education qualifications, so that they are equipped to address the social, economic, and cultural needs of their environment (South Africa, 1997). The e-Yethu project is one of the more successful examples of community interaction between a Higher Education institute, Rhodes University and Shuttleworth Foundation as well as Dell and Telkom South Africa (Hodgkinson-Williams et al., 2008). It provides information and communication technology services to schools in the Grahamstown District (Hodgkinson-Williams et al., 2008).

Community engagement, however, takes on many forms in Higher Education. It may be represented as participatory based research, distance learning, community based research, and service learning (Lazarus et al., 2008; Hodgkinson-Williams et al., 2008). Community engagement involves teaching and research combined to identify community development areas (Hodgkinson-Williams et al., 2008). These areas are then addressed through various teaching and research methods, providing economic development (Hodgkinson-Williams et al., 2008). Service learning is when students participate in an organised service activity that meets identified goals (Hodgkinson-Williams et al., 2008). Students reflect on the service activity to gain further understanding of the concept, to develop a broader appreciation of their discipline, and to gain an enhanced opinion of civic responsibility (Gerda Bender, 2007; Lazarus, 2007). Many Higher Education Institutions in South Africa are now incorporating service learning courses supported by CHESP in their curriculums to improve the quality of their staff and students (Lazarus, 2007). CHESP is the Community-Higher Education Service Partnership launched through the Joint Education Trust in 1999 in response to requirements of the White Paper of 1997 (Gerda Bender, 2007; Lazarus, 2007). In a project conducted in 2008, service learning was found to be an entry point for community engagement in 12 Higher Education Institutions, ranging from 1st year to Masters level, and in 39 different disciplines of study, with an enrolment of 10 000 students. These Higher Education Institutions were identified by CHESP because they are supported by it, or they use a tool provided by CHESP to audit their CHESP initiatives (Lazarus et al., 2008). Community engagement in tertiary institutions allows interaction between different genders, in a way that encourages development of someone's abilities. Gender does not block the progress of

disaster risk assessment as well as management. Instead, it promotes a level field for various individuals to bring together ideas on how best to address a certain risk. If students in tertiary institutions are moulded into socially responsible individuals, with a theoretical understanding of economic responsibility, they become more conscious of the need for disaster preparedness. Since they would have gained an understanding of the value of social responsibility, they become more involved in disaster risk assessment and management in their communities. The same initiative may be employed by Higher Education Institutes in Zimbabwe to groom professional and knowledge-based students who contribute to social and economic development in Zimbabwe.

2.4 Gender, marriage and empowerment, and their effect on disaster management

There are a few barriers to progress that exist, other than developing a culture of social responsibility and creative thinking for economic development. In every society, there are norms and ideologies accepted by the majority, which dictate the hierarchy of economic resources, access to health care, water and sanitation, and food availability, etc. (FAO, 2012; Kabeer, 1997). Gender, level of education, disease, water and sanitation, and marriage are some of the factors that affect how wealth is distributed (Morrow, 1999; Buvinic and Gupta, 1997). The same factors also tend to affect how societies respond to disasters.

2.4.1 Gender

Gender defines the roles of men and women, as well as boys and girls. Gender roles are socially constructed and reflect biological and cultural differences (Morrow, 1999; Kabeer, 1997). The movement of families or individuals to more developed economies in order to improve their financial worth also tends to contribute to changing gender roles (Neumayer and Plumper, 2008). As people move towards better opportunities, the roles between men and women are not divided according to gender, but according to ability, which increases competition and performance between the sexes for the same job opportunities (Neumayer and Plumper, 2008). This disregard for gender divide based on the sex of an individual will result in an elevation in the preparations for disaster management. Disaster risk management will therefore be carried out based on a person's ability, and not their designated social worth. Suitable individuals are hereby selected to spearhead disaster risk management projects, and palpable results are seen, because of the dedication of hardworking individuals to the cause. Once contribution to disaster management is

carried out through following specific protocols for recruitment and selection, it becomes more feasible to assess whether all areas of disaster management are represented in a disaster management team.

2.4.2 Marriage

For most African societies, marriage brings about a bond between a man and woman, where the woman becomes subject to her husband. Women bear children, and take care of their families, while man provide financially for their families. In these patriarchal societies, men's roles are mostly sequential, and the resources required for each activity are adequately provided for before tasks are started. They are found to be active in economic tasks, be it through formal employment or informal trading (Chant, 1997, Kabeer, 1997). Resources required to perform these tasks will be well financed and accessible. If the patriarchal hierarchy is maintained in disaster relief programmes, the protocol for disaster management follows the hierarchy already in place for a given society, resulting in unequal representation of families and unequal access to relief resources (Buvinic and Gupta, 1997; Kambarami, 2006). However, if there are no male children who can represent the female headed households at the recovery programmes, access to disaster relief resources becomes even more difficult (Chant, 1997).

In traditional communities, where hierarchy in society is divided along gender lines, gender roles affect how information is disseminated. For example, in an African traditional society in which men organize meetings to discuss the progress of their communities, women who head their own households are not allowed to participate. Through conversations with the elderly the researcher learned that *padare*, or the men's court was where all current affairs were discussed and any grievances arising from these discussions were dealt with in this setting. Traditional, spiritual, and other community leaders, most of whom are male, use these channels to transmit important information. This means that when early warning information of a pending disaster was disseminated through this channel, single parent households without sons to represent them became highly vulnerable to the worst possible end result of such a disaster. This affects the ability of a community to recover in the shortest possible time if female-headed households constitute a significant proportion of the affected community.

Women's roles in a patriarchal system are multivariate, and occur at the same time, with access to a limited number of resources for all of their varied activities (Chant, 1997). In most countries,

women are discriminated against in the areas of education, health, and the labour market (WGEKN, 2007). Women in developing societies attend to domestic related tasks, ranging from household chores to subsistence farming, to provide food for their families (Chant, 1997). In the absence of sufficient resources to complete their daily tasks, women take it upon themselves to maximise on the resources which they do have in order to try to meet their families' needs (FAO, 2012; Buvinic and Gupta, 1997). The result of this relationship is that women end up being less interested in additional programmes on disaster risk management. Because of physical exhaustion, they choose to let the men handle this crucial aspect of their livelihood, and when the disasters occur, they look to their husbands to rescue them. Since disaster risk management and assessment requires the contribution of both male and female members of the community, in patriarchal societies, less progress is observed in disaster risk management. The ideas of disaster management which can be raised by women, based on their day to day experiences, will therefore be left out of disaster management protocols. Their reluctance to add on to their daily burden of responsibilities, as a result of exhaustion, makes their communities weaker links in adapting efficient disaster management systems. If these women receive assistance in the completion of their day to day activities, in the form of access to portable water, economically empowering jobs, and access to education within their communities, their burden will be reduced. These few factors will improve their participation in disaster management.

2.4.3 Empowerment

In African populations, traditional values of two parent households, religion, and role divisions in line with sexual difference are still observed. This means that population groups which fall outside these bounds become ostracized and marginalized, increasing their vulnerability in the case of a hazard occurring (Ingraham, 2002). At other times, women may also be found leading disaster recovery programmes, but this happens in communities that interact with NGOs and have disaster management programmes in place (Prevention web, 2014; Buvinic and Gupta, 1997). Female-headed households have also been observed to consist of extended family members who require additional financial aid (Kambarami, 2006).

Women are the caregivers in most communities, and their vulnerability affects that of their families. Financial dependence on men relegates the economic functions of women to supplementary financial jobs such as domestic work, subsistence agriculture, craft production,

and vending (ZIMSTAT, 2012). These job opportunities do not always educate employees on disaster vulnerability or preparedness, and thus adversely affect disaster risk reduction (DRR) efforts. In addidtion, these jobs require the dedication of these women for longer hours to produce financial gain, than other economically empowering jobs, hence reducing these women's availability for community related disaster management preparations.

In 2013, in a statistical survey carried out in the United States, families headed by single mothers were over five times more likely to be poor than were two parent families (Pacific Standard, 2015). This ratio was discovered to be almost the same thirty years prior for this group. The difference in this statistic was in the mechanics of how they got to be single parents. Back in the 1980s, single mother families were mostly a product of divorce. More recently, single mother families are resulting from premarital fertility (Pacific Standard, 2015; Kabeer, 1997). In circumstances where these female-headed households are led by financially independent women, they are regarded as a threat to the social norm (Kabeer, 1997; Buvinic and Gupta, 1997). Their influence is regarded as disingenuous to young girls and their peers who are nurtured in two parent households. As a result of this social perception, such families may be targeted by gender based, violence, and they become more vulnerable during times of disaster (Silberschmidt, 2001; Kambarami, 2006). Studies have found that if traditional male roles are under threat, then the level of violence towards women increases (Hautzinger, 2003). These experiences, however, make women more resilient in the face of natural or manmade disasters (Kambarami, 2006; Our Africa, 2015). As a result of their economic empowerment, they are more equipped to handle disasters than those in patriarchal societies.

Gender differences in most African countries are pronounced, and the roles of men and women in South Africa are a subject of debate. Social perceptions of gender and sex influence vulnerability and resilience of women and men during periods of disasters (UNDP, 2011). However, South Africa has become more accepting of gender roles not dictated by the sex of individuals, as advocated by human rights and gender-based violence groups.

The South African Constitution of 1996, includes in Chapter 9, a clause which states that "everyone is equal before the law, and has the right to equal protection and benefit of the law. The state may not unfairly discriminate directly or indirectly against anyone on one or more grounds, including race, gender, sex, pregnancy, marital status, ethnic or social origin, colour,

sexual orientation, age, disability, religion, conscience, belief, culture, language and birth" (South African Constitution, 1996). This means that the South African Constitution stands in favour of gender freedom and marginalized groups (South African Constitution, 1996). This also means that unequal pay and unequal employment opportunities between men and women are unconstitutional and should not be tolerated. Unfair treatment between unmarried women, married women and single, previously married women, which exists in the workplace, should also not be tolerated.

The economic empowerment of women yields reliable financial gain. Once women are able to take care of their families, with time to spare, their influence in disaster management also increases. As they gain financial independence, they also gain more assets which they need to protect from disasters. Women also invest more in their children and extended families, when they are engaged in gainful employment. They thus become stakeholders in ensuring the progression and improvement of their communities. Disaster management is a crucial aspect of this improvement, and with women contributing, the results of disaster management become stellar.

In the same way, young men also need to become empowered to take care of themselves, and their families. I they do not qualify for mainstream economic empowerment, they require guidance in carrying out practical crafts, and in the financial conversion of those crafts. Zimbabwe has many polytechnic colleges and Skills training colleges. The problem does not lie in entrance to these colleges, but in the application of the skills gained after training. Disaster management improves if these young men are assisted with markets for their resulting practical efforts, whether be it leather tanning, agriculture, horticulture or metal fabrication etc. The absence of services that link their products to the consumer market reduces their economic independence, increases their agitation and threatens their financial stability. Development of clear markets for their skills thereby improves their livelihood, and reduces their likelihood to engage in gender based violence and other unruly activities. As they gain financial independence, they are also obliged to protect their acquired resources, and thus engage in economic improvement through preparation for disaster management.

2.5 Location of South Africa

South Africa is located at the southern tip of the African continent, between 35^0 and 22 ^{0}S latitude (Zuma et. al., 2012), which makes its borders a combination of land and sea. It is therefore vulnerable to floods, drought, tornadoes, and earthquakes. Between 1980 and 2011, there have been 77 recorded flood disaster events in South Africa (Zuma et al., 2012). The probability of flooding is 83.3 % and this increases the vulnerability of the population to water related disasters (Zuma et al., 2012). Pending disasters are not localized to only one area, but to the whole country. National disaster protocols are therefore necessary to provide adequate mitigation, disaster response and recovery measures, and development to prevent destruction of property in future disasters. Since some of these disasters are natural, it is not possible to completely prevent them from occurring, but their impact can be reduced.

2.6 Economy

The economy of a country determines the distribution of resources between those who have and those who do not. If a country has a large economic divide, there is potential for violence and social struggle between different societal classes, as a means of attaining a higher level of social and economic status (AFDB, 2007). The distribution of wealth across social classes, genders and age groups are important in the determination of the gender development index of a country, hence their inclusion in this report. Growth in GDP was estimated at 3.6 % for Africa, which beat 3.1 % for the global economy and 1.5 % for the European region (AFDB, 2016). That said, there is need to consider that African countries are still mostly growing economies used on agricultural and mining activities, while their European and Asian counterparts have been industrialised for more than 200 years, and are still growing. East Africa's GDP grew by 6.3 % in 2015, leading sub- Saharan Africa, while Southern Africa grew by 2.2 %, lower than the continental average of 4.2 % (AFDB, 2016). Southern African economies are mostly agro-based e.g. Zimbabwe, South Africa has mining and agriculture, Botswana engaging in mining, and Malawi in the food industry of fisheries. East African economies have been on a continuous rise due to financing in the cement industry, growth in trade, and increased populations involved in the economy for example in Nigeria. South Africa's GDP increased by 2.2 % in 2013, 1.5 % in 2014 and 1.3 % in 2015 (Stats SA, 2016). The economic performance of South Africa was not optimal, when compared to other African countries, and some contributors to this included industrial strikes, decreased export of processed goods and xenophobic attacks which were witnessed by the whole world. The continued hiring and firing of the Minister of Finance highly

impacted trading of the rand on the International market as well. All these factors and more, had various impacts on South Africa's economy. South Africa however, had the potential to become an economic powerhouse on the continent and accounted for 43 % of SADC's trade and 61 % of SADC's GDP. It was an active and key player in the G-20, G-24 and BRICS (AFDB, 2016). It had the capacity to drive economic integration in the region, but was failing to keep up with developments in the trade market for intermediate goods on the global front (AFDB, 2016). In addition to its economic success, South Africa was also the most unequal society in the world, with the widest gap between the poor and rich (AFDB, 2016). The gap between the rich and the poor does not call for equal sharing of financial resources, but instead calls for the improvement in business acumen, service delivery, and marketability of those individuals with low incomes. South Africa was considered to be a medium human developing country, and had a gender inequality index of 0. 407 (UNDP, 2015b). This indicated that there were more than twice the number men for every woman employed in an economically empowering job. Considering its high contribution to SADC's GDP, the gender inequality index also indicates that fewer women are engaged in financially stable jobs in South Africa, and when you consider that foreigners are also employed in South Africa when local South Africans are unavailable to fill certain posts, it also indicates that more men than women are hired in these jobs. Zimbabwe was considered to have low human development and had a gender inequality index of 0.504 ranking 112th in the world in 2014 (UNDP, 2015b). In Zimbabwe as well, for every woman gainfully employed, there were two men gainfully employed. This was explained by the fact that in most companies, as the job experience increases, fewer women are found in leading positions. In the twenty first century, it is still difficult for women to have children and succeed in the marketplace at the same time. As women bear more children, they become permanently employed in lower job positions, unless they have professional qualifications, which, at times, afford them similar opportunities to men. Given the economic turmoil in Zimbabwe, and the uncertainty on the economic market, the statistics of gainful employment may have increased in favour of men, or vice versa. It is not enough to depend on statistical Data of the Census conducted in 2012 alone to predict the workplace trends in 2017-2018 period, many companies were closed after 2012, and trade shifted mostly to informal trading. Statistics from the United Nations show that up to 42.9 % of the South African population lived on less than $2 per day between 2000 and 2006 (UNDP, 2008). The divide between the rich and the poor in South Africa is quite stark and these statistics

are indicative of that. Up to one million female-headed households were found in the rural areas (UNDP, 2008). When we consider that these female headed households in rural areas are not empowered, and have families to support, it brings forth that scenario where women work long hours for little gain, and have less time available to engage in disaster management. Data obtained in 2002 compared men and women showed that 840 000 Black and Coloured women, as compared to 180 000 men, were employed in the informal sector to perform low skilled labour (UNDP, 2008). This statistic shows that for every man, there were more than four women engaged in low skilled labour. These women were overworked, and underpaid, making them economically vulnerable. They were also vulnerable to gender based violence from their counterparts who would want to get the same low skill jobs but were not selected. The men who were not engaged in this low skilled labour workforce were also vulnerable to economic instability. Given that most communities are patriarchal in Africa, these men were likely to engage in violence against their female and male counterparts, who seemed more economically empowered than them. The vulnerability of these groups was assessed using various statistical databases which focused on inequality with respect to health status, access to health care, education, gender, and economic inequalities (UNDP, 2015a).

2.7 South Africa's Population

According to Statistics South Africa data released in 2014, the estimated population of South Africa was 54 million people, an increase from the 50.46 million in 2011. The South African population was expected to grow by 0.5 % per annum between 2010 and 2015 (United Nations Statistical Indicators, 2012). In 2011, however, the population grew by more than 1 % and this may have been attributed to by the migration of neighbouring Zimbabwe's professional workforce to South Africa in search of better opportunities. South Africa received migrants not only from Zimbabwe, but also Nigeria, Ghana, Mozambique and Somalia, to mention a few, all seeking a better playing ground on the economic market. The 2011 Life Expectancy at Birth for South Africa (LEAB) was ranked 14th globally for men and 18th for women (United Nations Statistical Indicators, 2012). In 2014, the LEAB for men was estimated at 59.1 years for men and 63.1 years for women, after including the impact of HIV/AIDS (Statistics South Africa, 2011). This means if a person was able to grow and gain employment, or start a business, the resources available to them would ensure a healthy life up to 59 years for men and 63 years for women. This does not take into account the possibility of random acts of violence. These statistics

indicated that the level of health care available in South Africa was adequate to prevent high childhood mortality rates, or deaths due to communicable diseases. It also means the health resources available in South Africa were adequate to protect someone from death due to communicable diseases up to the age where non communicable diseases such as hypertension, diabetes, obesity etc take over. The savings at household level were estimated at 20 % of GDP, which indicated a high probability of poverty in the country. Male-headed households had a 23 % probability of being poor, while female-headed households had a 48 % probability. Poof families in South Africa are eligible for welfare, so the statistics for these economically vulnerable groups may have been inflated by individuals with the potential to gain employment but who hadn't done so yet, hence were receiving aide. The urban population with access to improved drinking water sources was found to be 99.2 % of the population; while 88.3 % of the rural population had access to improved drinking water sources (South African Demographics Profile, 2014). These statistics indicate that for a country with a large population, South Africa's water distribution systems were fairly adequate to provide portable water in all urban populations and most rural populations. From community engagement with the low income communities in the Eastern Cape, the researcher also found out that in those communities without adequate portable water at their houses, alternative water sources were made available at strategic locations such as schools. The urban population with access to improved sanitation services was 81.7 %, while in the rural population access was 62.4 % (South African Demographics Profile, 2014). There is room for improvement in the access to sanitation statistics in South Africa's rural population, as well as the urban population.

2.8 Gender and education and how they impact human development in South Africa

Human development is measured in terms of health, empowerment and labour market (UNDP, 2015a). Health addresses gender based mortality ratios such as maternal mortality due to childbirth related conditions, adolescent birth rates or overall female reproductive health (UNDP, 2015a). Mortality that results from reproductive matters is biased towards women; therefore its impact on human development is significant (UNDP, 2015a). Empowerment refers to how well equipped each gender is for the workplace. Women and men receive varying levels of education, and varying skills in technical subjects (UNDP, 2008). This affects the kinds of employment opportunities that become available to them on completion of a specific stage in education

(UNDP, 2008). The level of education, representation in Parliament, and representation in various sectors of women vs. men, determines the level of empowerment afforded to each sex. Finally, female and male labour force participation ratios assist in the determination of their representation in the workforce. From this data, the gender inequality index may be determined.

Gender inequality index values were calculated with respect to the health status of the population. The Life Expectancy at Birth (LEAB) is an overall measure of health conditions between the sexes. Gender differences in this parameter are an indication of disease / health burdens in that population. Such information for any given country may then be used to understand gender vulnerability differences in the cases of disaster. It facilitates efficient gender specific medical assistance and response in disaster risk management planning. The data on life expectancy for men and women was obtained from the country statistics of South Africa on the United Nations Statistics database. The LEAB Inequality Index was calculated based on that data according to the equation:

$$LEABI = \frac{\text{Age (woman)}}{\text{Age (man)}} \qquad \text{Equation 2.1}$$

Age (woman) represents the life expectancy at birth for women in South Africa. Age (man) represents the life expectancy at birth for men in the country.

Maternal mortality rates are indicative of access to health care by prenatal women. It also reflects the extent to which women are exposed to health risks through fertility. A shortage in access to healthcare for mothers is a high risk to the whole family in terms of recovery from a disaster, since they are considered caregivers.

Statistics South Africa data showed that female-headed households were more prone to poverty and hunger (SSA, 2016). A significant proportion of female-headed households in South Africa were employed in the informal sector, hence their access to health care, water, and sanitation needs as well as to food was limited to their means. In a disaster situation, the economic background of the population would dictate their preparedness to evacuate affected areas (Nigg et al., 2006). It would also affect the recovery and sustainability of that community past the disaster. To evaluate the trend of unemployment, the Unemployment Inequality Index was used, based on the South African statistics of 2008-2011.

$$UEI = \frac{\text{Unemployment rate (women)}}{\text{Unemployment rate (men)}} \quad \text{Equation 2.2}$$

Unemployment rate (women) in equation 2.2 is an average unemployment rate for women in the productive range of 15-64. The unemployment rate (men) represents the average unemployment rate of men in the productive range 15-64.

Literacy rates were calculated using the enrolment at primary and secondary level for both male and female candidates, as well as literacy rates in men and women. The respective indices were calculated using the following equations:

$$LRII = \frac{\text{Literacy rate (women)}}{\text{Literacy Rate (men)}} \quad \text{Equation 2.3}$$

$$EII = \frac{\text{Enrolment rate (women)}}{\text{Enrolment rate (men)}} \quad \text{Equation 2.4}$$

Literacy rate (women) in equation 2.3 is the average literacy rate for South African women, expressed as a percentage of the total female population who can read. Literacy rate (men) is the average literacy rate for men in the country, expressed as a total percentage of the total male population who can read. LRII stands for Literacy Rate Inequality Index.

Enrolment rate (women) is the average enrolment rate for females in primary education and / or secondary education institutions across South Africa. Enrolment rate (men) is the average enrolment rate for males in primary and / or secondary institutions across South Africa. EII stands for Enrolment Inequality Index.

Early warning information and awareness campaigns improve disaster preparedness in the community. However, if such information is provided through documents or posters, and the majority of that community is illiterate, the information loses its purpose. Data obtained from literacy rates and enrolment rates into secondary and tertiary education will help to assess the efficiency of using early warning information in the form of posters and information leaflets in Disaster Risk management. The relationship between a country's developmental stage and gender inequality in that country, as determined by its economic drivers, has been analysed and

found to be existent (Kuznets, 1955). This relationship was investigated for South Africa using equations 2.1- 2.4 as a function of the Human Development Index (UNHDI, 2012).

2.9 Fatalities in disaster management

Effects of disasters may be evaluated in terms of material or infrastructural damage losses. This information is not always readily available to the public. It is mainly distributed through government officials in Disaster Management Committees (SSA, 2006). It may also be made available through Statistics South Africa after two or more years. The datasets consulted in this study included deaths from unnatural and non-natural causes, where the gender breakdown is available.

- The unnatural deaths of 1997-2004 consist of the following subcategories: 'death by firearm, death by knife (stabbing), poisoning, transport and undetermined intent and / or unspecified event' (SSA, 2006).
- The dataset for 2009 contains subtypes of non-natural deaths, namely: other external causes of injury, event of undetermined intent, transport accidents, assault, smoke inhalation, exposure to smoke, fire and flames, accidental drowning and submersion, accidental poisoning by exposure to noxious substances, exposure to forces of nature and to electric current, radiation, extreme ambient temperature and pressure, complications of medical and surgical care, intentional self-harm, and sequel of external causes of morbidity (SSA, 2011a).

During a disaster, the deaths of human beings may occur from causes directly related to that disaster or to side effects thereof (Kelman, 2012). People may die from drowning, smoke inhalation, burns, or assaults in the aftermath of a disaster, or from radiation exposure and crushing under falling debris or damaged buildings (Kelman, 2012). The following data was therefore removed to accommodate gender aspects of disaster related fatalities only:

- 'Death from undetermined intent / unspecified event' where the cause of death cannot be established. Patient complications in medical and surgical care may occur in disaster victims. However, human action, unrelated to the disaster itself, could potentially lead to a patient's death.

- The subcategory of 'sequel of external causes of morbidity and mortality' includes fatalities which can be related to transport accidents and intentional self-harm, amongst others, but the death generally occurs around one year after the causal event (WHO, 2012). Deaths assigned to this category were subtracted from the total number of unnatural deaths in further considerations.
- Mortality and morbidity from intentional self-harm is mainly related to social pressure, mental health problems of people committing it, or to political unrest (Laloe, 2004). This subcategory was also removed from disaster related fatality considerations.
- Road Traffic Accidents in South Africa have been extensively studied by various authors such as Meel (2008), and Lerer and Matzopoulos (1996), so these were removed from further disaster related fatalities.
- Assault may occur as a consequence of disasters (Kolbe et al., 2010) or in the aftermath of a disaster. These deaths are violent, and gender differences have been recorded. Assault is common to the South African population because of their high exposure rates to traumatic events (Williams et al., 2007). These deaths were included amongst the disaster related fatalities.

Drowning and smoke inhalation deaths result from flooding and fire disasters. Exposure to radiation in South Africa has been reported, mostly in the mining intensive areas (North West Provincial Government, 2002). Consumption of water in these regions increases the probability of getting exposed to radiation (North West Provincial Government, 2002). Ambient temperatures have been shown to vary around South Africa. Exposure to extreme temperatures and atmospheric pressure is therefore an important parameter in determining disaster related fatalities in South Africa. Inhalation of toxic gases tends to occur in mines, therefore unnatural deaths from poisoning and radiation exposure will be relevant to disaster studies in South Africa. The remaining datasets for causes of mortality according to the 2009 dataset were thus included in this analysis.

2.10 Results

2.10.1 Fatality calculations

Data for unnatural deaths in South Africa were reported per 100 000 citizens. They were also broken down to age group and gender (Statistics South Africa, 2011a). Data for the 15-64 years age group, which is the economically productive age group, was most suited for analysis of disaster death rates. The following equation was used:

DRDR = TUDR- TDR- MEDR- UDDR- SEJDR- PSHDR Equation 2.5

TUDR is the total death rate from unnatural causes in a given calendar year. TDR is the transport related death rates for the same time. MEDR is the death rate from medical and / or surgical errors. UDDR indicates the undetermined cause and / or intent death rate. SEJDR is the death rate from the sequel of external injuries. PSHDR is the death due to intentional self-harm.

All of these values were obtained separately for the male and female segments of the population. The unit of all death rates is number / 100 000 citizens (SSA 2006; SSA, 2011a; Bradshaw et al., 2003). Data from Statistics South Africa 2006, 2009b and 2011b were the sources for TUDR, TDR, UDDR for 1997-2004 and 2009, and MEDR for 2009.The SEDJR, MEDR and PSDHR values for 1997- 2004 were derived from estimates by Bradshaw et al. (2003).

The TUDR values for individual age groups of men and women were reported separately (SSA, 2006, 2011a). They were then converted into the overall death rates for the 15-64 years age groups, according to the following equation:

$$TUDR = \sum_{I=}^{K} \omega i \times TUDR_i \qquad \text{Equation 2.6}$$

$TUDR_i$ is the unnatural death rate for the respective age group and gender / sex (number of deaths per 100 000 citizens of South Africa). The symbol ω_i represents the weighting factor of that particular age group of the female / male population (dimensionless). Values of ω_i were calculated according to the following equation:

$$\omega_i = \frac{\text{Number (given age group)}}{\text{Number (total gender)} \times \Phi\ (15\text{-}64)} \qquad \text{Equation 2.7}$$

Number (given age group) represents the total number of males and females of a given age group in South Africa in a particular year. Number (total gender) is the total number of males and

females in the South African population in a given year. Finally, Φ (15-64) is the fraction of the total male or female population accounted for by the 15-64 age group (dimensionless). Official population estimates were used to indicate the total population of South Africa in 2003, 2004, and 2009. Values for 2003 and 2004 were averaged and assumed to be equal to the mean ω_i values for 1997-2004.

The following tables show the results obtained.

2.10.2 Table 2.1 Female TUDR Values for 1997- 2004

		Deaths per 100 000 citizens/ TUDR							
Age group	ω_i	1997	1998	1999	2000	2001	2002	2003	2004
15-19	0.168	53	47	50	46	44	40	39	38
20-24	0.150	75	75	76	72	74	86	92	91
25-29	0.140	79	82	84	78	79	80	89	86
30-34	0.120	84	85	84	80	81	84	82	85
35-39	0.104	89	90	90	77	74	79	75	82
40-44	0.092	91	87	78	75	71	73	73	72
45-49	0.078	94	84	87	73	69	71	64	69
50-54	0.062	107	90	90	73	66	70	68	70
55-59	0.046	106	96	95	83	77	73	69	73
60-64	0.040	106	100	89	92	89	84	85	82
UDDR		52.9	42.6	26.0	20.0	20.2	22.8	22.4	22.6
OVERALL FEMALE TUDR		66.9	64.5	64.6	58.8	57.6	59.9	60.4	61.1

The values and total death rates for 2003 and 2004 were averaged, and assumed to be equal to mean ω_i values for the 1997-2004 periods. The population estimate for 2009 was used for 2009 only. The unspecified event / undetermined intent categories were defined as percentages of TUDR in a particular calendar year for the period between 1997 and 2004. Table 2.1, 2.2, and 2.3 show the values calculated for TUDR in men and women.

2.10.3 Table 2.2 The male TUDR values for 1997-2004

		Deaths per 100 000 citizens/ TUDR							
Age group	ω_i	1997	1998	1999	2000	2001	2002	2003	2004
15-19	0.178	161	151	153	149	146	142	140	136
20-24	0.158	271	268	265	279	290	302	302	307
25-29	0.146	356	349	317	311	318	319	317	316
30-34	0.122	366	373	350	363	386	377	384	376
35-39	0.101	336	352	353	346	368	371	352	359
40-44	0.089	324	335	337	335	346	357	360	350
45-49	0.073	316	315	314	307	325	310	311	305
50-54	0.059	319	303	288	283	287	281	286	278
55-59	0.042	301	286	278	265	243	251	245	234
60-64	0.033	270	254	246	227	241	259	236	238
UDDR		232.3	192.8	113.3	96.111	102.2	111.3	107.6	106.7
OVERALL MALE TUDR		294.0	292.1	283.2	282.6	291.9	292.9	290.8	288.3

2.10.4 Table 2.3 The male and female TUDR values for 2009

Age group	ω_i (men)	ω_i (women)	Deaths per 100 000 citizens	
			Male TUDR	Female TUDR
15-49	0.962	0.956	57.7	12.5
50-64	0.038	0.044	8.9	2.8
Overall male TUDR			55.8	12.0

The relevant fractions Π (15-64) were equal to the following values: 0.79 in 1997, 0.66 in 1998, 0.40 in 1999, 0.34 in 2000, 0.35 in 2001, 0.38 in 2002, and 0.37 in 2003 and 2004. The UDDR was calculated as percentages of the TUDR according to the following equation:

UDDR (1997-2004) = Π (15-64) x TUDR Equation 2.8

UDDR values for 2009 were calculated from the death counts assigned to the cause of undetermined intent. TDR values were calculated using SSA data for death rates due to traffic accidents for the years between 2001 and 2004 and in 2009, according to Equation 2.9:

$$TDR = \frac{100\,000 \times \text{Gender deaths}}{\text{Total population (South Africa)}} \quad \text{Equation 2.9}$$

Gender deaths are the total number of deaths in South Africa for the given calendar year due to traffic accidents. Total population is the midyear estimate of the total South African population in a given calendar year. Death rates per 100 000 citizens in 2001 and 2004 were averaged to give the mean values of 6.0 % for men and 1.9 % for women. These values were assumed to represent the TDR for the 1997- 2004 period. The TDR for 2009 was 7.3 per 100 000 inhabitants for men and 2.1 per 100 000 inhabitants for women. All values of MEDR, SEJDR, PSHDR, UDDR for 1997- 2004 and 2009 were calculated using data by Bradshaw et al. (2003) and Statistics South Africa (SSA 2011a). Table 2.4 below shows the calculated TDR values:

2.10.5 Table 2.4 The gender segregated TDR values

Year	Male deaths due to traffic accidents	Female deaths due to traffic accidents	Total population	Male TDR per 100 000 citizens	Female TDR per 100 000 citizens
2001	2751	828	44 909 738	6.1	1.8
2002	2220	726	45 533 292	4.9	1.6
2003	2809	886	46 116 494	6.1	1.9
2004	3239	1006	46 664 771	6.9	2.2
2009	3607	1035	49 320 500	7.3	2.1

$$GDR = \frac{100\,000 \times \text{Gender deaths}}{\text{Total population (South Africa)}} \qquad \text{Equation 2.10}$$

GDR represents the death rate from a given cause for male or female (number of deaths per 100 000 citizens).

Gender deaths mean the total number of deaths in South Africa in a given calendar year from a particular cause of death, for males and females. Total population is the midyear estimate of population according to Statistics South Africa. Table 2.5 below shows the calculated values for GDR.

2.10.6 Table 2.5 The average GDR values for the 1997-2004 period calculated using Equation 2.5

Parameter	Male deaths (number of deaths)	Female deaths (number of deaths)	Total population	Male death rates per 100 000 citizens	Female death rate per 100 000 citizens
MEDR 1997-2004	245	247	46 508 215	0.5	0.5
PSHDR 1997-2004	4502	1386	46 508 215	9.7	3.0
SEJDR 1997- 2004	400	115	46 508 215	0.9	0.2
MEDR 2009	130	118	49 320 500	0.3	0.2
UDDR 2009	4628	1126	49 320 500	9.4	2.3
PSHDR 2009	262	81	49 320 500	0.5	0.2
SEJDR 2009	15	6	49 320 500	0.03	0.01

From this data, the Disaster Related Death Inequality Index (DII) defined in equation 2.11 was calculated:

$$DII = \frac{DRDR\ (women)}{DRDR\ (men)} \qquad \text{Equation 2.11}$$

DRDR (women) is the female death rate from disasters in South Africa (per 100 000 inhabitants). DRDR (men) is the male death rate from disasters in South Africa (per 100 000 inhabitants).

2.10.7 Health, empowerment and labour market and how they impact human development

The inequality indices calculated in the above equations indicate the presence or absence of gender differences. If the Inequality Index equals one, then there is no gender disparity. If the Inequality Index was greater than 1, then it indicated that more of the vulnerability leaned towards women than men. When the inequality index was less than 1, it indicated that men were more vulnerable to that given parameter than women.

2.10.7.1 The Health Status Inequality Index

Between 1980 and 2011, life expectancy at birth for women was in the range of 51-66 years, while that for men was 47-60 years. In 2011, life expectancies at birth were recorded at a minimum of 53 years for men and 54 years for women. The LEABI value was 1.084 while the Human Development Index (HDI) was 0.61.

There was no systematic trend between these two values. While South Africa has reached a medium level of human development, the life expectancy of women is about 10 % higher than that of men. Gender differences seem to decrease with time, while the level of health disaster vulnerability seems to be comparable for both genders. The health vulnerability for the population seemed to increase for the same time period (1980-2011) that life expectancy at birth decreased.

These statistics also indicated that there was no impact on gender through the life expectancy at birth inequality index. While considering gender divide along sex boundaries, both the male and female groups were afforded adequate health care to live long years, the latest statistics being 59 years for men and 63 years for women. There was no need to carry out gender specific disaster management in the case of a disaster occurring, since gender differences in life expectancy appeared to decrease with time. There was therefore a need to engage communities as one unit without favour or preference for one sex in discussing vulnerability in disaster management.

2.10.7.2 Maternal Mortality

Maternal Mortality refers to death due to complications from pregnancy or childbirth (UNICEF, 2015). Maternal Mortality Ratio (MMR) refers to the number of maternal deaths in a given time period per 100 000 live births in the same given period. From 1990 to 2015, the global MMR declined from 385 to 216 deaths (UNICEF, 2015). In the 15 years from 1990 to 2015, the number of deaths due to complications in pregnancy and childbirth reduced by 169 per 100 000 live births. This indicated an increase in resources available to women for childbirth. The women and girls who died from complications of childbirth and pregnancy reduced from 532 000 in 1990 to 303 000 in 2015 (UNICEF, 2015). This reduction of over 200 000 deaths from complications of childbirth and pregnancy indicate the results of a target based approach to provision of services such as healthcare, water and sanitation, as seen through the Millennium Development goals. Almost 99 % of maternity deaths occurred in developing countries and 88 % of these deaths occurred in sub Saharan Africa and South Asia (UNICEF, 2015). Southern Africa recorded MMR of 926 deaths in 1990 and 417 deaths in 2015 (UNICEF, 2015). MMR in Southern Africa decreased by 509 deaths per 100 000 live births which is very commendable in terms of improvement of maternal health services delivery in Southern Africa. In South Africa, the recorded MMR was 108 deaths in 1990 compared to 138 deaths in 2015 (UNICEF, 2015). Maternal services in South Africa however decreased in the same period, causing an increase of maternal related deaths by 20 for every 100 000 live births. MMR for Zimbabwe in 1990 were 440 deaths in 1990 and 443 deaths in 2015 (UNICEF, 2015). Even though Maternal health services were decreasing in Zimbabwe due to 'brain drain', the effect of this shortage of staff was countered by the provision of resources for maternal health, increasing MMR by 3 deaths for every 100 000 live births. Swaziland recorded an MMR of 635 deaths in 1990 compared to 389 deaths in 2015 (UNICEF, 2015). Botswana recorded MMR of 243 deaths in 1990 compared to 129 deaths in 2015. Namibia had an MMR of 338 deaths in 1990 compared to 265 deaths in 2015 (UNICEF, 2015). Swaziland, Botswana and Namibia all seemed to have their maternal health service on the rise as shown by the improved numbers in reducing MMR. The Eastern and Southern Africa region had a 3.2 % reduction in the average annual MMR which was significant in terms of achieving MDG goal 5 of reducing maternal deaths by three quarters by reaching an average annual MMR of 5.5 % (UN, 2014b). No trend was observed between the MMR and the HDI for South Africa. Gender plays a significant role in the reduction of MMR in Zimbabwe,

South Africa as well as Southern Africa. Deaths due to maternal health related matters arise from lack of resources, but also from lack of knowledge.

From practice in the retail pharmacy industry, the researcher found out that most men consider the child bearing process of labour to be an extravagant expense. Prenatal medication is considered vital and bought for the pregnant women consistently. The husbands tend to prepare financially for the hospital admission aspect of it, but when women complain of labour related pains, post partum depression or physical exhaustion after child birth, the men attribute this to weakness. The women therefore end up overexerting themselves, resulting in complications due to childbirth and pregnancy. This is more common in low income family households, which do not engage the help of the extended family to assist in the period after childbirth.

The pressure to recover back to normal is even worse in single parent households, where the mother is the sole breadwinner. She has to financially support herself before, during and after pregnancy, so she ends up working up until labour, and just after childbirth, which increases her chances of childbirth related complications if she doesn't get adequate help.

It is therefore imperative that gender based care be provided in cases of disaster to pregnant, new mothers and their caregivers. They have specific needs which they require to ensure the health of their young, and to protect their families from the impact of disasters, as well as the recovery from such disasters.

In order to be fully aware of these resources and how best to prepare for new mothers in disaster management, there is a need to include child bearing women, young and old, when designing disaster management protocols for communities.

They would also be useful in designing protocols for managing water resources after a disaster, since they would have experience in providing newborns with clean water and clean utensils at all times.

2.10.7.3 Unemployment Inequality Index

The UEI ranged from 1.163 in 2009 to 1.330 in 2008. These results indicated that women were more likely to be unemployed than men in South Africa. More women were therefore involved in low skilled labour, or entrepreneurial labour force. These women thus spend more time working and more time trying to find resources for their families. As a result, they become

unavailable for preparation of disaster management protocols for their communities, or for their families. The increase in unemployment levels also increased gender based violence in low skilled labour workforce. As seen in the statistics provided on women and men in the low skilled labour workforce, there were 4.6 women for every man in employment. Low skilled labour increases economic vulnerability, financial dependence. These women would therefore end up taking risqué employment, which exposes them to disasters, in order to provide for their families, thus increasing their disaster vulnerability.

2.10.7.4 Literacy rate

In 2007, 87 % of women and 91 % of men were literate in South Africa. In 2011, 98 % of women and 97 % of men were literate. The LRI values were therefore 0.956 in 2007 and 1.013 in 2011. The literacy rate increased between 2007 and 2011 for both genders, and neither gender is likely to experience vulnerability in this regard. The Enrolment Inequality Index for 2009 was 0.96 and 1.04 at primary and secondary levels. There was no vulnerability to be expected in education levels. The impact of literacy on disaster management was not derived from these results. There was no gender difference validating the vulnerability of one group; female over the other; male. Both the female and male groups had equal access to education resources, hence they could be persuaded to design disaster management protocols for their specific communities together. Gender was not a factor in access to education, and as a result, education provided a level field for discussion of disaster management in communities.

2.10.7.5 Human Development index

HDI values for South Africa fluctuated between 1980 and 2011 by 9.5 %. For developed countries in the G20, the HDI had increased, and then levelled off. The HDI for South Africa experienced a fluctuating trend. This was observed throughout the timeline, even for shorter periods such as 2008-2011. South Africa therefore did not follow a Kuznets model of gender inequality on the level of economic and human development. Human development was measured in terms of health, empowerment and the labour market. Even though the information from HDI, MMR, literacy rate and UII showed varying levels of vulnerability between men and women, this was not directly or indirectly proportional to human development. Health disaster vulnerability seemed comparable between the sexes, while life expectancy for women was 10 %

higher than that for men. MMR seemed to be increasing in South Africa between 1990 and 2015 (UNICEF, 2015).Women were more likely to be unemployed than men, and literacy rate increased for both genders between 2007 and 2011. In developed countries, the HDI increased linearly then levelled off. In South Africa, the HDI was observed to be fluctuating (SSA, 2011). This means no gender specific factor could be held accountable for the level of human and economic development in the country. The Kuznets model answers the question of whether inequality in income distribution affects the distribution of wealth in a growing economy and in South Africa's case, it did not. This therefore means, gender should not the only factor held accountable for disaster management. Other factors (water and sanitation health, empowerment) improve on disaster management, while others contribute to it (education, literacy), but disaster management is multi faceted, and requires the input of all available stakeholders.

2.10.7.6 Fatality rates

Death rates ranged from 38.3 to 172.6 for men and 7.2 to 33.2 for women. Minimum values were obtained for both genders in 2009, whilst maximum values were obtained for men in 2001 and in 2000 for women. DII values fluctuated throughout the period examined in this study, but no systemic trend was observed. The average DII value was 0.20, indicating that the male portion of the population is five times more vulnerable to disaster fatalities than its female counterpart. This may be attributed to the likelihood of men to engage in dangerous life threatening activities (risk takers) as opposed to the natural impulse to protect and nurture (risk averse) of women. Women would therefore make sensible candidates in designing disaster risk management and assessment protocols, while men would develop disaster recovery (or fix) protocols.

As expected in any developing country, there have been calls from various stakeholders to include women and children in disaster risk management planning (NDMC, 2009). The South African government responded to this, and at the employee level of Provincial Disaster Management Centres, the male to female ratio is 1, according to 2006 data (NDMC, 2009). While this is commendable, the same efforts need to be assigned with respect to economic vulnerability and women's access to quality health care. Statistical derivations from this study indicate that men are five times more susceptible to non-transport disasters than women. There also needs to be an increased focus on the male gender in South Africa, in the form of awareness

campaigns about disaster related risks. The respective materials have already been developed by the National Disaster Management Committee (NDMC), but they need to be translated into all 11 official languages. Women, men, and children should all be stakeholders in designing mitigation procedures to protect their communities from the full impact of disasters. Statistical databases that were used to derive approximate values for the Disaster Inequality Index in South Africa for male and female segments of the population were available in the public domain.

3 CHAPTER THREE

3.1 PRELIMINARY ASSESSMENT OF THE GENDER ASPECTS OF DISASTER VULNERABILITY AND LOSS OF HUMAN LIFE IN ZIMBABWE

3.2 INTRODUCTION

This chapter presents national statistics for Zimbabwe and indicates how they impact on the country's economy. It will also address the impact of various demographics such as health, gender, employment status, concurrent diseases, education level, and the hierarchy in households and their impact on disaster management and waterborne disease management in Zimbabwe.

Finally, it will use various equations to show the inequality between genders in Zimbabwe to illustrate the impact these have on disaster risk management and planning.

3.3 Country statistics for Zimbabwe

Zimbabwe is located 20 ^{0}S of the Equator and 30 ^{0}E of the Prime Meridian (ZLLM, 2016). It is a landlocked country in Southern Africa located between South Africa, Mozambique, Botswana and Zambia (ZLLM, 2016). The climate is tropical and is moderated by altitude (ZLLM, 2016). The lowest point in Zimbabwe is where Save River meets Runde River. The highest point is Inyangani Mountain (ZLLM, 2016). The population in 2010 was estimated at 12.34 million people, while in 2012 it was estimated at 12.974 million, an increase of 2.54 % (Indexmundi, 2014). From 2012 to 2014, the population increased by 1.1 % from 12.974 million people to 13.261 million people (Indexmundi, 2014). According to 2012 official Zimbabwe Statistical Office data, women constituted 52 % whilst men constituted 48 % of the population (ZIMSTAT, 2013). There were more women than men in most age groups except for the following: 0-4, 10-14 and 40-44 (ZIMSTAT, 2013). The highest population proportions were in the age group 0-4, with 15.6 % and 13.9 % of the total population for males and females respectively (ZIMSTAT, 2013). The age bracket of those who are economically active in a country is usually 19 to 65 years old. The distribution of ratios in Zimbabwe showed that the highest population group in the country fell in the age group 0-4 years, which is also the most vulnerable group. Overall statistics indicated that Zimbabwe had a higher population of women than men. Given that the male population was more gainfully employed than the female population, this showed that the majority of women in the working class in Zimbabwe were not economically independent. The Census of 2012 indicated that most women were employed in positions of domestic work, farming, or informal trading, while men were gainfully employed (ZIMSTAT, 2012). Since the Zimbabwean society follows the patriarchal social system, the most vulnerable population group are women, and they experience worse effects in a disaster situation. The higher populations of women in most age groups suggest that water and sanitation services, where available, are handled by the female population, who are generally more receptive of sanitation and health programmes. This may also be the reason why Target 7c of the Millenium Development Goals was achieved early: women are responsible for water and sanitation in most households, and they distribute their resources to meet their needs. Improved water and sanitation to communities

came about as a result of women working together in communities to make the most out of their communal water sources and sanitation resources.

3.4 Zimbabwe's economy

Zimbabwe has an agro-based economy that has suffered due to climate change and variability, as indicated by the droughts of 1992-3 and 2002 (Gotelind, 2011). More droughts are now being recorded on a yearly basis due to climate change, and this is affecting disaster preparedness in Zimbabwe. Between 1998 and 2008, Zimbabwe's economy recorded a 10 % GDP growth (Indexmundi, 2015). In 2009, the economy was dollarized in order to curb hyperinflation (Indexmundi, 2015). This resulted in the introduction of many foreign currencies, including but not limited to the United States Dollar (US$), Botswana Pula (P), and South African Rand (ZAR) (Indexmundi, 2015). This assisted in the resumption of trade, but did not solve the financial problems the country faced. Since then, the economy has experienced further challenges, some of which include large external debt burdens, infrastructure and regulatory deficiencies, reduced formal employment, and indigenisation pressures (Indexmundi, 2015). The absence of a local currency reduced the trust of the population in the financial capability of the Reserve Bank of Zimbabwe.

The closure of most companies in the industrial sector resulted in increased informal trading in the country, but recent amendments to the Control of Goods Regulations of 1974 targeted this form of trading too. The amendment, cited as the Control of Goods (Open General Import Licence) no. 2 (Amendment) Notice, 2016 (8) regulated the import of the following items through use of an import licence: synthetic hair products, second hand tyres, woven fabrics of cotton, bottled water, canned fruits and vegetables, and some building products (Statutory Instrument 64 of 2016). This control measure was set to limit quantities of goods imported duty free to minimal household quantities, while goods imported for trade purposes were now brought into the country after payment of an import licence and proof of duty payments (Statutory Instrument 64 of 2016).

3.5 Migratory patterns in Zimbabwe

The net migration rate estimated in 2014 was 21.78 per 1000 people (Indexmundi, 2015b). This number accounted for the population leaving Zimbabwe for other countries. Zimbabwean professionals have been migrating to African, Asian, and European countries (Chikanda, 2005;

AFDB, 2007). Statistics for internal migration were provided in the first chapter, and they indicated a tendency to migrate from rural provinces of Zimbabwe to the urban areas in search of gainful employment. There has been an increase in the migration rate of Zimbabweans into neighbouring South Africa in search of better economic opportunities, and this has been well documented (Indexmundi, 2015b). Such migration used to be limited to medical professions in the past, but after the closure of industries, it has extended to all professions (Chikanda, 2005; WHO, 2006). Because of its proximity to Zimbabwe, South Africa posed a viable option for professionals and non-professionals seeking economic redemption. Given South Africa's interaction with the Global Market, it posed better opportunities for Zimbabweans than do other neighbouring countries such as Mozambique, Botswana, Malawi, and Zambia (Indexmundi 2015b). However, Zimbabweans still traveled to these other countries in search of opportunities better than those offered by this country (FMSP,2009). Changing demographics, technological and socio-economic conditions, unplanned urbanization, geological hazards, climate change, and climate variability as well as competition for scarce resources all indicate a serious threat to the sustainability of the efforts of developing countries (ISDR, 2005). The World Health Statistics for 2006 showed that South Africa's population had a density of 0.77 physicians per 1 000 people, 0.28 pharmacists per 1 000 people and 4.08 nurses per 1 000 people in 2004 (WHO, 2006). Meanwhile, Zimbabwe had a density of 0.16 physicians per 1 000 people, 0.07 pharmacists per 1 000 people and 0.72 nurses per 1 000 people (WHO, 2006). These densities indicate that there was less than one healthcare professional available to provide basic health services to populations in both Zimbabwe and South Africa. South Africa had better statistics for nurses at 4 nurses per 1 000 people, but still, these statistics poor compared to those in developed countries (WHO, 2006). Such statistics in the health sector indicate that there will always be room for more healthcare practitioners in both South Africa and Zimbabwe, but because South Africa provides better working conditions, it is more attractive to qualified professionals between the two countries (Chikanda, 2005, WHO, 2006).

Zimbabwe, in addition to the many economic challenges it faces, is also vulnerable to both natural and manmade disasters. Migration of qualified professionals to other countries limits the level of economic development and social growth which can be achieved by those who remain. Unlike the South African Government's engaging Higher Education Institutions as partners to develop a sense of social responsibility and ownership of the development of the country

amongst its workforce, the Zimbabwean Government keeps losing skilled workforces who leave the country in search of better work opportunities (Chikanda, 2005). Absence of a skilled workforce impacts on the acquisition of the resources required to build up and develop the country. When development is not addressed by all stakeholders in the country, there is reduced accountability for those resources acquired to provide the basic requirements of the population, since the people skilled in these areas will not be present to monitor their distribution and use. In the case of Zimbabwe, this has affected the ability of the Municipalities to source the funds necessary for buying new equipment for Water Reticulation systems (City of Harare, 2016). Instead, they keep performing maintenance work on old equipment which should have been replaced twenty years ago (City of Harare, 2016). The increasing population in Zimbabwe adds further pressure to already underperforming potable water supply system and the unlikelihood of sustainable development no longer raises concern. As global warming takes centre stage, its effects on the African sub-continent are observed through droughts, which now occur on a yearly basis, and this affects access to potable water, and increases the risk for waterborne diseases due to water contamination from the increased number of users per water source.

3.6 Gender

Gender in the Zimbabwean context is divided along the lines of sex and the practice of patriarchal social system is dominant (Kambarami, 2006). There are other gender constructs, but these are not acknowledged. The family unit, in the Shona culture, promotes patriarchal practices and imparts them to their children through assigning sexually differentiated roles (Kambarami, 2006). Women are viewed as child bearers, dependant on and subordinate to men (Kambarami, 2006). The roles of young girls include fetching water, cooking, cleaning the homestead, washing clothes, and being caregiver to younger children and the elderly (Our Africa, 2015). Once they reach child bearing age, girls are married off to go and continue carrying out these responsibilities for their husbands (Our Africa, 2015). Young boys are considered the protectors of their female siblings, even when younger than them (Chant, 1997). This has resulted in the education of male children to higher levels than female children (Kambarami, 2006). Once they complete their education, male graduates find formal employment more readily than their female counterparts (ZIMSTAT, 2012). Even though the law prohibits bias in the employment of men over women by virtue of their gender, many companies prefer male employees. Statistics from the Census of 2012 show that men occupy higher paying jobs and dominate most positions in

Government, the Education sector, the Industrial sector, and so forth (ZIMSTAT, 2012; Malaba, 2006). One of the obvious reasons for this is that some women start to have children as soon as they reach child bearing age and, on average, one woman may have 2 to 5 children (ZIMSTAT, 2012). Women are entitled to maternity leave and breastfeeding periods while employed, and during their absence, their male counterparts spend more time on the job, gaining ample experience to supersede them when promotions become available. The end result is that women tend to occupy the same posts in the work place while their male counterparts explore better options and move on to better paying jobs. There also exists a small group of financially independent women, but this usually exists among women who postpone childbearing until their late thirties or forties (Kambarami, 2006). Their success protects them from economic vulnerability, but because most of them are not in marriages, this does not have an overall benefit for the rest of the population in terms of economic independence (UNHDI, 2012). This minority of women are financially equipped to handle most disasters, such as water shortages or waterborne disease problems, food shortage disasters, health related disasters, and road traffic accidents. They have many forms of insurance, and are able to employ a small group of people to cater for their health and social needs. In Zimbabwe, this gender disparity works in the favour of male-headed households, which gain a financial stronghold more easily than their female-headed household counterparts. The impact of this gender divide on the education system will be assessed using the Secondary and Tertiary Education enrolment information from surveys conducted by the Zimbabwe Statistical office. It will also be assessed in the Human Development indices calculated for the economically active age groups (UNHDI, 2012).

The division of roles between girls and boys determines what is considered appropriate for each gender (Malaba, 2006; Ingraham, 2002). In cases of disaster, it becomes difficult for males to show their vulnerability to women, which may prevent them from receiving much needed attention, be it health, financial, or otherwise in order to deal with the aftermath of a disaster (WGEKN, 2007). If a female child's training is limited to mastering a few feminine duties, it may become difficult for her to survive if she loses a caregiver to a disaster (Malaba, 2006). This gender divide therefore limits the level of interaction expected from both the male and female child in disaster relief and disaster mitigation projects, subsequently affecting disaster management (Malaba, 2006; Wenger, 2004).

Patriarchal practices can also be traced to religious convictions: traditional African, Christian, and other. Religious beliefs in Zimbabwe are divided as follows: part Christian, part traditional is 50 %; Christian only is 25 %; traditional beliefs account for 24 %; and Islam and other religions account for 1 % (Indexmundi, 2015c). Religion identifies the male figure as the head of the household, responsible for the welfare of his family (Kambarami, 2006). In child-headed households, this responsibility may rest with the female child if she is the eldest, or with the male child (Kambarami, 2006). Children who lose their parents are expected to seek the care of other guardians until they are legally considered adults at 18 years of age (ZIMSTAT, 2012b). When this transfer of custody does not occur, there is a stigma which surrounds these families, often involving rumours of HIV/ AIDS or other serious medical conditions (ZIMSTAT, 2012b). These children therefore become each other's guardians, and their security in a crisis comes from their numbers. If a disaster occurs in the form of floods, or a waterborne disease, these families become vulnerable to disease and economic loss due to their limited access to resources (Phillips, 2007). Female children who head families may also become vulnerable to opportunistic predators that appear to assist their family whilst harbouring a hidden agenda and this ends up in child marriages and abuse (Chant, 1997). It is acceptable in the Shona culture for young men to marry widowed women or single mothers, so that the women gain social status, and the men are assured of children in the future (Personal communication, 2015). This tradition, in a way, reduces disaster vulnerability and allows economically vulnerable women to be provided for by working men. As stated before, Zimbabwe is a religious country, and religion permeates all aspects of everyday life, including education, work, and social engagements. The impact of religion on disaster management in the Zimbabwean community will be assessed using census data from marriages, head of households and employment information, and how they fare against disaster vulnerability.

3.7 Disaster Management and the Hyogo Framework for Action

The Hyogo Framework for Action was designed for the time period between 2005-2015 (ISDR, 2005; Chikoto, 2004). There was an increase in disaster loss, with grave consequences for survival, dignity, and the livelihoods of individuals, especially those from poor and marginalized groups (ISDR, 2005; Manyena, 2006; Manyena, 2008; Hunter, 2004). Prior to this, the Millennium Development Goals were developed to target eight specific aspects, ranging from water and sanitation, poverty, hunger and disease, to women's empowerment (UN, 2014b).

These were established and adopted by world leaders in 2000. MDG target 7c aimed to halve the world population without sustainable access to safe drinking water and basic sanitation by 2015 (WHO/ UNICEF, 2013; UN, 2013). Access to improved drinking water sources was achieved five years ahead of schedule, as already mentioned in Chapter 1. There was, however, concern about the quality of drinking water which was being provided by drinking water sources (WHO/UNICEF, 2013). The Joint Monitoring Programme (JMP) for Water Supply and Sanitation of WHO/UNICEF cautioned that achievement of this goal did not take into account the quality of the water, nor did it reflect microbial safety and sanitary status (WHO/ UNICEF, 2013; Bain et al., 2014). This meant that there was still need, after provision of drinking water to most of the world population, to ensure that these water sources were not contaminated, thus making them sources of waterborne disease outbreaks. MDG target 3 was to promote gender equality and empower women. This target was achieved in all developing countries, which managed to eliminate gender disparity in primary, secondary, and tertiary education (UN, 2014b).

On the workforce, statistics from the 2012 census showed that 50 % of working age women participated in the workforce, compared to 75 % of working age men (ZIMSTAT, 2012). There were more women (41 %) employed in paid labor outside of Agriculture than in 1990 (35 %). The proportion of women in Parliament doubled from the numbers obtained in 1990 (UN 2014b). However, women still experienced worse effects of poverty, a discriminatory labor market, low wages, as well as an absence from public and private decision making processes (UN, 2014b). Target 4 of the MDGs was to reduce the under five mortality rate in children by two thirds. The global under five mortality rate reduced by more than half from 90 to 43 deaths per 1 000 live births (UN, 2015a). The total number of deaths declined from 12.7 million in 1990 to almost 6 million in 2015. Statistics for children in rural areas showed that they were 1.7 times more likely to die before their fifth birthdays than those in urban areas (UN, 2015a). At the same time, children of mothers with tertiary education were three times more likely to survive under five mortality than children of mothers without education (UN, 2015a).

The 18th of August 2014 marked the 500th day milestone of the end of the stated 10 year period. In his address to the nations, the Secretary General for the United Nations, Mr. Ban Ki Moon, offered these words:

> "There are many fires raging around the world today – political turmoil, bloodshed, and public health emergencies and human rights abuses. But there also burns a flame of hope – encouraging progress in the global drive to improve the lives of the world's poorest through the Millennium Development Goals" (UN, 2014b).

He encouraged the youth to contribute even more in helping to reach the stated goals. In order to achieve these goals, he proposed the following agendas: making strategic investments in health, education, energy, and sanitation, with a special focus on empowering women and girls, which boosts results across the board, and by focusing on the poorest and most vulnerable countries, communities, and social groups that have the toughest road to progress despite their best efforts. Deepening cooperation between governments, civil society, the private sector, and other organizations has helped make the MDGs the most successful anti-poverty drive in history (UN, 2014b). In Zimbabwe, a special focus was placed on empowering young girls and women, and this brought forth fruits in community and social development (UNICEF, 2004; Nestle, 2013). There were been efforts to reduce child mortality by the Ministry of Health and Child Welfare (ZEPI, 2014). There is a lot of work that still needs to be done in water and sanitation health. Detailed statistical data on the health status of communities also needs to be collected on an annual basis as opposed to every ten years, when a national census is carried out. A good example of this may be observed in South African mortality data, which is updated every year using ICD10 data received from health institutions (SSA, 2006, 2011a).

3.8 Literacy rate

Census data from 2012 showed that the literacy rate was at 96 % for the Zimbabwean population aged 15 years and above (ZIMSTAT, 2012). There was no significant difference in literacy rates between 15-39 years of age for males and females. Literacy rates were highest between 15-44 years of age, while, from 45 years upwards, literacy rates were higher in men than women, with the age group 75+ showing literacy rates of 83 % for males and 75 % for females (ZIMSTAT, 2012). In the age group 3-24 years, 12 % of this population had never been enrolled in school. The majority of this population, however, was less than 6 years of age and was likely to be enrolled in school later (ZIMSTAT, 2012). Literacy is very important in disaster management, as disaster preparedness is taught to communities using information leaflets or posters, and black

board or white board lessons. To reduce the effect of illiteracy on comprehending disaster information, radios may be used to transmit disaster warning information.

In Mozambique, radios were used to access the HF frequency of weather reporting that provided early warning systems of disaster management, and this helped in their disaster preparedness for Cyclone Favio (IFRC, 2007). Radios are fairly user friendly, but the information leaflets indicating levels of danger warning require a level of literacy and adequate training on how to interpret them. Using the literacy rate and education statistics provided by the census, it can be concluded that most of the Zimbabwean population would be able to access danger warning information in preparation for disasters if it was provided to them.

3.9 Mortality rate

Mortality rates across different ages are also an indicator of the health of a given population. Child mortality was estimated at 24 per 1 000 live births (ZIMSTAT, 2012). Under five mortality was 84 per 1 000 live births, and life expectancy at birth was 38 years. The overall MMR was 525 deaths (ZIMSTAT, 2012). Maternal mortality data refers to deaths occurring due to complications with pregnancy and childbirth, as well as to deaths occurring 42 days after giving birth, if they are childbirth related (ZIMSTAT, 2012). The level of health care in Zimbabwe was considered to be low when compared to its South African counterpart, which had a life expectancy of over 50 years, even after accounting for complications due to health. The MMR was also high, even though statistical data compared between the 2002 Census and the 2012 Census shows that this ratio has decreased in Zimbabwe (ZIMSTAT, 2012). Despite this decrease in MMR between 2002 and 2012, the current level of health care provided in the public health sector was low.

The migration of medical health professionals to other countries and the shortage of essential medicines in public hospitals made it difficult for individuals without Medical Aids or Health Insurance to obtain health care in the private sector, due to the high tariffs. A proportion of mothers in Zimbabwe has their first children after completing their high school education or further, and this proportion is expected to provide better care to their children in terms of sanitation and hygiene, thus reducing the number of deaths (ZIMSTAT, 2012). Vaccination programmes are provided in the public sector at no cost, and this improves infant health and the

health of the mothers (ZEPI, 2014). However, in the absence of potable water, which is the crisis being experienced by the country now, it follows that, should a health related disaster occur, there is very little that can be done to manage its effects, even if the population has the requisite knowledge, due to shortage of water, which is a basic requirement for all health related procedures and preparations. Where knowledge is present, it is important that the community is provided with adequate resources to manage the effects of a disaster, so that the disaster does not spread to other communities which are not affected at the time.

3.10 Vulnerability assessment

The Zimbabwe Central Statistical Office (ZIMSTAT) Database, World Health Organization, Indexmundi, and the United Nations were used to provide statistical data on health, water and sanitation, education level, head of households, and marriage. The way in which these various subjects affect disaster management was then investigated. From this data, the Inequality Indices across genders were calculated. Results obtained from these inequality indices were used to draw conclusions on whether there was any gender inequality in disaster management.

The life expectancy at birth (LEAB) for men and women is an overall measure of health conditions in a given country (United Nations, 2012). The relevant data on life expectancy for men and women was obtained from the ZIMSTAT database, as updated in 2012. According to the 2008 Inter Censal Demographic Survey (ICDS), the expectation of life at birth was 41 years for males and 46 for females. The LEAB Inequality Index (LEABI) was calculated based on that data, according to Equation 2.1

$$\text{LEABI} = \frac{\text{Age (woman)}}{\text{Age (man)}} \qquad \text{Equation 2.1}$$

The Human Development Index is a measure of long term progress and is assessed according to the following dimensions: a long and healthy life, access to knowledge, and a decent standard of living (UNDP, 2015). A long and healthy life is assessed by life expectancy (UNDP, 2015). This life expectancy is influenced by many factors, such as maternal health, provision of neonatal health care, access to vaccines necessary at birth, as well as access to immunisation drugs for growing children (UNDP, 2015). Knowledge level was measured according to years of

enrolment in an educational institution for adults 25 years and older, as well as expected period for enrolment periods for children of school going age (UNDP, 2015). Standard of living is measured by Gross National Income per capita, converted using purchasing power parity rates (UNDP, 2015). Access to knowledge was addressed by the level of education obtained through census data. A long and healthy life was addressed through life adjusted years in HIV /AIDS positive populations. Life expectancy data was also used. A long and healthy life, as interpreted from life expectancy information, and mortality data, indicates the quality of life available in a given country (UN, 2012). It indicates the amount of health resources available for the development of an individual from infancy up to geriatric age. A country with adequate resources for its infants will experience low child mortality rates, low maternal mortality rates, high life expectancy for both genders, and a larger population of both genders over the age of 75 years (UN, 2012). The data which depicts level of education in new mothers was found to be linked to an increased understanding of sanitation and hygiene, which reduced the under five mortality rate in children, and also reduced maternal mortality rates (ZIMSTAT, 2012). An increase in the level of education for women was credited for the improvement in the application of sanitation and health information disseminated at hospitals (ZIMSTAT, 2012). Good health, improved sanitation and hygiene, and reduced mortality rates all ensure that communities are managed by well-informed individuals who can better prepare for any form of disaster.

When disaster information is made available to both genders, there is no risk of this information being lost, as both genders would be literate and able to translate to less literate individuals. In the case of disasters related to water, women, who engage in the majority of activities that require water, would benefit from information about conscientious water usage, and from community development programmes that promote recycling and re-usage of water. If these community channels are in place, any water related disaster is easier to handle, and when not possible, the recovery measures for the disasters may be implemented through these community channels, promoting sustainable development.

3.10.1 Child labour

Activities in which children were involved in child labour were divided into economic and non-economic activities (ZIMSTAT, 2012). According to the International Labour Organization (ILO) definition, a child who spends at least one hour per week on any economic activity is

considered to be in economic child labour (ZIMSTAT, 2012). For Zimbabwe, three major variations were introduced, namely:

(a) a cut off of three hours or more per day in relation to economic activities;
(b) provision to allow for involvement of children aged 15 and above in some form of work as per national law; and
(c) a cut off of five hours or more per day for children involved in housekeeping activities as constituting non-economic child labour (Public Service, 1999).

The 2011 Labour Force and Child Labour Survey (LFCLS) revealed that there were about 4.1 million children aged 5 to 17 years, 3.2 million aged 5 to 14 years and 860 000 were aged 15 to 17 years (ZIMSTAT, 2012). Of the total children aged 5 to 14 years, 1.2 million were engaged in economic activities and 2.4 million were engaged in non-economic activities (ZIMSTAT, 2012). 10 % of the total children aged 5 to 14 years were in economic child labour, while 1 % of this age group was engaged in non-economic child labour (ZIMSTAT, 2012). In the age group 15 to 17 years, 59.9 % were involved in economic activities. Most of the children engaged in economic / non-economic child labour in the age group 15-17 years did so to help take care of their families. 30 % of these children were from households where the head of the household earned between US$ 101 and US$ 200, and 29.5 % of the children were from households where the household head earned between US$ 201 and US$ 300 (ZIMSTAT, 2012). The following example gives a brief insight into the kind of lifestyle a low income family may have in theory, in Zimbabwe, in a given month.

Considering an average family of four (mother, father, child, hired help) which requires electricity for US$20, transport costs for US$100 for parents and a child of school going age, groceries worth US$100, water bills for US$15, rentals for US$ 100, and US$70 - $100 for hired help (this amount varies with location and many other factors). An approximate budget for this family requires them to have a minimum of US$400 to meet their basic requirements. When load shedding of electricity occurs, they may require the use of alternative sources of energy, which adds to their expenditure. Households earning less than US$ 400 will therefore need to supplement their incomes to meet their basic needs. This results in children being encouraged to engage in economic labour once they are old enough to secure part time work.

The alternative to this scenario would be a child-headed family, with the oldest caregiver being a minor. The family would still require most of the above mentioned expenditure items, except that there would be no parents to provide the minimum amount of US$ 300. This would result in the eldest children engaging in economic child labour to take care of their siblings. These children seek employment in areas that require physical strength, such as basic construction work, heavy lifting, moving jobs, or farm work. Even when they show signs of physical fitness, children get easily fatigued, and the children in this scenario miss out on the educational activities that their peers will be enjoying. These jobs that accommodate children require the maximum amount of labour for minimum wages. This means that at the end of this hard labour, these children still remain impoverished, and they are exposed to industrial and health hazards in the work place. If these children pass the culture of child labour on to their siblings, they promote a generation of poorly educated adults with limited economic resources. Poverty also forces them to seek accommodation in the least expensive residential areas, which are marred by poor water quality and sanitation. They run the risk of contracting communicable diseases that easily spread in crowded areas. This increases their vulnerability to health related disasters, waterborne disease disasters, and other manmade disasters. When Non Governmental Organisations bring in disaster relief programmes, it is difficult for such families to comprehend the importance of following disaster management procedures, as they spend more time trying to earn an income in order to survive, rather than learning new skills.

There was a percentage reduction in economic child labour to 2.9 % and 2.8 % for children who were in households headed by individuals who earned between US$ 401 and US$ 500, and US$ 1 001 and US$ 3 000, respectively (ZIMSTAT, 2012). 35.9 % of children in non-economic child labour were from households where the head earned less than US$ 100 and 27.1 % of them were from households headed by persons who earned between US$ 101 and US$200 (ZIMSTAT, 2012). The results indicated that economic child labour generally decreased as the income of the head of the household increased (ZIMSTAT, 2012). Of the 424 000 in economic child labour, 2.9 % were injured in the twelve months prior to the Labour Force and Child Labour Survey. This constituted about 12 400 children, 70 % of whom were male and 30 % of whom were female. Of these, 49 % of the injuries sustained were deemed not serious and required no medical treatment. Another 39 % received medical attention at the workplace or in public health facilities and, of those who were treated, 62.5 % were male and 37.5 % were female. Injuries

were mostly sustained in the agricultural sector, at 78 %, while 3.1 % of injuries were sustained during domestic labour (ZIMSTAT, 2012). Injuries sustained in the workplace that were not considered serious may have been deemed so due to the possibility of losing work should the victim admit an inability to perform their tasks. Injuries in the workplace that were not well treated increased the risk of permanent damages to limbs, which increased the disaster vulnerability of their families in the wake of disasters.

Economic child labour exposes children to working conditions that are not ideal for the mental development of children (Levison and Murray-Close, 2005). Industrial hazards, air pollution, limited personal safety equipment, and extended working hours limit their ability to comprehend the same information that would be easily understood by someone their own age who has attended school (Buvinic and Gupta, 1997). These children, however, are unable to understand the risk to their health associated with their working conditions, or the means available to assist them if they identify such public health risks (Levison and Murray-Close, 2005). When they are treated as adults in their workplaces, they fail to develop mentally and to achieve the level of academic improvement achieved by their peers (Mogotlane et. al., 2010). Basic academic achievement would assist them in making informed decisions in the employment they can carry out, and their own safety. It would not guarantee economic independence, but it may promote active participation of these young children in the development of disaster management programmes for their immediate communities. An appreciation for the standard operating procedures of a workplace where they are employed helps workers to be better equipped for disaster risk reduction measures. This comes from acquiring a certain level of education before being formally employed (Chant, 1997). As obtained in the Labour Force and Child Labour Survey of 2004 and 2011, 57.2 % of children engaged in economic child labour were aware that they required protective clothing for their jobs (ZIMSTAT, 2012b). This did not, however, guarantee their access to these safety clothes. Child labour impacts on the level of education to which vulnerable children may be exposed. A low level of education has been found to be linked to decreased awareness of sanitation and hygiene levels ideal for raising children (Chant, 1997). If these children start their own families, they add to the statistics of uneducated parents that lose their children before they reach five years of age, due to conditions that can be easily managed in a healthcare institution. Improved levels of education go a long way in the implementation of

water and sanitation developments in communities (UN, 2015c). This in turn provides the basic foundation for building sustainable development projects that help in preparing for disasters.

3.10.2 Level of education

Concerning the level of education of the heads of household, 24.8 % of the children in economic child labour were under household heads that had completed secondary education, whilst 20.2 % were under household heads that had completed tertiary education (ZIMSTAT, 2012b). For those children in households with heads that didn't attain primary education, 62.5 % were males and 37.5 % were females (ZIMSTAT, 2012b). As for the children involved in non-economic child labour, 28.6 % were under household heads that had attained tertiary levels of education, and 24.6 % were under heads that had completed secondary education (ZIMSTAT, 2012b). The results also showed that 79.5 % of the children whose heads of households had no primary education were females. This survey showed that non-economic child labour generally increased as the level of education of the household head increased (ZIMSTAT, 2012b). This may be due to the theory that parents who attain tertiary education prefer their children to undergo a period of manual or unpaid labour so that they can get the responsibility and discipline required to manage their family's income (ZIMSTAT, 2012b).

An analysis of the causes of child labour revealed that child labour was most common in households where the head of household had low incomes (ZIMSTAT, 2012b). 83 % of children in economic child labour were from households where the head of the household earned less than US$ 300 (ZIMSTAT, 2012b). The cause of child labour was therefore to supplement household income.

Economic child labour was highest, 37.4 %, in households of 5 to 6 members, while non-economic child labour was highest in households of 3 to 4 members, at 34.2 % (ZIMSTAT, 2012b). Non-economic child labour in smaller families is therefore considered to be for training purposes for young adults. An economic labour working culture amongst children could give rise to them not achieving higher levels of education, leading to a failure to provide for their future families to their best abilities. It also repeats the cycle of uneducated parents bringing up uneducated children who fail to sustain themselves through formal employment, as other families would, given similar conditions. Uneducated parents are more difficult to convince when it becomes necessary for them to change their way of living so as to reduce the risk to their

health. To better understand the distribution of male and female children in secondary education and the reasons behind it, Table 3.1 and Table 3.2 indicate the level of education against sex.

3.10.3 Table 3.1 SEI Index for children enrolled in secondary school.

Level of education	Male %	Female %	SEI Index
Form 1	49.5	50.5	0.9802
Form 2	49.1	50.7	0.96844
Form 3	50.2	49.8	1.00803
Form 4	52.3	47.7	1.09644
Lower 6th	54.3	45.7	1.18818
Upper 6th	56.7	43.3	1.30947

*SEI Index-Secondary Education Inequality Index

This data is made available by statistics for the first term of 2010. The Secondary Education Inequality Index shows that more males acquired higher levels of education than females. This may be caused by early marriage, the need to provide home care for ailing parents and relatives, the inability to source equal funds for male and female children, and by a lack of motivation of some students.

The inequality in education between males and females also affects disaster management. When women are educated, you educate the whole community. As a mainly patriarchal society, Zimbabwe would benefit from the improvement of education in both male and female children. Educated women are able to provide for their families' social and health needs, through accessing clinics and hospitals, even without financial stability. Educated women would be useful in developing water and sanitation hygiene protocols for their families, which would benefit their whole communities in the end. Educated women would also be well informed in maternal health matters, and would willingly pass this information to their communities to their

less educated counterparts. The education of men and women equally makes them competent stakeholders in determining the safety of their communities in terms of water and sanitation health, hygiene, workplace safety, maternal health and disaster management. Educated adults also encourage their children to be educated, thus empowering them for significant economic competence.

3.10.4 Table 3.2 TEI Index of male and female enrolment at tertiary institutes

	Enrolment at a technical tertiary institution		
Year	**Male %**	**Female %**	**TEI Index**
2000	71	29	2.44
2008	61	39	1.56
2009	34.8	65.2	0.53
2010	59.3	40.7	1.46

*TEI-Tertiary Education Inequality Index

The Tertiary Education Inequality Index shows the discrepancy between educating a female adult and a male adult (ZIMSTAT, 2012b). Table 3.2 shows gender representation in tertiary institutes. More males than females were enrolled in tertiary institutions, according to the LFCLS survey of 2011. This trend was observed in 2000, 2008, and 2010. More females than males were recorded in 2009, when economic recession hit the country at the highest level (ZIMSTAT, 2012b). This may be explained by the fact that more men resorted to informal employment than education, so that they could afford to take care of their families and dependants. After analysing the social construct in many Zimbabwean families, it is clear that the male child is educated to tertiary levels more often than the female child. This is why more Zimbabwean human rights based groups concentrate efforts on the empowerment of women and girls, e.g. The Girl Child Network. The higher proportion of males who have acquired tertiary education could also suggest the hypothesis that women were more likely to marry early and settle down before

having obtained tertiary education. As a result, they tended to focus more on household duties and developed a financial dependence on the men. Since more men were involved in tertiary education than women, this could have provided a platform on which young women were educated on community enhancement programs, such as disaster relief protocols, becoming community health care workers, becoming sanitation monitors and assisting in water quality monitoring. Secondary education in Zimbabwe is nothing to scoff at, and these women may have provided their communities with far better preparation for disasters and how to manage them.

The delegation of household responsibilities may be used to determine which gender should be empowered with knowledge on the management of disasters due to waterborne diseases in the grassroots projects of the Civil Protection Unit. Tertiary education was also found to be a core contributor to successful sanitation and hygiene projects according to the Census of 2012. Increased levels of education for both parents made them more appreciative of postnatal health, maternal health, and vaccination programmes, which increased the life expectancy of their children and of the parents as well.

3.10.5 Marriage

Another aspect of disaster vulnerability assessed was marriage. The age group with the highest proportion of married men was 50-54 years (91 %), while that for females was 35-39 years (89.8 %). A difference in the patterns for women and men was explained by differences in ages at marriage and differences in longevity (ZIMSTAT, 2013). Women tended to get married early, and also to marry older men. Widowed males tended to marry younger women, thus accounting for the high proportion of married men, even in the older age group of 50-54. From these results, it was seen that most young women did not get married early, but some of them had children out of wedlock. As a result, younger women were now left with the responsibility of raising their children as unmarried mothers. This made them more susceptible to disasters, especially because of their children, who depended on them. From the statistics of the LFCLS of 2011, 19.2 % of female children were married, compared to 17.5 % of males. This was in part facilitated by the Marriage Act (Chapter 5:11) of 1996 which states that a male adult of age 18 years or a female of age 16 years may legally marry. This age difference resulted in young females becoming vulnerable to early marriage.

The empowerment of women in community programmes as stated above would equip them for adulthood, responsibility of raising families, as well as resilience in the face of disasters. There is a gap which exists between completion of secondary education and marriage, which needs to be filled with empowerment programmes for young women, which can help to reduce their disaster vulnerability, as well as their financial dependence on men.

3.10.6 Heads of household

The 2011 LFCLS revealed that males headed about 65 % of households in the country, while females headed 35 % (ZIMSTAT, 2012). The proportion of heads of households was larger for males in all age groups other than the 12 to 14 group, where 66 % of households were headed by females (ZIMSTAT, 2013). The households headed by females in the 12-14 age groups tended to be families of children orphaned by health-related cases or road carnages (ZIMSTAT, 2013). The survey also revealed that children under 18 years headed 0.8 % of households, which is a small proportion (ZIMSTAT, 2013).

Several children were orphaned at an early age by HIV/AIDS, cancer or other life threatening diseases. Such families required a lot more assistance other than preparing for drought and prevention of epidemics of waterborne diseases in order to survive, such as assistance with school fees for education purposes (Phillips, 2011). Families headed by young adults were particularly vulnerable, as they were subject to poverty, unqualified for employment in the formal sector, and were less likely to acquire economically viable jobs (Phillips, 2011; Mogotlane et. al., 2010). Analysing the 65 % of households headed by men compared to 35 % by women, one may deduce that the traditional family value of men as the head of households is still being observed (ZIMSTAT, 2012). The 35 % of households headed by women relied on incomes that were either gained by formal employment or employment in the informal sector, termed Small to Medium Scale Enterprises (SMEs) (ZIMSTAT, 2012). Low skilled labour results in increased labour hours, low income, and increased risk of gender based violence, water and sanitation health diseases, unemployment etc. In the current economic situation observed in Zimbabwe, these families have to work twice as hard, compared o the two parent households, to meet their basic needs, which gives them less time to prepare for disaster vulnerability, or participate in the development of such measures in their communities. They therefore become

the most vulnerable when disasters occur, as well as the least likely to receive aid, since they are not well known in their communities.

3.10.7 Employment

To evaluate the trends in employment, the dimensionless Unemployment Inequality Index (UEI) was calculated using Equation 2.2 based on the available Zimbabwean statistics (ZIMSTAT, 2013).

$$UEI = \frac{\text{Unemployment Rate (women)}}{\text{Unemployment Rate (men)}} \qquad \text{Equation 2.2}$$

In Equation 2.2, Unemployment Rate (women) is the average unemployment rate for women in Zimbabwe (percent of the female population in the productive age of 15-64), while Unemployment Rate (men) is the average unemployment rate of their male counterparts in Zimbabwe (percent of the male population in the productive age of 15-64). There were more women than men who were unemployed.

Using the values obtained in Table 3.2:

UEI = 14.5/6.5

= 2.3

Table 3.3 below shows the distribution of male and female employees in the various sectors of employment according to the 2012 census. The same results are further represented in the form of a graph in Figure 3.1 as well.

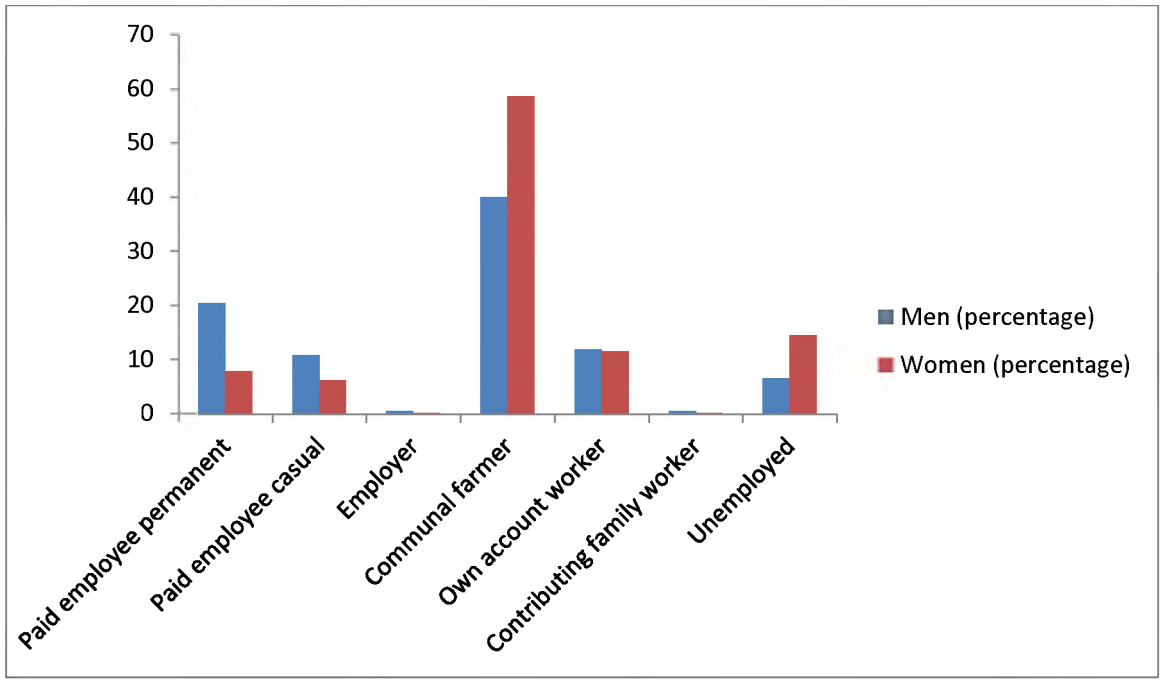
3.10.8 Table 3.3 Distribution of the economically active population

Activity	Male %	Female %
Paid employee permanent	20.4	7.9
Paid employee casual	10.8	6.2
Employer	0.6	0.2
Communal farmer	40	58.5
Own account worker	11.9	11.6

Contributing family worker	0.6	0.2
Unemployed	6.6	14.5

These results indicate that for most forms of employment, for every woman employed, there were two men in that position. This is caused by the low tolerance of the workplace to childbearing while employed. This natural process is considered an expense by most organisations and in the end, women end up giving in and resigning before their time, to avoid the disappointment of being passed up for promotions/training and professional development. The census statistics also indicated that there were more women than men to begin with, so this distribution in the workplace is certainly orchestrated purposefully, not by accident.

As explained under marriage, education and empowerment, the uplifting of women is a significant contributor to disaster resilience. The fewer women you have a stakeholders in disaster management, the less effective that protocol becomes, especially in communities where women are the caregivers.



3.10.9 Figure 3.1 Distribution of the working class between men and women

According to UNDP, more than 70 % of the world's poor are female, and so the share of women among the most vulnerable is disproportionately high (Gotelind, 2011). Even for the same work, women are paid less than men, and this discrepancy seems to persist (Gotelind, 2011). Women, especially younger women, experience unemployment for a longer period of time than men after receiving their qualifications (Mogotlane et. al., 2010). Recent data, for example, from the European Commission, shows that women were working mainly in 'feminized' sectors and professions, and remained in lower job categories with less access to senior positions (Gotelind, 2011). Young women still tended to choose these 'female' occupations, while their share in engineering, manufacturing, and construction jobs was less than 25 % (Mogotlane et al., 2010). This was also observed in the survey carried out by ZIMSTAT on Zimbabwean women and their occupations, the LFCLS survey of 2011.

Table 3.3 and Figure 3.1 show how the sexes were divided in employment. Of the total employees of 5.4 million in the country, about 3.6 million were in the agriculture, forestry, and fishing sectors (ZIMSTAT, 2013). About 55 % of employees in this sector were women, showing that women still dominate in proportions (ZIMSTAT, 2013). Women were also dominant in private households, human health and social work, accommodation and food service activities, wholesale and retail trade, education, and activities of extraterritorial organizations and bodies (ZIMSTAT, 2013). Less than 10 % of people employed in the following sectors were women: mining and quarrying; electricity; gas; steam and air condition supply; construction; and transport and storage (ZIMSTAT, 2013). Census data showed that between 2009 and 2013, the proportion of women was lower than the proportion of men in the aforementioned industries (ZIMSTAT, 2013). In 2008, there were no women holding positions as town clerks or treasurers. There were 8 female municipal heads compared to 16 males in the same category (ZIMSTAT, 2013).

In 2011, At least 60 % of women workers in developing countries were in informal employment, which is generally a larger source of income for women than for men (Phillips, 2011). For instance, in Sub-Saharan Africa, 84 % of women were informally employed in the non-agricultural sector, compared to 63 % of men (AFDB, 2007). Of the world's estimated 100 million home-based workers, the majority were women (Doane, 2007).

In Zimbabwe, although women's share in the labour force increased over the years, the gap between the percentage of women in paid employment and that of men remains wide. In 2011, 31 % of economically active men were in paid employment, compared to 14 % of women. 59 % of women were involved in communal farming (ZIMSTAT, 2013). The data also showed that women constituted a greater proportion of the unemployed population. There is a strong relationship between occupation and the skill level that one possesses. The 2011 LFCLS showed that 83 % of the employed population was unskilled, 6 % was skilled, and 5 % semi-skilled and 5 % were professional. 54 % of the unskilled employees were females while 59 % of professionals were males (ZIMSTAT, 2013). The higher proportion of unskilled employee positions which were occupied by women, made them easily replaceable once they took maternity leave, and removed their financial stability as heads of households. In communal farming, 59 % of positions were found to be occupied by women (FAO, 2012). This implied that the main source of livelihood for these families was agriculture. If inadequate rains or natural disasters such as hailstorms were experienced, it made such families highly vulnerable to drought. Droughts or floods bring about a range of waterborne diseases associated with them, and floods increase the microbial content of dams and rivers. These raw water sources are used for water treatment and, since most treatment plants are generally not adjusted for variations in microbial content according to season, some microbes are likely to escape the filtration process, which results in mass contamination of piped water. The empowerment of women in agriculture to handle mass contamination of water sources would help to prevent whole communities from using contaminated water sources. That would in turn prevent the spread of water borne disease disasters, as well assist the community disaster management members in recovery after flooding or drought disasters.

3.10.10 HIV / AIDS

HIV/ AIDS is still a very serious disease on the African continent. Zimbabwe experienced a steady fall in HIV prevalence since the 1990s due mainly to a significant change in sexual behaviour (ZIMSTAT, 2013). Although the estimated adult prevalence dropped from 20.1 % in 2005 according to the Zimbabwe Demographic Health Survey (2005-06 ZDHS) to 15 % in 2010 (2010-11 ZDHS), HIV continues to be a serious problem. The 2010-11 ZDHS showed that more females (18 %) were infected than males (12 %). The Ministry of Health and Child Welfare encouraged every citizen of Zimbabwe to know their HIV status by getting tested. As a result,

HIV testing and counselling were offered free of charge at most health institutions (ZIMSTAT, 2013).

Figures from the 2005-06 ZDHS and the 2010-11 ZDHS indicated that a larger proportion of females than males aged 15-49 years were tested (ZIMSTAT, 2013). Women in this age bracket were of childbearing age. They therefore received health care more frequently than men, in the form of Tetanus vaccines, PAP smears, Voluntary Counselling and Testing for HIV / AIDS, to mention but a few. As a result, they were more likely to know their HIV status than their male counterparts. Also to be considered for this group is that most commercial sex workers were found in this age bracket. Education drives involving commercial sex workers were conducted, and these women tended to be more conscious and aware of their HIV / AIDS status than the average family man or woman. This is because they protected themselves from either being infected or re-infected by their sexual partners, as this was their source of livelihood. A change in sexual behaviour in mainly married men and women will go a long way to reduce the burden of HIV and AIDS and thus the threat of public health risk. The occupations and roles that men are expected to hold in society generally expose them to illnesses and injuries, and more males than females die early (ZIMSTAT, 2013). Men exposed to HIV infection by accident would most likely prefer to remain anonymous than to seek immediate medical attention, because of the stigma associated with HIV infection. Anonymous infected persons are more likely to cause damage to the communities, in terms of spreading the retroviral disease, as well as other concomitant diseases, to various partners.

There is a need to educate the male population on public health risks so that they can be able to live long enough to provide for their families. Women tend to receive this education at prenatal clinics, which they visit throughout pregnancies and also at Postnatal clinics when they get their children vaccinated against common childhood diseases. Infection with HIV / AIDS affects children by forcing them to become caregivers: women become heads of households while young male adults have to quit school to tend to their families. All of these factors make such families highly vulnerable to health related disasters.

They therefore need to be equipped through counselling centres and community empowerment programmes on how to deal with such statuses, without adding stigma to their situation. They

also need to be informed of the dangers of re-infection, as well as the risk of spreading the retroviral disease to un-infected partners.

3.10.11 Water, Sanitation, and Health

Analysis of progress towards achieving MDG target 7c, which stipulated that all households should have access to improved drinking water sources by 2015, was reviewed. According to the 2011 LFCLS, 78 % of households used safe water for drinking and cooking (ZIMSTAT, 2013). 34 % of these households had their source of water on the premises (ZIMSTAT, 2013). The survey also revealed that 63 % of households used safe sanitation, which implied that they used one of the following toilet facilities: flush, blair, or pit toilets with slab (ZIMSTAT, 2013). 26 % of households, however, did not have a toilet facility (ZIMSTAT, 2013). This 26 % of households needed to be significantly reduced by 2015 if the MDGs for sanitation were to be met. Information collected during the 2009 Multiple Indicator Monitoring Survey (MIMS) revealed that 37 % of households had water on premises (ZIMSTAT, 2013). Of households without water on premises, 19 % took less than 15 min to collect water, while 17 % took between 15 and 30 min (ZIMSTAT, 2013). This was a significant step toward achieving the MDGs focused on access to improved water and sanitation. It also meant that the threat to public health posed by the consumption of untreated water and the transmission of waterborne diseases would be reduced. In the likelihood of a waterborne disease outbreak, it would be easier to control the source of the infection if it was within one household. For those using a communal source of water, the source could be isolated and treated as required. Water, sanitation, and hygiene (WASH) are fundamental to health (UN, 2014a). Access to safe drinking water sources and toilets helps to reduce the spread of many diseases (UN, 2014a). Despite progress in child mortality, infectious diseases still posed a huge threat to the health of young children (UN, 2014a). Despite the significant reduction in child mortality observed in Zimbabwe, infectious diseases remained a major predicament. Infection, such as diarrhoeal diseases, was the third biggest killer of children less than five years old in Sub-Saharan Africa, and almost 90 % of cases of diarrhoea were caused by poor WASH (UN, 2014a). Half of the cases of under-nutrition were due to a lack of WASH, and under-nutrition was an underlying risk factor for around 30 % of under-five deaths (UN, 2014a). Repeated episodes of diarrhoea predisposed under-nourished children to pneumonia (UN, 2014a). A lack of hygiene and sanitation and the associated

diarrhoea also contributed to stunted and inhibited cognitive development in millions of children worldwide (UN, 2014a).

In Zimbabwe, water shortage is a serious problem that warrants attention. The replacement of old water reticulation pipes with new sets should not be taken lightly and should be carried out urgently. The development of reticulation systems that support areas surrounding Harare, such as Chitungwiza, Ruwa, and Norton, would also significantly reduce the population load on the Morton Jaffray Treatment Plant. Once the population load is reduced on the Morton Jaffray Treatment Plant, it may be easier to source the treatment chemicals required to support smaller populations on each system, and to develop sustainable microbial quality monitoring stations across the country.

3.11 Empowerment

The literacy rate was found to be 97 % overall, while the unemployment rate was 10.7 % (ZIMSTAT, 2012). The percentage of unemployed people indicated that the majority of people of productive age were engaged in either formal or informal sectors as a way to sustain their livelihoods. The engagement of adults in the informal sector in disaster preparedness programs, would improve their skills level, as well as increasetheir economic potential in the society.

The most recent update of the Education Act (25:04; referred to below as EA 25:04) is known as the Education Act 25 of 2001. In this Act, every child in Zimbabwe has the right to school education. He / she may not be discriminated against by the imposition of conditions controlling admission into any school (EA 25:04 section 4). Primary education for every child of school going age is compulsory, and school tuition should be marked at the lowest possible fees, consistent with the maintenance of high standards of education (EA 25:04 sections 5 and 6). The Minister of Education may provide grants and other subsidies to schools to provide for the attainment of this objective (EA 25:04 section 6). The Minister may also promote and enhance the education of the people of Zimbabwe and the progressive development of institutions dedicated to that purpose (EA 25:04 section 7). Every child of school going age may be enrolled at a primary or secondary school closest to their place of residence unless that particular school is full (EA 25:04 section 10). This Act also provides for students in secondary schools. For the attainment of Higher and Tertiary education, the Act regulating this level is the Manpower Planning and Development Act (Chapter 28:02) 1 of 2001, to be referred to as MPDA 28:02

hence forth. This Act seeks to provide for the establishment, maintenance, and operation of technical / vocational institutions, universities, teachers' colleges, and vocational schemes. It also aims to provide for and to promote research, planning and development of human resources, and to provide for the continued existence of the Zimbabwe Manpower Development Fund (MPDA chapter 28:02).

The Minister of Higher and Tertiary Education, or any Minister appointed by the president to execute this Act, shall provide for the establishment and development of institutions devoted to the production of qualified manpower. He will also be responsible for the standardisation of technical and vocational education and control of professional qualifications other than degrees awarded by universities (MPDA chapter 28:02 section 4). The Minister may establish and develop vocational teachers' colleges or technical institutions, equip and maintain conditions which he considers necessary for the instruction of persons at such an establishment (MPDA chapter 28:02 section 6). He may also provide conditions promoting research and development, as well as facilities for teacher education at such institutions (MPDA chapter 28:02 section 6). The Minister may grant rebates, refunds, and remissions, whether in whole or in part of fees paid, as he considers desirable for students (MPDA chapter 28:02 section 7 part 3). The Acts governing primary, secondary, and tertiary education in Zimbabwe promote the education of both sexes in children and in adults. They also promote the teaching of trainers for all of these institutions.

Technical college skills training, disaster management drives and community maternal health training would help to create self sustaining communities, which do not constantly seek donor approval for aid to survive. Tertiary institution collaborations between various departments would help in developing solid disaster management and relief programmes.

3.12 Disaster management in weather related hazards

Poverty plays a major role in the vulnerability of a group to the impact of climate change (Gotelind, 2011). Due to their living conditions, the poor are often more exposed to hazards and have fewer resources to avoid or cope with the impact of disasters (Gotelind, 2011).The response to disastrous climate hazards, such as disaster risk reduction, early-warning systems and post-disaster relief, recovery, and reconstruction needs to build upon both women's and men's contributions to be effective (ZIMSTAT, 2013). The very high proportion of unskilled workers,

even though literate, may present a barrier to the implementation of disaster preparedness measures. Personal safety is not only at risk during a disaster, but also during often difficult post-disaster situations, mainly because of threats posed by other people who need assistance (Gotelind 2011). Cooperation of both males and females helps in the transition from a state of disaster to recovery. Housing and shelter are massively impacted by disasters, especially in settlements in areas prone to floods or to landslides (Gotelind, 2011). In Zimbabwe, a prominent example is that of the Tokwe - Mukosi basin flooding. Disaster management measures help to prepare for such disasters and to implement protocols after they occur. Mobility can be constrained in post-disaster situations, increasing the risks to personal safety (Gotelind, 2011). Disaster protocols need to incorporate transportation measures to a point with less risk once disasters occur.

3.13 Study Findings

Table 3.4 shows the life expectancy at birth for various age groups, as approximated from the graph provided by the ICDS survey in 2008. It also provides values for the LEABI index, as calculated on a Microsoft Excel spread sheet.

3.13.1 Table 3.4 Life expectancy by age for men and women in 1997, 2002 and 2008

Table	3.1:	Female	and	Male	Life	Expectanc	1997,	2002	and
Year	1997	2002	2008						
Male	Female	Male	Female	Male	Female	Male	LEABI 199	LEABI 200	LEABI 200
0	52.6	57.2	42.7	45.9	40.8	46.2	0.91958	0.930283	0.883117
1	56.2	61	45	47.9	42.7	47.7	0.921311	0.939457	0.895178
5	54.3	59.1	43.3	46	40.9	45.1	0.918782	0.941304	0.906874
10	49.9	54.8	39.1	41.6	36.3	40.9	0.910584	0.939904	0.887531
15	46	50.7	34.7	37	31.6	36.6	0.907298	0.937838	0.863388
20	42.1	46.6	30	32.5	27.5	32.2	0.903433	0.923077	0.854037
25	38.6	42.7	25.8	28.9	23.6	29	0.903981	0.892734	0.813793
30	35	38.8	22.6	26.7	20.4	27.4	0.902062	0.846442	0.744526
35	31.4	34.9	20.6	25.7	19.4	26.4	0.899713	0.801556	0.734848
40	27.8	31.1	20	25.2	19.6	25.4	0.893891	0.793651	0.771654
45	24.3	27.3	19.3	25	18.3	26	0.89011	0.772	0.703846
50	20.8	23.5	18.3	23.2	16.7	23.8	0.885106	0.788793	0.701681
55	17.5	19.5	16.7	20.6	15.3	21.7	0.897436	0.81068	0.705069
60	14.3	16.2	14.8	17.7	13.7	18.1	0.882716	0.836158	0.756906
65	11.4	12.9	12.5	14.5	10.9	15.4	0.883721	0.862069	0.707792
70	8.8	10	9.8	11.2	7.6	13.3	0.88	0.875	0.571429
75	6.7	7.7	6.8	7.6	6.9	10.6	0.87013	0.894737	0.650943
80	4	4.5	5.3	8.5			0.888889	0.623529	
Source:	CSO	(2002),	Zimbabwe	National	Populatio	Census	Report		
CSO	(1997,	2008),	Inter-Cen	Demograp	Survey	Report			

The life expectancy at birth was used to calculate LEABI values for the years 1997, 2002, and 2008, as well as life expectancy in different age brackets.

Zimbabwe had an LEABI index less than 1.0, which indicated that men are more vulnerable than women to early mortality. The Unemployment Inequality Index was greater than 1.0 across the age groups, which meant that more women were vulnerable to disaster aspects, as a result of unemployment. More women were at risk, regardless of whether they were younger (under 15 years) or older (15- 64 years), and were vulnerable to the disastrous aspects of climate change, drought, and diseases. The Tertiary Education Inequality Index and the Secondary Education Inequality Index were greater than 1, which indicated that more women were vulnerable to unskilled employment than men. The overall life expectancy decreased from birth with increasing age. These results were observed in figures from 1998, 2000, 2002, and 2008.The overall health vulnerability of the population increased over the same period, as life expectancy at birth decreased from 1998 to 2011.

Information from the Indexmundi website was also used to determine the LEAB for the Zimbabwean population. LEAB was 45.77 in 2009, 47.55 in 2010, 49.64 in 2011, 51.82 in 2012, 53.86 in 2013, and 55.68 in 2014 (UNDP, 2015). The LEAB Index was not calculated, as the LEAB value was inclusive of both genders and the total population.

These statistics indicated gender disparity between the health of men and women in Zimbabwe. Better healthcare was therefore required to help reduce the disease burden on women so that they could provide better health care for their children. If women were engaged in disease management workshops targeting childhood diseases, they would be better equipped to protect their children and to reduce childhood mortality rates due to common childhood diseases. During the Cholera outbreak of 2009, female headed households reported more infections than male-headed homes, due to their continued engagement with health care providers. (Bepete, 2014).

The Human Development Index for Zimbabwe in 2014 was 0.509 and it was grouped under the category of low human development (UNDP, 2015). Zimbabwe was 155 out of 188 countries and territories. This HDI changed between 1980 and 2014 from 0.437 to 0.509, an increase of 16.4 % and an average increase of 0.45 % (UNDP, 2015). Zimbabwe's HDI for 2014, when adjusted to account for inequality across all three aspects of measurement was reduced to 0.371 (UNDP, 2015).

The Gender Inequality Index was computed using the general mean of general means across different orders. It was calculated by first;

1. treating zeros and extreme values, then
2. aggregating across dimensions within each gender group, using geometric means,
3. then aggregating across gender groups using a harmonic mean,
4. then calculating the geometric mean of the arithmetic means of each indicator,
5. then calculating the Gender Inequality Index.

The Gender Inequality Index for Zimbabwe was calculated using data from reproductive health, empowerment, and economic activity between genders. Reproductive health was measured by maternal mortality and adolescent birth rates; empowerment by the share of parliamentary seats and attainment of higher education by each gender (UNDP, 2015). Economic activity was measured by labour market participation rates for men and women. The GII may therefore be

interpreted as the loss in human development due to inequality between male and female counterparts (UNDP, 2015).

The Gender Development Index is calculated according to the following steps;

1. Estimating the male and female earned incomes,
2. Normalising the indicators,
3. calculating the female and male Human Development index values and finally,
4. calculating the gender development index (UNDP, 2015)

According to data on Zimbabwe in 2015, the wage ratio for females to males was 0.8. The estimated female earned income per capita was $1 387 while that for males was $1 850. The female health index was 0.560 while the male health index was 0.595. The female and male education index values were 0.521 and 0.562 respectively. The female human development index was 0.487 and the male human development index was 0.529. As a result, the Gender development index was 0.922 (UNDP, 2015).

The Gender Development Index, i.e. the ratio of female to male HDI as calculated in 2014, was 0.504, ranking Zimbabwe 112 out of 155 countries in the 2014 index (UNDP, 2015). Zimbabwe had a GII of 0.504, whereas Kenya and Lesotho had 0.552 and 0.541 respectively (UNDP, 2015). Zimbabwe was ranked 112th while Lesotho was ranked at 124th and Kenya at 126th. Parliamentary seats occupied by females were 35.1 % for Zimbabwe, 26.8 % for Lesotho and 20.8 % for Kenya (UNDP, 2015). Zimbabwe's population with higher education qualifications was 48.7 % and 62 % for female and male groups respectively, while that for Lesotho was 21.9 % and 19 % for female and male, and Kenya had 25.3 % and 31.4 % for female and male respectively (UNDP, 2015).

The Gender Inequality Index showed that women were more vulnerable than women to inequality in the workforce. The Human Development Index showed that women were more vulnerable than men in empowerment. The Gender Development Index showed that women were more vulnerable to human development than men. Vulnerability in human development also increases vulnerability to disasters. Women were more vulnerable to disasters in most areas, however, it is also important that men be included in disaster management planning and training. Women, men, and children should all be stakeholders in designing mitigation procedures that

protect their communities from the full impact of disasters. Efforts should also be made to engage men in disaster awareness campaigns through workshops and social activities. Population Services International (PSI) in Zimbabwe engaged various famous male artists to promote male sexual health procedures. Similar platforms may be used to draw the attention of men and to encourage them to participate in disaster reduction programmes.

4 CHAPTER 4

4.1 WATER QUALITY ASSESSMENT IN HARARE, ZIMBABWE.

This Chapter will provide results from the assessment of microbial quality of raw water, treated water, and alternative water sources in the Manyame Catchment area, which provides water to Harare. The analysis was conducted in Harare because of its accessibility to the researcher. During the period of this research, the researcher was also interning and performing community service requirements for registration as a pharmacist in Zimbabwe. Areas outside Harare in which this study was conducted were also accessible, and they contributed to the Morton Jaffray Water treatment facility as either recipients of (i.e. Norton) its treated potable water, or tributaries to (i.e. Mupfure River, Mutsige River) its main water source, Manyame River. This Chapter will also address responses to the questionnaire distributed to various members of the Harare community, with regard to their perspective of the microbial quality of their water, as well as its aesthetic appeal. Information gathered during these interviews will also be included in

the assessment. WHO guidelines for microbial quality of domestic water sources were used for comparison of the water samples obtained from potable water sources, as well as from those rivers, that function as domestic water sources. The chapter will also address various areas that affect disaster management in Zimbabwe, and provide recommendations, based on other countries' success in disaster management, that could be used in the Zimbabwean context to improve its disaster preparedness, disaster relief, and disaster mitigation procedures. In addition, this chapter will provide literature which investigates the impact of engaging various stakeholders in addressing the problems of microbial water quality and water availability in Zimbabwe, and compare these to the South African management of microbial water quality. Finally, this chapter will present strategies that can assist in improving the availability of safe potable water sources that have recommended microbial water quality levels.

4.2 Description of study area

Harare has a population of 2.1 million people and a land area of 872 km^2 (ZIMSTAT, 2012). The water supply infrastructure includes 6 000 km of water pipes. Of this length, 200 km of iron pipes have so far been replaced with polyvinyl chloride (PVC) pipes (City of Harare, 2015). The city's water supply infrastructure was originally designed to supply 350 000 people, and has been progressively upgraded to supply 1.5 million people (ZIMSTAT, 2012). The current population expected to benefit from this improved infrastructure is approximately 4.5 million people, three times more than its current capacity (ZIMSTAT, 2012). Over the years, maintenance of the pipelines and the treatment plant were prioritised over a complete upgrade of the water supply infrastructure. The projected water demand of 1 400 000 m^3/d for 2015 is much more than the combined capacity of Lakes Chivero and Manyame, which have a combined carrying capacity of 727 417 000 m^3 (Nhapi, 2009). The pipes used in this Reticulation System were asbestos cement (AC) and steel types. The AC type was vulnerable to breakage due to ground movement, both during and after the rainy season, as well as due to soil expansion and contraction (Nhapi, 2009). Steel pipes corroded with age, resulting in an increased leakage rate and burst frequency (Nhapi, 2009).

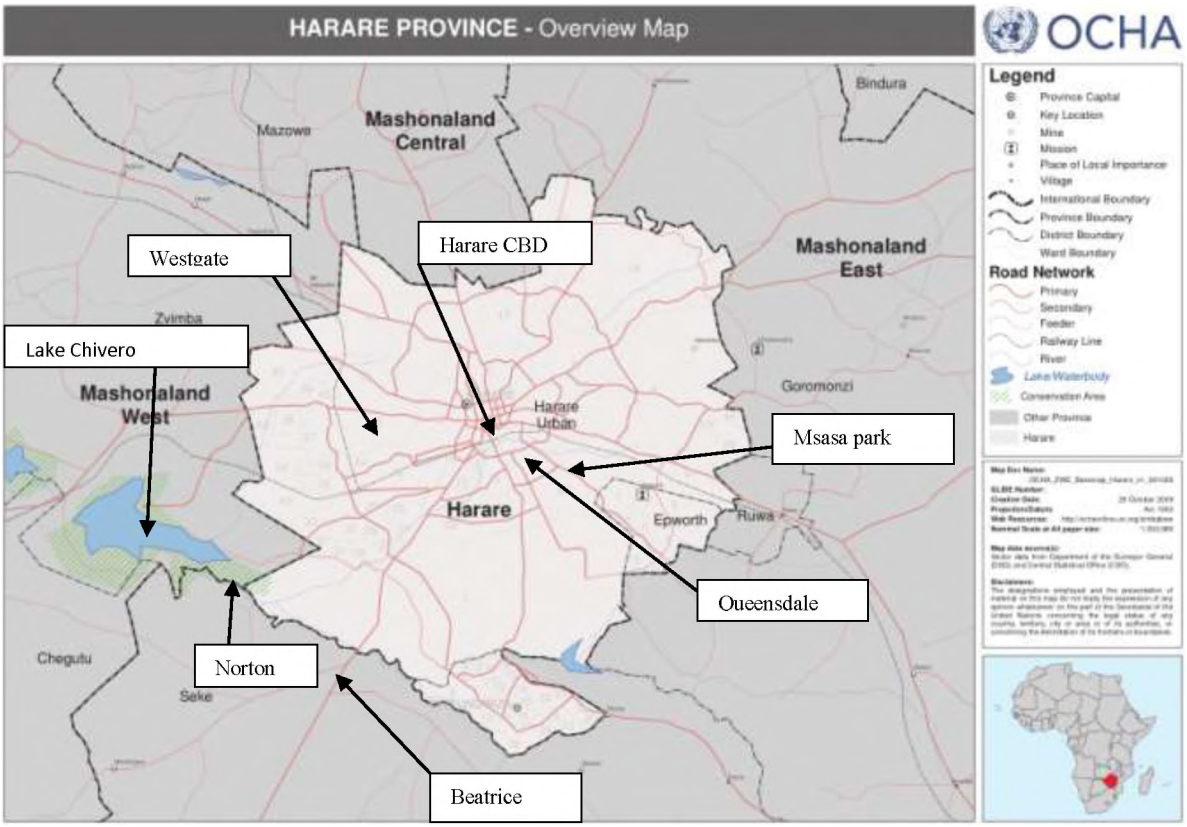


Figure 4.1 Map of Harare province showing sampled areas for the study. (Superimposed on Harare map obtained from Reliefweb, 2016)

The disposal of sewage waste was a major problem in Harare. The Chitungwiza area, which receives its water from Morton Jaffray Water Treatment Plant, was affected by sewage disposal problems. This resulted in industrial companies disposing of their untreated sewage waste into rivers that drain into Manyame River. In response to this, the Government of Japan assisted the Chitungwiza Municipality by building the Chitungwiza City Sewerage Treatment Improvement Project (Japan ODA, 2013). This helped to reduce the disposal of untreated sewage into the Manyame River's tributaries, which would eventually cause an increase in the cost of treating the water for domestic use.

4.3 Methodology

The following methods were used to assess the microbial quality of water in Harare and surrounding areas. The ability to process potable water for supply to the Manyame catchment

area was assessed through water quality monitoring along the water distribution system from the main river sources, namely the Manyame, Mupfure, and Mutsige rivers, to the households of Norton and Harare (Queensdale, Msasa Park, Westgate and the central business district). Microbial water quality was assessed using the H_2S test according to Venkobachar et al. (1994), and Sobsey and Pfaender (2002), as modified by Luyt et al. (2011), and heterotrophic bacteria plate count using R2A agar from Sigma-Aldrich (Johannesburg, South Africa). The H_2S strip test can detect the presence / absence of faecal contamination in drinking water (Luyt et al., 2011). It has been used in microbial water quality monitoring in isolated areas with limited infrastructural and personnel availability, as assessed by Luyt et al. (2011). The heterotrophic bacteria plate count is used to quantify microbes found if the strip test reports positive for faecal contamination.

4.4 Water Sampling

Samples were collected between January and November 2013. The dates selected for sampling were between the 9th and 11th of each month in order to maintain consistency. Sampling was done between 9:00 and 14:00 on either Friday or Saturday, depending on the distance between the various locations. Samples were delivered to the plating site in a portable ice chest. Table 4.1 shows the specific dates for the sampling procedure and the locations which were tested.

4.4.1 Table 4.1 Sampling times and locations at which water samples were collected

Sampling locations and times		
Day	**Location**	**Time**
11 January 2013 12 January 2013	Queensdale 1 Westgate	9.00 – 9.20 13.30 – 14.00
10 May 2013 11 May 2013	Queensdale 2 Manyame River	9.00 - 9.30 11.00 – 11.30
9 August 2013 10 August 2013	Msasa Park Mupfure River	11.00 – 11.30 10.30 – 11.00
9 November 2013 10 November 2013	Samora Machel Mutsige River	12.00- 12.30 11.30 – 12.00

4.4.2 Household level

The external tap fittings in the selected households were chemically sterilised using 70 % ethanol. They were opened and allowed to run for 10–15 seconds. The sampling kit was then opened and filled with 20 ml of tap water. One 20 ml volume for the H_2S sampling kit and one sterile 100 ml bottle were collected per household. Samples were then stored on ice during transportation from the sources to the testing site. All H_2S samples collected were stored in a dark box at room temperature for 72 h, while checking at 24 h intervals for any shifts in colour from brown to black. Water samples collected in the sterile bottles were used to assess for heterotrophic bacteria using the spread-plating technique. Samples were collected from households in the Queensdale, Norton, CBD (Samora Machel Avenue), Westgate, and Msasa Park areas. All of these areas are supplied by water from the Morton Jaffray Treatment Plant.

4.4.3 Source level

Samples were collected from the main river that supplies the Morton Jaffray Treatment Plant, i.e., Manyame River as well as its tributaries from January to November 2013. Samples were collected from the lower Manyame Catchment area, starting at Beatrice, to Norton located on the Bulawayo road water weeds were observed in the river water when samples were being collected. However, after the rains experienced from November 2012 to March 2013, the water weeds were washed down river. Clear waters were observed from the Manyame River bridge, stretching for at least 100 m in both directions, where the water weeds used to be. For water samples collected from raw water sources, single 100 ml sampling containers were collected to test for heterotrophic bacteria as well as faecal contamination. Fifteen 100 ml sampling bottles were bought from Proplastics (Harare, Zimbabwe) and cleaned using boiled water. They were then chemically sterilised in 1 % sodium hypochlorite and 16 % sodium chloride solution for 30 min, and left to dry at room temperature until required. Nitril gloves were worn onsite. The bottles were then opened near running water to collect enough water to fill the bottles, and were closed immediately after. At the testing site, 20 ml of water was poured into the H_2S test kit for faecal contamination assessment. The samples were left to stand in a dark box at room temperature for 72 h and checked every 24 h for a colour change from brown to black. This colour change represented a positive result for faecal contamination. The remainder was used for heterotrophic bacteria plate count.

4.4.4 H_2S test

The H_2S test strip medium of Venkobachar et al. (1984) was modified using deoxycholate (0.5 % w/v) to decrease the frequency of false positive results (Luyt et al., 2011). All chemicals were purchased from Sigma Aldrich (Johannesburg, South Africa). Additional equipment in the form of 100 ml collecting bottles was purchased from Proplastics Pvt. Ltd. (Harare, Zimbabwe). The H_2S test strips were prepared as described by Luyt et al. (2011). Urine jars were placed in a Panasonic carbon dioxide incubator sourced from Panasonic Biomedical Sales UK, and heated at 54 °C for over 16 h, which was sufficient to provide sterile H_2S strip test kits. Thereafter the sampling kits were assembled and stored away from direct sunlight, at room temperature until required for use.

4.4.5 R2A plates

A digital LCD electronic scale (Quintet Industries Limited, Hong Kong) was used to measure accurately a mass of 20 g of R2A agar required to make a solution with 1.1 litre of distilled water. The powder was suspended in the water, and boiled in a pressure cooker to dissolve the medium completely. Previously boiled water was used to dissolve this medium faster and a time of 20-25 min was found to be ideal for this process. Soon after cooling the pressure cooker, it was opened and an adequate amount of hot agar poured into each Petri dish near an open flame to avoid contamination. The test media were left to cool and used to plate samples within 24 h. Sterile controls were included, and no growth was observed on the sterile and un-inoculated plates.

4.4.6 Heterotrophic bacteria plate count

Sterile syringes of volume 10 ml (Merck Pty. Ltd. (Johannesburg, South Africa)) were used to collect 1 ml samples from each of the sampling kits collected at both households and raw water sources. A single syringe was used to collect two 1 ml samples from the kit and to inoculate two separate Petri dishes filled with R2A agar. These 1 ml samples were then spread-plated onto the agar, labelled, and left to stand at room temperature for 72 h. Each syringe was used for plating two Petri dishes from the same sampling bottle, and discarded after use. Results were reported as CFU/ml.

4.4.7 Questionnaire

Qualitative data on respondents' perceptions of water quality were analysed, using responses to the questionnaire administered to the public. Open-ended questions were designed to limit these results to usable data. Additional information elicited by the questionnaire was included in the

report. A total of 120 questionnaire documents were distributed for this study. Participants were selected randomly in their workplaces around the Harare CBD. Due to the diversity of workplaces, most of the suburbs in Harare were well represented, with participants originating from high, medium and low density areas. Consent forms were provided to participants, and the questions were written in English and Shona to accommodate most of the participants involved. Some participants were interested in contributing to the study, but did not have time to complete questionnaire. These participants provided responses in the form of a group discussion. These discussions tackled questions regarding the aesthetic appeal of their potable water and the frequency with which water cuts were experienced in their households. The same questions used in the questionnaire were used in these discussions.

4.4.8 Interviews and the responses obtained

The first interview was carried out with a member of the GA Laboratory. He provided insight on how water quality was tested at their laboratories. He also discussed the limitations that were encountered in the assessment of water quality at national level, and how external input may improve water quality testing services. The second interview was conducted with Drug and Toxicology Information Services personnel. They explained how they held workshops with hospital staff at the Corporate 24 and Parirenyatwa Hospitals to improve the ways in which poisoning cases that presented with diarrhoea, which could be confused with gastro-enteric disease, were managed. The third interview was conducted with the elders in the community, who provided insight on the traditional way of administrating the community, as well as women's roles in the community.

4.4.9 Figure 4.2 Iron pipes removed from the CBD water reticulation system.

Figure 4.2 below shows some images obtained from the CBD in Harare. These pipes were dug out by the Municipal workers and replaced with PVC pipes underground. The images show rusting inside the pipes.

4.5 Results and Discussion

4.5.1 Water samples

Samples obtained from the City Centre and the Westgate area had limited microbial growth. All river samples had elevated concentrations of the R2A heterotrophic plate count bacteria (HPC), with actual values ranging from 225 to 452 CFU/ml. Considering that this was untreated water, these results indicated that the consumption of the sampled surface water without treatment could result in the medium public health risk of a waterborne disease outbreak, as the HPC ranged from 100-1000 CFU/ml. Water treatment prior to human consumption was thus required and there was room for improvement in the microbial water quality. All three river water samples tested positive for faecal contamination on all sampling days, based on the qualitative signals in the improved hydrogen sulphide test kit, which was not recommended in water used for domestic purposes. This represented 33 % of all the samples taken for this study. Households recorded CFU/ml counts of 1 to 7. This is slightly outside the range of the recommended 0 CFU/ 100ml for drinking water use. Samples from the household level showed microbial growth, although to a lower extent than in river water. Water samples collected did not have visible floating particles in them. There was no significant odour in treated water samples upon collection.

Samples from Norton had no faecal contamination and a heterotrophic plate count of 2 CFU /ml, i.e. the risk to public health from the water consumption was negligible. This may have resulted from an improvement in the quality of the pipe network after replacing old iron pipes with PVC ones.

4.5.2 Questionnaire

A total of 120 questionnaire documents were distributed in the Harare Central Business District (CBD) area. 105 of these were returned after being completed. The respondent rate for this study was 96 %. 65 of these questionnaire documents were completed by tap water users, while 40 were completed by borehole water users. Ten respondents used the group discussion platform.

All participants who responded to these questions were participating in formal or informal business in Harare. Some were home owners, while others resided in rental homes in Harare. At the time when this study was conducted, water shortage problems had already started, and most of the rivers were operating below their usual capacities (Chadenga, 2016).

75 % of those respondents who said they had access to potable water were residing in households which had tap water supplied by the Harare Municipality. Water cuts were usually scheduled in advance for various locations, especially in medium to high density suburbs. Low density suburbs close to the CBD experienced very few water cuts, but low density areas further out of the CBD had already set up alternative water sources, using borehole water as the main source of potable water. Respondents who described their water as containing greenish particles at times were located in mostly low density areas, and had shrubbery and remarkable vegetation in their yards, due to consistent water supplies. They mentioned that the greenish particles in their water started showing after they had experienced a potable water dry spell for a period of 3 months or longer. Some interviewees reported that, after letting the water sit for a while, green suspended particles settled at the bottom of the containers and they were able to decant the sediment- free supernatant into another container.

Water described as having brown suspended particles was more common in high density areas, as a result of the use of iron water pipes in the reticulation system. Interviewees who reported rusty-coloured water said that it had a metallic taste and that they boiled it before use. However, after boiling the water in a pot, a cream to brown precipitate formed which settled at the bottom of the pot and which was then removed by filtering the boiled water through a clean cloth.

For the respondents who answered the questionnaires in the form of a group discussion, the following responses were obtained. Water cuts were usually scheduled in advance for various locations, especially in medium to high density suburbs. Low density suburbs close to the CBD experienced very few water cuts, but low density areas further out of the CBD had already set up

alternative water sources, using borehole water as the main source of potable water. Some interviewees reported that, after letting the water sit for a while, the green suspended particles settled at the bottom of the containers and they were able to decant sediment-free supernatant into another container.

In other studies, a brown colour found in the water indicated rusting in the pipes (Keyser, 1997). A metallic taste suggested the presence of iron or manganese in the pipes (Keyser, 1997). Green particles in the water indicated the presence of copper precipitates (Keyser, 1997). Cloudy water was indicative of organic or inorganic particles which cause turbidity when suspended in the water (Keyser, 1997). Further studies should include analysis of municipal water for the presence and concentrations of heavy metals, and the geographical distribution of their occurrences. In addition, other organic and inorganic material present in this water needs to be identified.

Participants, who mentioned that they had experienced either Typhoid or Cholera outbreaks, were scattered in areas in and around Harare's main CBD. From the statistics found on the Ministry of Health website, very few locations were spared from Typhoid and Cholera outbreaks. This indicated how diminished the health services had become in Harare.

The researcher also received data from tank water users. These were mostly residents in low density suburbs of Harare. As mentioned earlier, low density areas in Harare are mostly located in the outskirts of the CBD, such as Mount Pleasant Heights, Shawasha Hills, Borrowdale, and their proximity to reservoirs collecting water from the Morton Jaffray Treatment Plant was further than most locations.

These residents mentioned that they had connected water pumps to fill up their water tanks for domestic use. Some households had access to potable municipal water sources, but when the water cuts became serious, they resorted to using water pumps and potable water from water tanks. There were also water tank users who filled their tanks with tap water, in areas where tap water was more reliable.

Tables 4.2 and 4.3 represent the results obtained from the questionnaire.

4.5.3 Table 4.2 Responses provided to the questionnaire by tap water users

QUESTION	ANSWERS

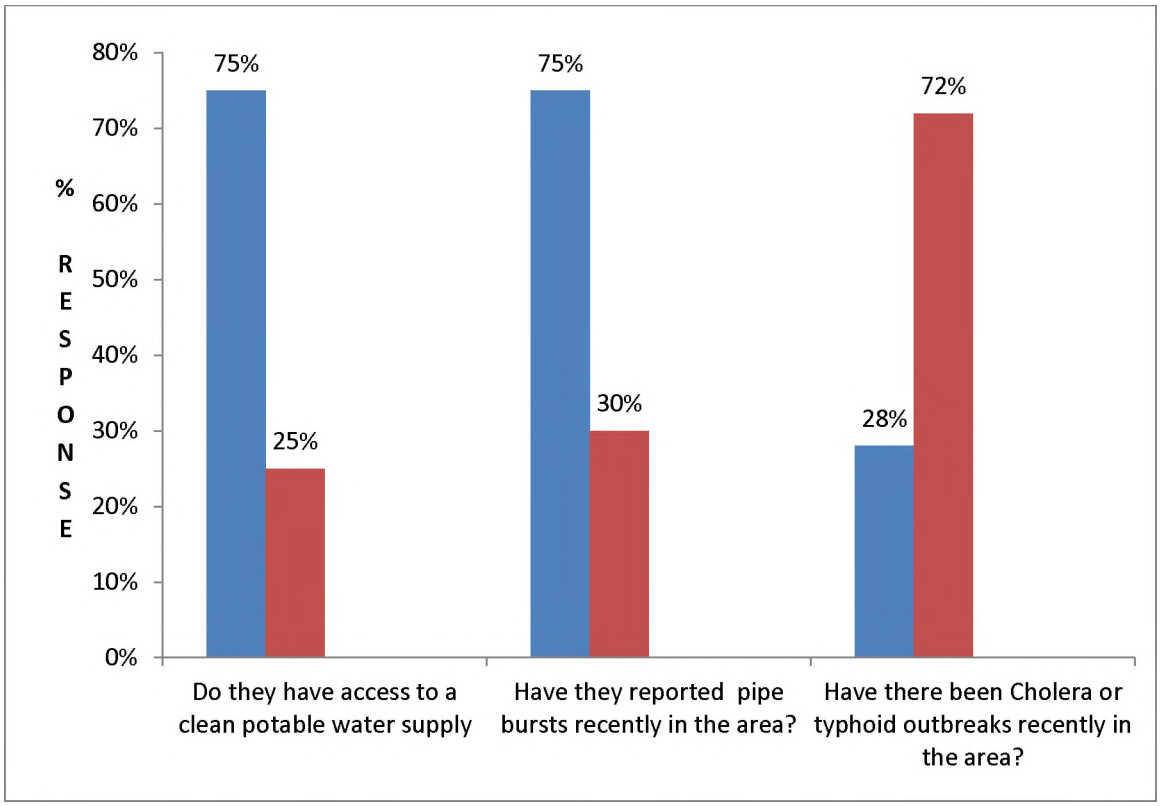
Access to clean potable water at their household?	75% yes 25% no
How often they experience water cuts?	55% monthly 25% weekly 20% never
Are there times when water is not appealing to drink? Brief description of how it looks.	60% yes: colourless with suspended green particles 40% yes: brown suspension
Reports of pipe bursts recently in the area? Were they repaired since then?	Yes :70% reported 30% did not report
Outbreaks due to water-borne diseases in the area recently and when.	Yes: 18 % Cholera, 2008 Yes: 10 % Typhoid 2011

4.5.4 Table 4.3 Responses to questionnaire by water tank users

QUESTIONS	ANSWERS
What is the water in the tank used for and how often?	100 % domestic purposes and every day.
Chemical treatment of water? With which chemicals?	Borehole source, no treatment Rainwater, no treatment Tap water, Waterguard® dilute chlorine solution.
Do they boil water before use?	Yes: tap water filling users No: borehole and rainwater harvesting tank owners
Source of water supply for tanks?	Rain 50 % Wells 35 % Tap water 15 %

4.5.5 Figure 4.3Responses to the questionnaire by tap water users.

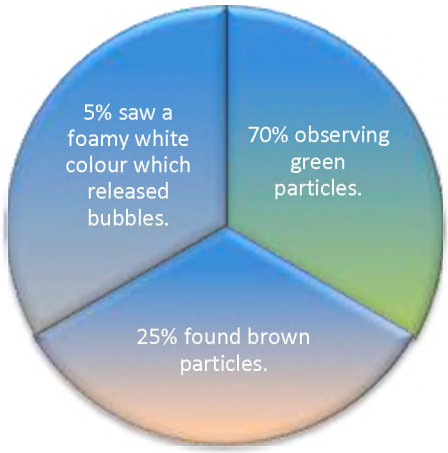
The bar graphs in Fig 4.3 below represent some of the information obtained from the questionnaire as well as from the discussions about water quality. These responses have also been discussed from the tabular representation provided in Table 4.2.



The pie chart in Figure 4.4 below represents responses obtained when tap water respondents were asked to describe the colour of their treated water when it came through the pipes. The responses were tallied against the total number of respondents and represented as a pie chart. The respondents also described the water's aesthetic appeal for their use and what they thought it meant concerning the quality of their water supply. Descriptions varied according to the frequency of tap water supplies and the type of pipeline in the area.

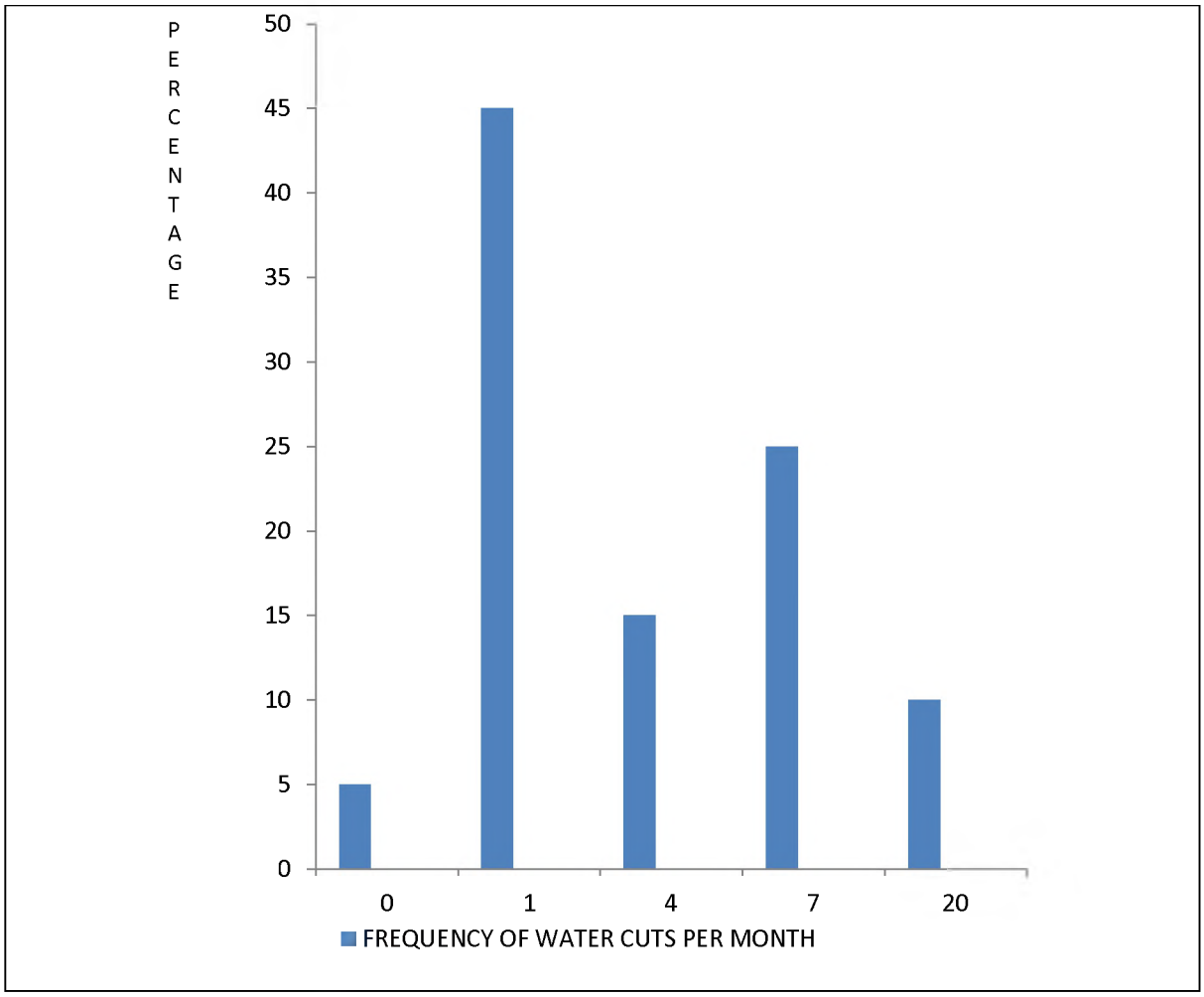
The 5 % who reported milky white coloured water, which cleared up after they let it settle for a moment, had the least problems with water quality. A milky white colour in water is caused by air bubbles trapped in the water, which is why the colour disappeared after they let it settle for a moment. The percentage of respondents who identified green particles in their water had been

advised through the Ministry of Health to filter and boil it in order to destroy any microbes (Ministry of Health, 2009). Respondents who saw brown coloured particles in their water were warned of rusty iron pipes in some sections of the Reticulation System by the researcher, and were also asked to filter and boil the water, just in case there was a microbial build up in some of the broken iron pipes.



4.5.6 Figure 4.4 Responses for colour observations on the water by group discussion participants.

The bar graph below provides information obtained from the questionnaire which indicated frequency of water cuts experienced by the respondents. The questionnaire required that respondents provide details of the average frequency of water cuts experienced per week. These were then used to determine the monthly frequencies of water cuts in the different suburbs. The calculation method is provided below the graph.



4.5.7 Figure 4.5 Frequency of water cuts experienced per month versus percentage of respondents.

Frequency of water cuts experienced was calculated as follows:

$$\text{Frequency} = \frac{\text{x water cuts}}{\text{7 days/week}} \times 30 \text{ days} \qquad \text{Equation 4.1}$$

$$\text{Percentage response} = \frac{\text{Number of respondents}}{\text{Total number of respondents}} \times 100 \qquad \text{Equation 4.2}$$

45 % of respondents stated that they had experienced a single water cut each month. This response was common amongst respondents residing in low density areas of Harare. Approximately 50 % of respondents stated that they experienced more than four water cuts a

month. Such scenarios required that they find alternative sources of water for domestic use. It also made them susceptible to waterborne diseases due to the use of community boreholes, which could easily be contaminated by other users.

4.5.8 Table 4.4 Results of microbial water quality tests

	JANUARY		**MAY**		**AUGUST**		**NOVEMBER**	
Location	H_2S	R2A	H_2S	R2A	H_2S	R2A	H_2S	R2A
Manyame River (−17.980877, 30.962373)	+ve at 36 hours	394	+ve at 36 hours	452	+ve at 24 hours	386	+ve at 24 hours	420
Mupfure River (−17.857129, 31.088408)	+ve at 72 hours	274	+ve at 72 hours	360	+ve at 24 hours	320	+ve at 24 hours	290
Mutsige River (−18.254817, 30.864880)	+ve at 72 hours	225	+ve at 36 hours	280	+ve at 24 hours	260	+ve at 24 hours	245
Queensdale household 1 (−17.857129, 31.088408	-ve	1	-ve	7	-ve	2	-ve	2
Queensdale household 2 (−17.857129, 31.088408	-ve	3	-ve	6	-ve	2	-ve	0
Msasa Park (−17.863594, 31.114810	-ve		-ve		-ve		-ve	
Samora	-ve	1	-ve	0	-ve	0	-ve	0

Machel Avenue (−17.823972, 31.059056)								
Westgate, Harare (−17.764211, 30.977170)	-ve	0	-ve	0	-ve	0	-ve	0
Norton (−17.873334, 30.765766)	-ve	2	-ve	2	-ve	1	-ve	1

WHO guidelines for domestic water use recommend that tested samples should be negative in the hydrogen sulphide test, and also recommends a heterotrophic plate count of 0 CFU/ 100 ml sample of water (WHO, 1997).

4.5.9 R2A Agar test findings

These results provide an analysis of heterotrophic bacteria results obtained during the testing period between January and November 2013. The overall type of bacteria growing on R2A agar was cream to dark brown. In samples collected from households, the colonies presented with a cream to beige colour, i.e. samples from Samora Machel offices, Norton, Queensdale, and Msasa Park. Samples collected from the rivers presented with bacterial overgrowth, which initially appeared to be cream but turned a darker brown after 48 hours. These colonies were spread out distinctly throughout the plate which allowed for easier counting.

4.5.10 H_2S test findings

All the samples collected from households were negative for faecal contamination. This result was as expected, since water at the end user point is supposed to have no microbial contamination. Samples collected from rivers showed affirmative results after 24 hours for the Manyame, Mutsige, and Mupfure Rivers from August and September samples. This may have been due to the approaching rainy season, which allowed for surface runoff into rivers and hence human and animal wastes were washed off. In the early months of January and May, microbial concentrations were recorded at their highest in all 3 rivers, as this marks the end of the rainy season, approaching winter. The results of both H_2S and R2A are shown in the tables.

Heterotrophic bacteria require carbon to grow and, due to the displacement of water weeds by the rains, more nutrients and carbon became available for the growth of heterotrophic bacteria upstream. Samples for the study were collected upstream to reduce the possibility of nutrient overload in the raw water source.

4.6 Conclusion

In response to the seven objectives posed at the beginning of this project, the following answers were obtained:

1) To identify the guidelines used to determine a water source safe for domestic use, according to the Standard Guidelines for domestic water quality in Zimbabwe, and how this compares to the quality of water available for domestic use in the Harare area.

The Government Analysts' laboratory uses WHO guidelines for drinking water quality of 1997 in its determination of microbial quality of water. These guidelines state that drinking water should contain no faecal matter, and that it should have 0 CFU/ 100 ml of water. The GA laboratory is a product of the Department of Environmental Health, in the Ministry of Health and Child Welfare of Zimbabwe. These guidelines are used to analyse treated water samples, bottled water, and any water samples brought to the Laboratory for testing.

The microbial quality of treated water in Harare, Zimbabwe, was found to be almost within the range expected for treated water samples, and the same result was obtained for raw water samples, as measured against the microbial levels of raw water sources. A significant difference in microbial water quality levels existed between water obtained from raw water sources which feed into Manyame River, and that distributed after treatment at the Morton Jaffray Treatment Plant. The rivers recorded a minimum of 225 CFU/ ml and a maximum of 452 CFU/ ml. This level of contamination indicated a medium risk to public health, as determined by the Guidelines for domestic water use, which provides a range of 100- 1000 CFU/ml for heterotrophic bacteria.

Household samples had no faecal contamination, and heterotrophic plate counts of 0- 7 CFU/ ml. As a result of the use of old pipes for distribution, the water found in taps at the end user point and was found to contain particles floating in the water. After assessment, these particles were

confirmed to not be microbes but, instead, iron pipe rust, algae, and, at times, debris stuck in ground level pipes which had not received water in a long time. From this study, it was found that the majority of Harare residents believed their water was contaminated and trusted alternative water supplies over municipal water. Most households responded to having experienced water cuts for long periods of time. This information was necessary to establish whether the maintenance status of some reticulation pipes may have contributed to the poor quality of water at those households which rarely received pipe water. As discovered in this study, some of the older iron cast pipes were being replaced with PVC, but the rate of this replacement was not fast enough to cover the whole Harare area due to funding problems at Morton Jaffray.

2) To identify the risk to public health resulting from a water source that does not meet the standards for microbial quality of water using literature review.

From literature review conducted for this study, it was discovered that contaminated water sources posed a serious risk to public health. Reports of Rotavirus, Cholera, and Typhoid outbreaks showed the hazards imminent if further contamination of drinking water sources is not prevented. There were many recorded cases of Cholera and Typhoid outbreaks, which the Ministry of Health failed to control within the required time, to minimise the loss of human life. This was caused by the lack of necessary resources as well as staff shortages. Waterborne disease outbreaks also threatened the vulnerable groups such as women, orphans, and people with disabilities. These groups were at times strategically located in the face of disaster outbreaks, but others failed to access health care resources because of their distance from health clinics. This increased their vulnerability to illnesses from using contaminated water sources, and from failing to access basic health care for wounds and injuries resulting from disasters.

3) To address waterborne disease outbreaks as a biological hazard, and to gain insight on the disaster management procedures and legislation available for waterborne disease outbreaks in the Zimbabwean community using literature review.

From further research into the Ministry of Health, it was discovered that there were guidelines designed to cater for Typhoid and Cholera outbreaks, but after the outbreaks of 2008-9 and 2010, these guidelines were revised to match updated procedures for the provision of health care to affected patients. The study also realised that the Ministry of Health benefitted from the professional expertise of a team from the International Centre for Diarrhoeal Diseases Research in Bangladesh. This gave the team of medical staff in designated quarantine areas for the management of disease outbreaks a fighting chance. There was, however, still need to increase the material resources available for controlling disasters. To address this crisis, a checklist was designed which to be used to determine how the most effective communities were managing waterborne disease outbreaks. Table 4.5 below shows these recommendations.

The Civil Protection Act of 2001 was identified as the legal document designed to oversee the establishment of the National Civil Protection Committee and support committees. It had information which could be used to derive a useful disaster management organisation. It was further supported by the Draft Disaster Risk Management Bill of 2011, which needed to be reviewed and updated to include information on the microbial water quality assessment needs of Zimbabwe.

4) To investigate the impact of concurrent diseases, gender, education, and marriage in the management of waterborne diseases in Zimbabwe and South Africa.

The conclusions to this objective were drawn based on literature review of country statistics. Gender inequality in education was found to have less impact in disaster management, compared to gender inequality in employment and health. Inasmuch as women may be affected differently from men when disasters occur, this did not directly translate to vulnerability. Women were seen to be caregivers who were resourceful and resilient in times of crisis, which gave them a significant role to play in recovery after natural or manmade disasters occur within a community. Gender-based violence existed in societies where men felt more economically vulnerable than women.

Education was found to influence the level of health care provided by mothers in their households. Those with higher education were found to have children that were three times more

likely to survive childhood diseases than those who did not. In child-headed households, level of education was determined to be a limiting factor in the extent to which these families were able to take care of themselves in a disaster situation. Children heading households were more focused on preserving the few resources they had than on seeking external help, since their circumstances had made them self-reliant. These households were likely to be vulnerable to diseases resulting from a disaster, due to their use of contaminated water sources and poor sanitation.

Marriage had a positive effect on mitigating the impact of disasters. Two parent families were less vulnerable to disasters than single parent families. In single parent households, this situation was worse if the remaining parent was the mother. However, due to empowerment programmes that were being initiated for women and children, these women were prepared for pending disasters in their communities.

HIV / AIDS prevalence in Zimbabwe was steadily falling. Women in the 15-49 years age bracket were identified as being more aware of HIV than their male counterparts. They also participated in many education drives and workshops for people living with HIV / AIDS, and were thus better equipped to educate their families on the impact of HIV / AIDS in their households. Stigmatisation, however, was still a prominent issue in communities, indicating a need for more awareness programmes to train the community in how to interact with people living with HIV / AIDS.

5) To assess the impact of engaging various stakeholders in addressing the microbial water quality and water availability problem in Zimbabwe, as compared to the South African setting.

This objective was narrowed down to address the engagement of other stakeholders in the development of microbial water quality and availability problems. There was an analysis of existing procedures in disaster management for provinces in Zimbabwe and in South Africa. The participants contributing in the development and the application of these disaster management protocols were then considered as the other stakeholders in disaster management.

The engagement of various stakeholders in Zimbabwe was observed in disaster recovery in the health sector mainly. The Zimbabwean community benefitted from the professional expertise of the team from ICDDR, B in the management of the Cholera outbreak of 2008-9. Zimbabwe was observed to be less involved in the preparation of disaster preparedness mechanisms outside of the health sector, which meant there was less room to invite other stakeholders in disaster management before the actual disasters occurred.

South Africa benefitted from partnering with Tertiary Institutions in addressing water delivery, microbial water quality, and providing alternative water sources. South Africa had a wider text in the area of disaster management and recovery programmes, and its use of tertiary institutions to draw in various stakeholders significantly improved its disaster preparedness. Because of the availability of a wider pool of experts in tertiary institutions, disaster recovery protocols could be easily developed across a wide range of essential fields, within a small geographical location, while targeting a wide range of possible scenarios for disasters.

It was therefore recommended that Harare, and Zimbabwe as a whole, welcome independent stakeholders who want to invest in the assessment of microbial water quality in treated water and water distribution and water reuse initiatives. Engagement of multiple stakeholder partnerships in water service delivery would be a positive step towards improved microbial water quality monitoring in households and for alternative sources of water.

Investigating water operator partnerships occurring elsewhere in the world would provide guidance as to how best Zimbabwe could welcome independent stakeholders and create sustainable Public-Private Water Partnerships. The Zimbabwe National Contingency Plan was seen as a positive step towards disaster preparedness, and inclusion of microbial water quality monitoring, could make it even more influential.

The text on provision for recruitment of volunteers in Zimbabwe for disaster management was found to be ambiguous. Engagement of volunteers also required clarity in terms of bounds within which partners must confine, as well as objectives which they were supposed to achieve while operating within the Civil Protection Unit. Inclusion of Tertiary Education Institutions would also lessen the burden of disaster management planning, mitigation and relief program

development. The use of academic resources, manpower and technological resources would significantly improve the country's disaster management planning.

6) To determine the microbial water quality of raw water, treated water, and alternative water sources in the Manyame catchment area, which provides water to Harare.

This study found that the City of Harare municipality was unable to provide adequate quantities of clean, treated water to the entire municipal area on a daily basis. It was, however, able to supply limited quantities of treated water that meets WHO guidelines for daily domestic water use in a few locations in the city. Households recorded CFUs/ml counts of 1 to 7. This is higher than the recommended 0 CFU/ 100 ml for drinking water use. All river samples had elevated concentrations of the R2A heterotrophic plate count bacteria (HPC), with actual values ranging from 225 to 452 CFU/ml. Considering that this was untreated water, these results indicated that consumption of the sampled surface water without treatment would result in medium public health risk of a waterborne disease outbreak as the HPC ranged from 100-1000 CFU /ml for raw water sources.

7) To provide strategies that will help to improve the availability of safe, potable water sources that have recommended microbial water quality levels.

Although the Zimbabwean population increased, the Water Reticulation Systems deteriorated over time. After independence, more people moved into the cities, but no capacity building measures were initiated to accommodate the shift in the load on the urban reticulation system. In addition to this increasing urban population, pipes set up initially during the colonial era broke down due to age, and needed replacement rather than repair.

Efforts need to be placed to decentralise the provision of water in Harare. A few more water treatment plants need to be set up close to the other dams in the city to accommodate the increasing population. After the problem of water supply is addressed, water quality monitoring should then be addressed. Funding of an interdisciplinary involvement inclusive of microbial water quality monitoring scientists would significantly improve on the departmental approach to

water services' delivery and microbial water quality monitoring services at a national scale in Zimbabwe.

RECOMMENDATIONS

1. Retrospective data could be used to determine trends in disaster occurrence. The Namibian Disaster Management Act has protocols which use this system to prepare for disaster mitigation and relief.
2. Engaging various stakeholders already involved in Water and Sanitation hygiene would make it easier for communities to survive the impact of disasters.
3. Investing in volunteer training and support has proven to be useful insofar as the transmission of early warnings and evacuation efforts at local levels is concerned.
   In each community, records of the following information should be compiled: existing prevention and mitigation measures; relevant hazards; communities at risk; and suppliers of essentials goods and services.
4. In order to reduce the impact of hazards, there is need to adopt both mitigation and preparedness strategies in disaster management.

5. To provide funding for the strategic construction of water treatment plants in various locations across the country, which cater to a small radius and are adequately, equipped to do so.

6. In terms of monitoring the impact of waterborne diseases, a partnership between personnel qualified in disease epidemiology and surveillance with microbial water quality monitors could help to map the likelihood of disease outbreaks. Measures to curb outbreaks and to source control measures for pending disasters can then be put in place before the disasters occur.

7. As seen in the more successful South African disaster management system, Zimbabwe could also benefit from partnerships with Higher Education Institutions. Most tertiary education institutes teach courses on environmental health; therefore such a project would be well equipped in terms of manpower and resources.

8. Finally, a team of professionals dedicated to the development of disaster management protocols for Zimbabwe needs to be established. There needs to be a committee which consists of experts with experience in the various disasters specific to Zimbabwe, who assign various projects to Provincial Civil Protection Committees to bolster national disaster management and resilience. This committee needs to include microbial water quality analysts, epidemiologists, analytical chemists, community leaders, NGO representatives, administrative assistants, agricultural specialists, civil engineers, building contractors, journalists, environmental health inspectors, international relations graduates, and drivers etc.

The following table was designed to in order to help determine the target areas for disaster management and how to handle them. It briefly describes important questions that need to be addressed in order to adequately control disaster resulting from waterborne disease outbreaks. They cover the areas of hazard identification, vulnerability assessment, preparedness, resilience, and exposure to a disaster for a small civil protection area.

4.6.1 Table 4.5 How to manage a disaster situation in a designated disaster area.

LOCATION:	**XXX**
HAZARD	Focal person for microbial water quality analysis? Waterborne disease microbial analysis and method of controlling the outbreak? Geographical area likely to be affected by outbreak?
VULNERABILITY	**Economic** Access to alternative water sources? Access to health care? Access to food resources during outbreak? Microbial quality of alternative water sources? Quantity of clean and safe water being brought in by the

	Municipality / volunteers? **Social** (Number of) Child-headed households Female-headed households People with disabilities **Health (Number of families with-)** People living with HIV / AIDS? People with diarrhoeal illness not related to the outbreak? Access to health care specialists?
EXPOSURE	Distance from source of contamination? Method of spread of disease? Incubation period for the disease? Record of individuals who visited the area before the outbreak was announced, and then left?
PREPAREDNESS	Protocols in place for managing the waterborne disease? Key person responsible for ensuring the protocols are followed? Resources required to manage disaster? Resources already available in the community? Method of communication with DCPC? Focal person in charge of record keeping and notifying authorities? Financial, food, transport resources available for disaster management focal persons in the area? Registered volunteers for disaster management in the area?
RESILIENCE	Most recent waterborne disease outbreak experienced? Time taken to eradicate it? Key contacts involved in managing this outbreak?

4.7 Significance of the study

4.7.1 To the Harare residents

1. This research will be useful in addressing public perceptions of the microbial water quality of Municipal tap water and alternative water sources.
2. It will also assist in the determination of control measures that could be used to improve the monitoring of microbial water quality.

4.7.2 To the University

1. Community engagement of Higher and Tertiary Institutions with the communities in which they are located is an important aspect in providing well-rounded educational qualification. Engagement of students with their communities while conducting research allows them to be better informed of the core needs of these communities, validating their studies, and providing them with an opportunity to contribute appreciably to the community. Universities usually have vast resources at their disposal for educational purposes, and it would be a valuable interaction if they use these resources, especially in the area of microbial water quality monitoring, to assist Government or municipal entities.
2. It also makes it easier to trace prior research and to identify how it could be improved upon.

3. Research of this nature may be used to recommend microbial water testing procedures that are easy to analyse in settings with limited resources or restricted access to more expensive laboratory testing methods.

4. It may also be used by current Rhodes University students for comparative purposes, should the microbial quality of water in Harare be considered a significant project by the University.

4.7.3 Delimitation of the study

1. This research was limited to households in the Manyame Catchment area (of which Harare is a part) that receive water from the Morton Jaffray Treatment plant and Norton.

Participants selected for the questionnaire were employed within the Central Business District (CBD) while residing in residential areas outside of the Harare city centre.

2. The number of participants and their selection was based on their willingness to participate. The area covered by this study was within a 50 km radius from the Central Post Office of Harare to allow the researcher ease of access for household water quality monitoring, as well as access to the river tributaries that supply Manyame River.

3. Statistical databases assisted in the provision of demographic data, and the use of statistical information obtained from the 2012 Census, the United Nations country statistics database, and *Indexmundi* were used to obtain country specific demographics, level of development, and information about disease burden for this project.

4.7.4 Limitation of the study

1. In trying to achieve an accurate representation of water quality from raw water sources to households, the researcher had to obtain samples from the Morton Jaffray Treatment Plant. Unfortunately, this was not approved by the managing staff at the site, citing misrepresentation of facts by previous researchers as the main obstruction. The questionnaire designed for the Morton Jaffray Treatment Plant employees therefore could not be used in the study.
2. Archived records showing microbial water quality monitoring done through the Quality Assurance Laboratory of Harare City Municipality were not available for use, as they were classified as private and confidential. Instead, an interview approved by the Harare Municipality water quality monitoring manager was carried out with laboratory technicians to address this shortcoming.

5 References

Abbott, L., and Luke, N., (2011). Local Hierarchies and Distributor (Non) Compliance: A Case Study of Community-Based Distribution in Rural North India. *Health Care for Women International*, *32*(3), 225–242. (Online) Available from: http://doi.org/10.1080/07399332.2010.529217 [Accessed on 15th June 2016]

AFDB (2007) 2007 AEC- Gender earnings differentials and power: some African evidence. Fabusuyi, T. (Online) Available from; www.afdb.org/fileadmin/uploads/afdb/Documents/Knowledge/25068312-EN-TFABUSUYI-AEC-PAPER-0907.PDF [Accessed on 17th June 2016]

AFDB (2016) African Development Bank. Republic of South Africa. Country Strategy Paper 2013-2017. (Online) Available from: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/2013-2017_-_South_Africa_-_Country_Strategy_Paper_01.pdf [Accessed online on 23rd August 2016]

Ahmed, S., Bardhan, P. K., Iqbal, A., Mazumder, R. N., Khan, A. I., Islam, M. S., Cravioto, A. (2011). The 2008 Cholera Epidemic in Zimbabwe: Experience of the icddr, b Team in the Field. Journal of Health, Population, and Nutrition, Volume 29 (5), pp 541–546. (Online) Available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3225117/ [Accessed on 10 August 2014]

Alexander, K.A. and Blackburn, J. K., (2013) Overcoming barriers in evaluating outbreaks of diarrheal disease in resource poor settings: Assessment of recurrent outbreaks in Chobe District, Botswana. [Online] *BMC Public Health* 13 p.775 (online) Available from: http://www.biomedcentral.com/1471-2458/13/775 [Accessed on 8th August 2014]

Bain R., Cronk, R., Wright, J., Yang, H., Slaymaker, T., (2014). Faecal contamination of drinking water in low- and middle-income countries: A systematic review and meta-analysis. (Online) Available from: http://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001644 [Accessed 12th July 2013]

Bain, R. E. S., Gundry, S.W, Wright, J. A., Yang, H., Pedley, S., et al. (2012) Accounting for water quality in monitoring access to safe drinking-water as part of the Millennium Development Goals: Lessons from five countries. Bull World Health Organ 90: 228–235A. (Online) Available from: http://www.who.int/bulletin/volumes/90/3/11-094284.pdf [Accessed on 14th October 2015]

Bepete, L. (2014) Unsafe drinking water caused 2009 Cholera outbreak: WHO. Chronicle news. 22 November 2014. (Online) Available from: http://www.chronicle.co.zw/unsafe-drinking-water-caused-2009-Cholera-outbreak-who/ [Accessed 30 November 2014]

Betera, L. (2011) Overview of Disaster Risk Management and Vulnerability. [pdf] Department of Civil Protection. (Online) Available from: www.civilprotectionunit.co.zw [Accessed: 13th August 2013]

Bongo, P., Chipangura, P., Sithole, M., Moyo, F. (2013) A rights-based analysis of disaster risk reduction framework in Zimbabwe and its implications for policy and practice. Jamba: Journal of Disaster Risk Studies, North America. (Online) Available from: http://www.jamba.org.za/index.php/jamba/article/view/81/179 [Accessed: 27th November 2014].

Bradshaw, D., Groenewald, P., Laubscher, R., Nannan, N., Nojilana, B., Norman, R., Pieterse, D., Schneider, M. (2003). Initial burden of disease estimates for South Africa, 2000. *Burden of Disease Research Unit*, Medical Research Council, Cape Town, South Africa.

Bulilima (2008) Bulilima District Disaster preparedness and Response plan. Compiled by L. Zinahwa. (Online) Available at http://practicalaction.org/docs/southern_africa/Bulilima-disaster-preparedness-plan.pdf [Accessed on 29th October 2016]

Buvinić, M., & Gupta, G. (1997). Female-Headed Households and Female-Maintained Families: Are They Worth Targeting to Reduce Poverty in Developing Countries? *Economic Development and Cultural Change, 45*(2), 259-280. (Online). Available from; http://0-www.jstor.org.wam.seals.ac.za/stable/1154535 [Accessed on 5th December 2016]

CDC (2006) Centres for Disease Control and Prevention. Prevention of Rotavirus gastroenteritis among infants and children. MMWR 2006; 55(RR-12):1–13. (Online) Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5512a1.htm [Accessed on 8th December 2013]

CDC (2014a) Cholera (Online) Available from: http://www.cdc.gov/Cholera/index.html [Accessed 12th January 2014]

CDC (2014b) *E.Coli*. (Online) Available from: www.cdc.gov/ecoli/ [Accessed: 1st December 2014]

CDC (2014c) *Campylobacter jejuni.* (Online) Available from: www.cdc.gov/nczved/divisions/dfbmd/diseases/campylobacter/ [Accessed: 1st December 2014]

Chadenga, S. (2016) Gweru to introduce water rationing. The Southern Eye. 3 February 2016. Online. Available at https://www.southerneye.co.zw/2016/02/03/gweru-to-introduce-water-rationing/ [Accessed on 22nd October, 2016]

Chaminuka, L. and Nyatsanza, T. D. (2013) Assessment of water shortages and coping mechanisms of Harare residents: A case of Msasa Park and Dzivarasekwa Extension. *Journal of Agriculture and Veterinary Science.* 4 p. 21-35.

Chant, S. (1997). Women-headed households. Diversity and dynamics in the developing world. Basingstoke, England, Macmillan Press, 1997. ix, 338 p. (Online) Available at; http://www.popline.org/node/273953 [Accessed on 13th July 2016]

Chigonda, T. (2010) Water Supply and Sanitation in New residential areas in Zimbabwean towns: The case of Maridale high-density suburb in Norton. *Journal of Sustainable Development in Africa* 12 (3) p. 349-355.

Chikanda, A. (2005) Medical Leave: The Exodus of Health Professionals from Zimbabwe, SAMP Migration Policy Series No. 34, Idasa, Cape Town and Queen's University, Kingston. Available from: http://ir.uz.ac.zw/bitstream/handle/10646/43/Medical_Leave_SAMP_Acrobat34.pdf?sequence=1&isAllowed=y [Accessed 6th June 2016]

Chiketo, B. (2016) Mutare, villagers clash over water. The Daily News. 9 November 2015. Online Available at https://www.dailynews.co.zw/articles/2015/11/09/mutare-villagers-clash-over-water [Accessed on 22nd October, 2016]

Chikoto, G.L. (2004) Zimbabwe's Emergency Management Systems, Disaster Management Research project (Online) Available from: http://training.fema.gov/EMIWeb/edu/CompEmMgmtBookProject.asp [Accessed 3rd August 2012]

Child Labour Report (2014) Zimbabwe Statistical Office, ZIMSTAT (2014) Child Labour Report 2004 (Online) Available from: http://www.ZIMSTAT.co.zw/dmdocuments/Labour/Labour.pdf [Accessed: 22nd November 2014]

Child Labour Survey Report (2012) Zimbabwe Statistical Office, ZIMSTAT (2012).2011 *Child Labour Survey Report.* (Online) Available from: www.ZIMSTAT.co.zw [Accessed: 16th July 2014]

Chirenda, T. G., Srinivas, S. C., & Tandlich, R. (2015). Microbial water quality of treated water and raw water sources in the Harare area, Zimbabwe. Water SA, Volume 41(5), pp 691-697. Online. Available at https://dx.doi.org/10.4314/WSA.V41I5.12 [Accessed on 20th September 2015]

Chitagu, T. (2014). Villagers force way back into Tokwe Mukosi basin Newsday 14 August 2014 (Online) Available from: https://www.newsday.co.zw/2014/08/14/villagers-force-way-back-tokwe-mukosi-basin/ [Accessed 13th October 2014]

City of Harare. (2013) Environmental Health Services. (Online)Available from: http://www.hararecity.co.zw/index.php/template-features/health-services/150-environmental-health-services [Accessed 15th September 2013]

City of Harare. (2016) Water Distribution. (Online) Available at http://www.hararecity.co.zw/index.php/template-features/harare-water/124-water-distribution [Accessed 10th June 2016]

Civil Protection Act Chapter 10:06 (Pdf) Available as CIVIL_PROTECTION_ACT_10_06.pdf [Accessed online on 23rd May 2015]

Clarke, P. H. (1953) Hydrogen sulphide production by bacteria. J Gen Microbiol. Volume 8(3) pp 397–407 (Online) Available from: http://www.ncbi.nlm.nih.gov/pubmed/13061742 [Accessed on 11th August 2016]

Committee on Economic Social and Community Rights (2002) General comment no. 15, The right to water. UN Doc. E/C.12/2010. New York: United Nations.

Disaster Management Act no. 57 of 2002. South Africa. (Online) Available from: http://www.info.gov.za/view/DownloadFileAction?id=68094 [Accessed: 22nd October 2013]

Doane, D. L., (2007). Living in the background: Home based women workers and poverty persistence. Homenet, South East Asia. CPRC working paper 97. Chronic Poverty Research Centre. (Online) Available from; www.chronicpoverty.org/uploads/publication_files/WP97_Doane.pdf [Accessed on 13th march 2015]

Education Act 25:04 (2001) (Online) Available from: http [Accessed on 10th March 2015]

EMA (2016) Environmental Management Agency. Water Testing Services (Online) Available from: http://www.ema.co.zw/index.php/2014-06-12-03-49-33/2014-06-12-03-50-38/ema-services/50-water-testing-services.html [Accessed 26th February 2016]

EMU Namibia, (2008) Report of the Auditor-General on The Office Of The Prime Minister Emergency Management Unit Disaster Preparedness for the Financial Years 2002-2007. Junias Etuna Kandjeke Auditor-General. Windhoek, September 2008. (Online) Available at https://afrosai-e.org.za/sites/afrosai-e.org.za/files/reports/606_EmergencyManagementUnit_2002-07.pdf [Accessed Online On 24th October 2016]

FAO (2012) Module 1: Conceptual framework: gender issues and gender analysis approaches. Training Guide - Gender and Climate Change Research in Agriculture and Food Security for Rural Development, CCAFS & FAO, 2012 (Online) Available as http://www.fao.org/climatechange/31734-02e69e384b4ef76bd49477a9650ef4db6.pdf [Accessed on 11th June 2016]

FAO, (2016) Chapter 2 - Water Quality Monitoring, Standards and Treatment. (Online) Available from: http://www.fao.org/docrep/X5624E/x5624e05.htm [Accessed on 20th October 2016]

FMSP, (2009) Forced Migration Studies Programme, Wits University. Report on Human Smuggling across the South Africa/ Zimbabwe Border. (Online). Available at http://archive.kubatana.net/docs/migr/fmsp_human_smuggling_zim_sa_0903.pdf [Accessed 20th October, 2016]

Gerda Bender, C. J., (2007) Pathways of change for integrating Community Service-Learning into the core curriculum, Education as Change. Issue 11:3, pp 127-142, (Online) Available from: http://dx.doi.org/10.1080/16823200709487184 [Accessed on 23rd November 2016]

Gleick, P. (1999). The Human Right to Water. *Water Policy*, 1(5) p.487-503. (Online) Available from: http://pacinst.org/app/uploads/2012/10/basic_water_needs_human_right_to_water.pdf [Accessed on 16th May 2012]

Global Water Partnerships Operations Alliance. (GWOPA) (2015) Africa: Progress on WOPs [online] Available from: http://www.gwopa.org/index.php/news-and-events/news/4059-africa-ofid-progress [Accessed: 20th February 2015]

Gogo, J., (2015) Water supply shortages, pollution and poor sanitation pose disease threat to residents of Zimbabwe's capital. (Online) Available at http://news.trust.org/item/20160129120007-ghqpv/ [Accessed 9th June 2016]

Gotelind A. (2011). Thematic report prepared for Cities and Climate Change Global Report on Human Settlements 2011. (Online) Available from: http://www.unhabitat.org/grhs/2011 [Accessed: 16th July 2014]

GoZ, (2016) Government of Zimbabwe. Ministry of Local Government, Public works and National Housing. Department of Civil Protection. (Online) Available at http://www.mlg.gov.zw/component/content/article/11-departments/8-civil-protection [Accessed on 11th October 2016]

Gumbo, B., Juizo, D. and Van der Zaag, P. (2003). Information is a prerequisite for water demand management: Experiences from four cities in Southern Africa. Elsevier Ltd. Physics and Chemistry of the earth, Volume 28 p. 827-838. (Online) Available from: http://www.sciencedirect.com [Accessed 9th June 2013]

Hautzinger, S., (2003) 'Researching men's violence: Personal reflections on ethnographic data', *Men and Masculinities* 6(1), 93–106. (Online) Available from: http://dx.doi.org/10.1177/1097184X03253139 [Accessed on 16th June 2015]

Health Matters (2011) Zimbabwe, Ministry of Health publication. Health Matters; for a healthy community. Sanitation; A threat to Public Health. p.9

Hodgkinson-Williams, C., Slay, H. and Siebörger, I. (2008), Developing communities of practice within and outside higher education institutions. British Journal of Educational Technology, 39: 433–442. doi:10.1111/j.1467-8535.2008.00841.x

Hunter, M. (2004). Masculinities, multiple-sexual-partners, and AIDS: the making and unmaking of Isoka in KwaZulu-Natal. *Transformation* 54 p. 123-153. (Online) Available at http://scnc.ukzn.ac.za/doc/Health/Aids/Hunter_M_Masculanities_multiple_partners_KZN_Isoka.pdf [Accessed 10th June 2016]

ICT (2011). Report on the multi-stakeholder meeting on the use of Information and Communication Technologies (ICT) in disaster Management: Saving Lives. 28- 30/11/11 Rainbow Towers, Harare. Available from: http://www.itu.int/ITU-D/emergencytelecoms/events/Zimbabwe_2011/ZIMBABWE-REPORT-Final.pdf [Accessed: 16th February 2015]

IFRC, (2007). International Federation of Red Cross and Red Crescent Societies. Mozambique: cyclone early warning system in practice. (Online) Available from: http://www.ifrc.org/Global/Case%20studies/Disasters/cs-ewea-mozambique-en.pdf [Accessed 27th October 2016]

IMF (2016) International Monetary Fund. A Guide to Committees, Groups and Clubs. (Online) Available from: https://www.imf.org/en/About/Factsheets/A-Guide-to-Committes-Groupsand-Clubs [Accessed on 7th September 2016]

Indexmundi. (2014) Zimbabwe Population. (Online) Available from: www.indexmundi.com/zimbabwe/population.html [Accessed on 12th August 2016]

Indexmundi. (2015) Zimbabwe Economy- Overview. (Online) Available from: www.indexmundi.com/zimbabwe/economy-overview.html [Accessed on 12th August 2016]

Indexmundi. (2015b) Zimbabwe Net Migration rate. (Online) Available from: www.indexmundi.com/zimbabwe/net_migration_rate.html [Accessed on 12th August 2016]

Indexmundi. (2015c) Zimbabwe Religions. (Online) Available from: www.indexmundi.com/zimbabwe/religions.html [Accessed on 12th August 2016]

Indrani, B., Sasirekha, R., Beryl, P., Prabhakar, M., Miren, I-G., Gray, J.J., Shabbar, J., Bindhu, M,, Jaya, P.M., Brown, D.W., Estes, M.K. and Gagandeep, K.,(2006)Comparative Study of the Epidemiology of *Rotavirus* in Children from a Community-Based Birth Cohort and a Hospital in South India *J. Clin. Microbiol.* 44 (7, 2) p. 2468-2474

Ingraham, C., 2002, 'The heterosexual imagery', in S. Jackson & S. Scott (eds.), *Gender: A sociological reader*, pp. 79–84, Routledge, New York.

ISDR, (2005). International Strategy for Disaster Reduction. Hyogo Framework for Action 2005-2015. Building the Resilience of nations and communities to Disasters. Hyogo-framework-for-action-english.pdf. (Online) Available from: www.unisdr.org/wcdr [Accessed: 16th August 2014]

Kabeer, N. (1997), Editorial: Tactics and Trade-Offs: *Revisiting the Links Between Gender and Poverty*. IDS Bulletin, 28: 1–13. (Online) doi:10.1111/j.1759-5436.1997.mp28003001.x Available from; http://0-onlinelibrary.wiley.com.wam.seals.ac.za/doi/10.1111/j.1759-5436.1997.mp28003001.x/abstract [Accessed on 5th December 2016]

Kambarami, M., (2006). Feminity, Sexuality and Culture: Patriarchy and Female Subordination in Zimbabwe. Understanding Human Sexuality Seminar Series. Africa Regional Resource Centre (ARSRC) / Health Systems Trust, South Africa and University of Fort Hare. 2006 (pdf) Available from: kmabarami.pdf [Accessed on 12th August 2016]

Kasolo, F., Yoti, Z., Bakyaita, N., Gaturuku, P., Katz, R., Fischer, J. E., & Perry, H. N. (2013). IDSR as a Platform for Implementing IHR in African Countries. *Biosecurity and Bioterrorism : Biodefense Strategy, Practice, and Science*, *11*(3), 163–169. (Online) Available from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3779000/ [Accessed on 15th June 2015]

Kavhu, S. (2014) Contaminated tap water kills 328. *The Sunday Mail*. 18th May 2014. (Online) Available from: http://www.sundaymail.co.zw/?p=4665 [Accessed: 20th May 2014]

Kawadza, S. (2016) Water Woes Dog Harare Residents. (Online) Available at http://www.herald.co.zw/water-woes-dog-harare-residents/ [Accessed on 10th June 2016]

Kelman, I. (2012). Disaster deaths. (Online) Available from: http://www.ilankelman.org/disasterdeaths.html [Accessed on 10th November 2013]

Kolbe, A. R., Hutson, R. A., Shannon, H., Trzcinski, E., Miles, B., Levitz, N., Puccio, M., James, L., Noel, J. R., Muggah, R. (2010). Mortality, crime and access to basic needs before and after the Haiti earthquake: A random survey of Port-au-Prince households. *Medicine, Conflict and Survival* 26(4): 281-297.

Köster, W., Egli, T., Ashbolt, N., Botzenhart, K., Burlion, N., Endo, T., Grimont, P., Guillot, E., Mabilat, C., Newport L., Niemi, M., Payment, P., Prescott, A., Renaud, P. and Rust, A. (2003) Assessing Microbial Safety of Drinking Water: Improving Approaches and Methods. IWA Publishing; London, UK: 2003. Analytical Methods for Microbiological Water Quality Testing; pp. 237–282. Chapter 8.

Kuznets, S. (1955). Economic Growth and Income Inequality. *American Economic Review* 45(1): 1-28.

Laloë, V. (2004). Patterns of deliberate self-burning in various parts of the world: A review. *Burns* 30(3): 207-215.

Lazarus, J. (2007) Embedding Service Learning in South African Higher Education: The Catalytic Role of the CHESP Initiative. Education as Change Vol. 11, Iss. 3, 2007. (Online) Available from: http://0-dx.doi.org.wam.seals.ac.za/10.1080/16823200709487182 [Accessed on 23rd October 2016].

Lazarus, J., Erasmus, M., Hendricks, D., Nduna, J., Slamat, J. (2008) Embedding community engagement in South African higher education. ECSJ (Online) Available at http://www.che.ac.za/media_and_publications/kagisano-series/kagisano-issue-number-6-community-engagement-south-african [Accessed on 29th October 2016]

Lerer, L. B., Matzopoulos, R. (1996). Meeting the challenge of railway injury in a South African city. *Lancet* 348(9028): 664-666.

Levison, D. and Murray-Close, M. (2005). Challenges in Determining How Child Work Affects Child Health. *Public Health Reports*, *120*(6), pp 614–621. (Online) Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1497776/ [Accessed on 23rd August 2016]

Liu, L., Johnson, H. L., Cousens, S., Perin, J., Scott, S., et al. (2012) Global, Regional, and National causes of Child Mortality: An updated systematic analysis for 2010 with time trends since 2000. *Lancet* 379 p.2151–2161.

Luyt, C. D., Muller, W. J., Tandlich, R. (2011). Factors influencing the results of microbial surface water testing in South Africa. *International Journal of Medical Microbiology* 301(S1): 28-29.

Luyt, C. D., Tandlich, R., Muller, W. J., Wilhelmi, B. S. (2012) Microbial monitoring of surface water in South Africa: An overview. *International Journal of Environmental Research and Public Health* 9 (8) pp. 2669-2693. (Online) Available from: https://www.mdpi.com/1660-4601/9/8/2669/pdf [Accessed 12th December 2013]

Luyt, C.D., Muller, W.J. and Tandlich, R., (2011). Low cost tools for microbial quality assessment of drinking water in South Africa. HealthMed, vol. 5(6) Supplement 1, pp. 1868-1877.

Malaba, J., (2006) Poverty measurement and gender: Zimbabwe's experience. Inter-Agency and Expert Group Meeting on the Development of Gender Statistics 12-14 December 2006. United Nations, New York. (Online) Available from; http://mdgs.un.org/unsd/demographic/meetings/egm/genderstats06/DOC%2014.2%20Zimbabwe.pdf [Accessed online on 15th September 2015]

Mangwe (2008) Mangwe District Disaster Preparedness and Response Plan. (Online) Available at http://practicalaction.org/docs/southern_africa/Mangwe-district-disaster-preparedness-plan2.pdf [Accessed on 29th October 2016]

Manyena, B. S. (2006). Rural local authorities and disaster resilience in Zimbabwe. *Disaster Prevention and Management* 15 (5) pp. 810-820.

Manyena, S. B., Mutale, S. B. and Collins, A. (2008). Sustainability of rural water supply and disaster resilience in Zimbabwe. *Water Policy* 10 p. 563–575

Manzungu, E., Chioreso, R. (2012) Internalising a Crisis? Household Level Response to Water Scarcity in the City of Harare, Zimbabwe. *Journal of Social Development in Africa*. 27 (1) p. 111- 135.

Manzungu, E., Mabiza, C. (2004) Status of water governance in urban areas in Zimbabwe: some preliminary observations from the city of Harare (pdf). Physics and Chemistry of the Earth. 29. p. 1167-1172.

Maponga, B., Chirundu, D., Gombe, N. T., Tshimanga, M., Shambira, G. and Takundwa, L. (2013). Risk factors for contracting watery diarrhoea in Kadoma City, Zimbabwe, 2011: A case control study. Biomed Central Infectious Diseases. Volume 13:567. (Online) Available at http://bmcinfectdis.biomedcentral.com/articles/10.1186/1471-2334-13-567 [Accessed on 15th January 2015]

Matenga, M. (2016) Surviving Dry taps in Harare. (Online) Available at http://www.thestandard.co.zw/2016/02/14/surviving-dry-taps-in-harare/ [Accessed 10th June 2016]

Medema, G.J., Payment, P., Dufour, A., Robertson, W., Waite, M., Hunter, P., Kirby, R., and Anderson, Y. (2004). Safe drinking water: An on-going challenge. In Assessing microbial safety of drinking water: improving approaches and methods. DUFOUR, A. (editor) Organization for Economic Co-operation and Development, and World Health Organization. IWA Publishing, London, UK. p. 11–45.

Meel, B. L. (2008). Fatal road traffic accidents in the Mthatha area of South Africa, 1993-2004. *South African Medical Journal* 98(9): 716-719.

MLG, (2016) Ministry of Local Government, Public Works and National Housing, Zimbabwe. The Department of Civil Protection. (Online). Available at http://www.mlg.gov.zw/component/content/article/11-departments/8-civil-protection [Accessed on 22nd October 2016]

Mogotlane, S. M., Chauke, M. E., van Rensburg, G. H., Human, S.P., & Kganakga, C. M. (2010). A situational analysis of child-headed households in South Africa. *Curationis*, *33*(3), 24 (Online) Available from; http://0-www.scielo.org.za.wam.seals.ac.za/scielo.php?script=sci_arttext&pid=S2223-62792010000300004&lng=en&tlng=en. [Accessed online on 5th December 2016]

MoHCW (2009) Zimbabwe Cholera Control Guidelines 3rd edition. Ministry of Health and Child Welfare and the World Health Organisation Zimbabwe. (Online) Available at http://www.mohcc.gov.zw/acts-policies/viewcategory/7-acts-and-policies [Accessed on 14th October 2016]

MoHCW (2011) Guidelines for the Management of Typhoid Fever. Ministry of Health and Child Welfare and the World Health Organisation Zimbabwe. (Online) Available at http://www.mohcc.gov.zw/acts-policies/viewcategory/7-acts-and-policies [Accessed on 14th October 2016]

Morof, D., Cookson, S.T., Laver, S., Chirundu, D., Desai, S., Mathenge, P., Shambare, D., Charimari, L., Midzi, S., Blanton, C. and Handzel, T. (2013) Community mortality from Cholera: Urban and Rural Districts in Zimbabwe. American Journal of Tropical Medicine and Hygiene Volume 88 p.645–650. (Online) Available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3617847/# [Accessed 9th June 2016]

Morrow, B. H. (1999), Identifying and Mapping Community Vulnerability. Disasters, 23: 1–18. (Online) Available from; doi:10.1111/1467-7717.00102 [Accessed online on 23rd November 2016]

Mosley, L. (2005) Water Quality of Rainwater Harvesting Systems Sopac Miscellaneous Report. (Online) Available from: www.pacificwater.org/userfiles/file/mr0579.pdf [Accessed: 17th March 2014]

MPDA (1998) Zimbabwe Manpower Planning and Development Act Chapter 28:02 (Online) Available from: http://www.parlzim.gov.zw/acts-list/manpower-planning-and-development-act-28-02 [Accessed on 10th February 2015]

MSD (2015) Meteorological Services Department Zimbabwe. (Online) Available from www.weather.co.zw [Accessed on 13th July 2013]

MSD (2016) Meteorological Services Department Zimbabwe. Drought Conditions and Management Strategies. Online. Available from http://www.weather.co.zw/index.php?option=com_content&view=article&id=113&Itemid=102 [Accessed on 20th October 2016]

Munyebvu F. (2011) Variations in groundwater in protected and unprotected water sources of Murehwa (Online) Available from: http://ir.uz.ac.zw/jspui/bitstream/10646/1310/1/Munyebvu_Variations_in_groundwater_quality_in_protected_and_unprotected_water_sources_of_Murehwa.pdf [Accessed 26th February 2016]

Mwando, C.J.H. and Matambanadzo, P. (2003). Integration of Indigenous Knowledge in Space Technology Information Processing for Disaster Management in Africa: A Case of Drought

National Disaster Management Centre (NDMC, 2009). Draft Minutes: Meeting of National Disaster Management Advisory Forum (NDMAF). *Meeting held on 13th August 2009*, National Disaster Management Centre, Pretoria, South Africa.

Ndhlovu, R. (2016). Bulawayo tightens water supply. The Financial Gazette. 22 March 2016. Online. Available at http://www.financialgazette.co.zw/bulawayo-tightens-water-supply/ [Accessed on 22nd October 2016]

NDRMA (2012) Namibia Disaster Risk Management Act. Act 10 of 2012 (Pdf) Available as http://www.preventionweb.net/files/28778_namibiadisasterriskmanagementact1.pdf [Accessed on 10th July 2016]

NDRRS (2013) Botswana National Disaster Risk Reduction Strategy. National Disaster Management Office. Office of the President. National Disaster Risk Reduction Strategy 2013-2018. Beyond vulnerability – Towards resilience. (pdf) Available as Botswana National Disaster Risk Reduction Strategy –April 2013.pdf [Accessed on 15th July 2016]

Nestle (2013).Partnerships and Multi-stakeholder Platforms. Available from http://www.nestle.com/csv/what-is-csv/partnerships-alliances/partnerships [Accessed: 20th February 2015]

Neumann, N. F., Smith, D. W., Belosevic, M. (2005) Waterborne Disease, an old foe re-emerging? *Journal of Environmental and Engineering Science.* Vol. 4 p.155–171 (Online) Available from: http://jees.nrc.ca/ [Accessed: 8th August 2014]

Neumayer, E. and Plümper, T. (2008). The Gendered Nature of Natural Disasters: The Impact of Catastrophic Events on the Gender Gap in Life Expectancy, 1981–2002. Annals Of The Association Of American Geographers Vol. 97, Iss. 3, 2007. (Online) Available from; http://0-dx.doi.org.wam.seals.ac.za/10.1111/j.1467-8306.2007.00563.x [Accessed on 23rd October 2016]

NGWA (2015) The Ground Water Association. Distribution of the Earth's water. (Online) Available at http://www.ngwa.org/Fundamentals/teachers/Pages/information-on-earth-water.aspx [Accessed on 26th February 2015]

Nhapi, I. (2009) The water situation in Harare, Zimbabwe: A policy and management problem. *Water Policy* 11. IWA Publishing p. 221-235.

Nigg, J. M., Barnshaw, J., Torres, M. R. (2006). Hurricane Katrina and the Flooding of New Orleans: Emergent Issues in Sheltering and Temporary Housing. The ANNALS of the American Academy of Political and Social Science 604(1): 113-128.

North-West Provincial Government (2002). State of the Provincial Environmental Report. (Online) Available from: http://www.nwpg.gov.za/soer/FullReport/water.html#ref1 [Accessed on 12th October 2012]

NPoDM (1996) Botswana: National Policy on Disaster Management. (Online) Available from http://www.ifrc.org/Docs/idrl/281EN.pdf [Accessed on 15th July 2016]

Nyamukondiwa, W. (2016) Zimbabwe: Zim Ups Disaster Management. *The Herald*. 27 June 2016. (Online) Available from http://allafrica.com/stories/201606270172.html [Accessed on 24th October 2016]

O'Brien, E. (2006) Volunteers conduct bacteria methods comparison study. *The Volunteer Monitor*. San Francisco, California, United States of America. (Online) Available from: http://water.epa.gov/type/rsl/monitoring/upload/2006_10_23_monitoring_volunteer_newsletter_volmon18no2.pdf [Accessed 10th January 2014]

OHCHR (2010). The Office of the High Commissioner for Human Rights (OHCHR). The Right to water. Fact Sheet number 35. (Online) Available at http://www.ohchr.org/Documents/Publications/FactSheet35en.pdf [Accessed online on 15thNovember 2012]

Our Africa, (2015) Our Africa- Women. (Online) Available at www.our-africa.org/women [Accessed on 30th October 2016]

Pacific Standard (2015). The changing economics of single motherhood. (Online) Available from: https://psmag.com/the-changing-economics-of-single-motherhood-f2462687ce6d#.ont8abqbz [Accessed on 9th May 2016]

PATH. (2014) Vaccine Access and Delivery (VAD) Rotavirus Disease and vaccines in Zimbabwe. PATH. (Online) Available at https://www.path.org/publications/files/VAD_Rotavirus_zimbabwe_fs.pdf [Accessed 9th June 2016]

Payne, D. (2009) Detailed Review Paper on Rotavirus Vaccines. (2009). To be presented to the WHO Strategic Advisory Group of Experts (SAGE) on Immunization, April 2009. (Online) Available at http://www.who.int/immunization/monitoring_surveillance/burden/vpd/surveillance_type/sentinel/3_Detailed_Review_Paper_RotavirusVaccines_18_March_2009.pdf [Accessed on 13th August 2016]

Personal communication, 20 September 2012. Ministry of Health and Child Welfare, Harare, Zimbabwe.

Phillips, C. (2007). Child headed households: A feasible way forward, or an infringement of children's right to alternative care? (Online) Available from; http://eric.ed.gov/?id=ED527864 [Accessed online on 25th September 2015]

Podschun, R., and Ullmann, U. (1998). *Klebsiella* spp. as Nosocomial Pathogens: Epidemiology, Taxonomy, Typing Methods, and Pathogenicity Factors. *Clinical Microbiology Reviews*, *11*(4), 589–603. (Online) Available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC88898/# [Accessed on 12th March 2016]

Prevention Web. (2014) Rural Zimbabweans struggle to cope with flooding. 14 Mar 2013 (Online) Available from: http://www.preventionweb.net/english/professional/news/v.php?id=31699[Accessed 27th of November 2014]

Prone Zimbabwe. Proceedings of the 21st International Cartographic Conference (ICC), Durban, South Africa. August 10-16 2003.

Reliefweb (2016) Map of Harare. (Online) Available from; http://img.static.reliefweb.int/sites/reliefweb.int/files/styles/attachment-large/public/resources-pdf-previews/16271-E60060EB8543F91885257664007E6F33-map.png [Accessed 6th December 2016]

Reliefweb, (2000) United Nations Country Team. Floods Disaster in Zimbabwe. (Online) Available at http://reliefweb.int/sites/reliefweb.int/files/resources/5DEECD113DEC5728C125689E004B7F2C-zimappeal.pdf [Accessed on 29th October 2016]

Rompre, A., Servais, P., Baudart, J., de-Roubin, M-R., Laurent, P. (2002) Detection and enumeration of coliforms in drinking water: current methods and emerging approaches. Journal of Microbiological Methods 49. p 31 – 54 (Online) Available from: http://envsci.rutgers.edu/~phelps/coliforms.pdf [Accessed 23rd June 2016]

SADC. (2015) SADC @ 35 Success Stories. Volume 1. 2015. (Online) available from https://www.sadc.int/files/8914/4007/4304/SADC_Success_Stories_final_English_PDF_3.pdf [Accessed on 15th August 2016]

SAZ (1997). Standards Association of Zimbabwe, Water for Domestic Supplies. Zimbabwean Standard No. 560:1997, SAZ, Harare. http://www.sciencedirect.com/science/article/pii/S1474706508001605 17/04/2012

Schwan, K. (2016). Poor water quality threatens Zimbabwe's health. *The Disease daily.* (Online) Available at http://www.healthmap.org/site/diseasedaily/article/poor-water-quality-threatens-zimbabwes-health-4212 [Accessed on 10th June 2016]

Sigma-Aldrich, (2016) Hydrogen Sulfide Test Strips for microbiology. (Online) available from http://www.sigmaaldrich.com/catalog/product/sial/06728?lang=en&region=ZW [Accessed on 12th October, 2016]

Silberschmidt, M., (2001) 'Disempowerment of men in rural and urban east Africa: Implications for male identity and sexual behaviour', World Development 29(4), pp 657–671. (Online) Available from: http://dx.doi.org/10.1016/S0305-750X(00)00122-4 [Accessed on 16th June 2015]

Sobsey, M. D. and Pfaender, F. K., 2002. Evaluation of the H2S method for detection of faecal contamination of drinking water. Water, Sanitation and Health Department of Protection and the Human Environment World Health Organization.http://www.who.int/water_sanitation_health/dwq/WSH02.08.pdfAccessed 13th March 2014

South Africa Demographics Profile. (2014) South Africa Demographics Profile (Online) Available from www.indexmundi.com/south_africa/demographics_profile.html [Accessed on 17th June 2016]

South Africa. (1997). White Paper 3: A programme for the transformation of higher education. Notice 1196 of 1997. Government Gazette, 386 (18207)1:55, August 15

South African Constitution, (1996). Constitution of the Republic of South Africa. Act number 108 of 1996. (Online) Available from: http://www.gov.za/sites/www.gov.za/files/images/a108-96.pdf [Accessed online on 20th November 2016]

Statistics South Africa (SSA, 2006). Adult mortality (age 15-64) based on death notification data in South Africa: 1997-2004. *Statistical Report no. 03-09-05*, Statistics South Africa, Pretoria, South Africa, pp. 200.

Statistics South Africa. (SSA, 2011a). Mortality and causes of death in South Africa, 2009: Findings from death notification. *Statistical release P0309.3*, Statistics South Africa, Pretoria, South Africa.

Stats SA, (2016) Statistics South Africa. The economy: winners and losers of 2015. Online. Available from; http://www.statssa.gov.za/?p=6233 [Accessed on 23rd October, 2016]

Statutory Instrument 64 of 2016. (2016) Control of Goods (Open General Import Licence) Number 2. Amendment notice, 2016. Number 8. Chapter 14:05)

Sutton, S. (2010) The Most Probable Number Method and Its Uses in Enumeration, Qualification, and Validation. Journal of Validation Technology. Volume 16, number 3 pp 35-38. (Online) Available at http://www.microbiologynetwork.com/doc/sutton.jvt_.16.3.pdf [Accessed on 10th August 2016]

Tandlich, R., Luyt, C. D., Wisch, M. H., Madikizela, P., Chirenda, T. G., Pyle, D. M. (2014). Stakeholder participation and sustainable disaster management planning in South Africa. Published in the peer reviewed proceedings from the 1st International Conference on Information and Communication Technologies for Disaster Management paper number 109;24- 25 March 2014

The Disaster Management Regulations: Disaster Management. South African Government Gazette Notice no. 1689 of 2005, Department of Local and Provincial Government, Pretoria, South Africa, 2005.

The Financial Gazette. (2014) CZI launches Purchasing Managers Index (online) Available at http://www.financialgazette.co.zw/czi-launches-purchasing-managers-index/ [Accessed on 9th June 2015]

The Holy Bible, New International version. 1984 Edition.

The Zimbabwe Mail (2016) Water rationing looms countrywide. 25 August 2016. Online. Available at http://thezimbabwemail.com/farming-27547-water-rationing-looms-countrywide.html [Accessed on 22nd October 2016]

Thomas, K. E. (2012) Study of Rainwater Harvesting Quality. *Clear Waters.* (06/ 2012) p. 33-35.

Todar, K. (2012). Todar's online textbook of Bacteriology. (Online) Available from: http://textbookofbacteriology.net/e.coli.html [Accessed 14th March 2014]

Tomasulo, A. (2012) Update: Zimbabwe reports 1500 cases of Typhoid. The Disease Daily. (Online) Available at http://www.healthmap.org/site/diseasedaily/article/update-zimbabwe-reports-1500-cases-Typhoid-2112 [Accessed on 9th December 2013]

UN (2013) *United Nations Goal 7: Ensure Environmental Sustainability.* [(Online) Available from: http://www.un.org/millenniumgoals/environ.shtml [Accessed 28th August 2014]

UN (2016) Sustainable Development Goals. 17 Goals to Transform our World. Goal 6: Ensure access to water and sanitation for all. (Online) Available at http://www.un.org/sustainabledevelopment/water-and-sanitation/ [Accessed on 12th October 2016]

UN, (2012) United Nations Statistical Indicators. 'Statistics and indicators on women and men'. (Online) Available from: http://unstats.un.org/unsd/demographic/products/indwm/ [Accessed 20th June 2012]

UN, (2015c) Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015. (Online) Available from: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E [Accessed on 12th October 2016]

UN. (2015a) Water for life decade 2005-2015. The human right to water and sanitation (Online) Available from: http://www.un.org/waterforlifedecade/human_right_to_water.shtml [Accessed 13th January 2012]

UN. (2015b). We can end poverty. Millennium Development Goals and beyond 2015. (Online) Available from: http://www.undp.org/millenniumgoals/environ.shtml [Accessed: 3rd March 2015].

UNDP (2015a) Zimbabwe Human Development Report. (Online) Available from: http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/ZWE.pdf [Accessed on 15th June 2015]

UNDP (2015b) Gender Inequality Index (GII). (Online) Available from; http://hdr.undp.org/en/content/gender-inequality-index-gii [Accessed on 18th June 2015]

UNDP. (2008) United Nations Development Programme, 2008, *UNDP Development Indices*, UNESCO Institute for Statistics, Geneva, Switzerland.

UNDP. (2011) Namibia. Integrated Dry lands Development Programme. 1 April- 30 November 2011. (Online) Available at http://www.undp.org/content/dam/undp/library/Environment%20and%20Energy/sustainable%20land%20management/IDDP_countries/IDDP_Namibia.pdf [Accessed online on 10th August 2016]

UNICEF, (2004) National Plan of Action for Orphans and Other Vulnerable Children Zimbabwe Online. Available at http://www.unicef.org/zimbabwe/1_Zimbabwe_NPA_for_OVC_2004.pdf [Accessed on 20th October 2016]

UNICEF. (2015). Maternal Mortality. Online. Available from; http://data.unicef.org/corecode/uploads/document6/uploaded_pdfs/corecode/Trends-in-MMR-1990-2015_Full-report_243.pdf [Accessed on 23rd June 2016]

UNIDSR. (2014) The United Nations office for Disaster Risk Reduction. UNIDSR (2014) Terminology. (Online) Available from: http://www.unisdr.org/we/inform/terminology [Accessed: 22nd September 2014]

UNISDR (2009). Evaluation report: strengthening capacity for disaster management in Zimbabwe Project. 2005-2009. (Online) Available from http://www.unisdr.org/2005/mdgs-drr/national-reports/Zimbabwe-report.pdf [Accessed: 16th February 2015]

United Nations (2012). Healthy Life Expectancy at Birth. (Online) Available from: www.un.org [Accessed: 16th August 2012]

United Nations (2014a). Sustainable Development Knowledge Platform.Achieving good health for all. Why water, sanitation and hygiene are crucial determinants of health. (Online) Available from: http://sustainabledevelopment.un.org/index.php?page=view&type=9502&menu=1565&nr=6 [Accessed: 21st August 2014]

United Nations (2014b). The Secretary-General--Message on the 500-Day mark to the conclusion of the Millennium Development Goals"500 Days of Action to Build a Better World". (Online) Available from: http://www.un.org/millenniumgoals/pdf/mdg.500.statement.08.15.13.30.FINAL.REV.pdf [Accessed: 21st August 2014]

Walby, S., 2002, 'Gender, class and stratification: Towards a new approach', in S. Jackson & S. Scott (eds.), *Gender: A sociological reader*, pp. 93–96, Routledge, New York.

WASH Atlas (2008-9) *Intervention Mapping for Water, Sanitation and Hygiene (WASH) in Zimbabwe. Who is doing what and where?* Volume 1. Fifth Edition.

Water Act. (2002) Chapter 20:24 (Online) Available from: http://www.parlzim.gov.zw/acts-list/water-act-20-24 [Accessed on 13th February 2014]

Wenger, E. (2004). Communities of practice: a brief introduction. Accessed December 10, 2007, from http://www.ewenger.com/theory/communities_of_practice_intro_WRD.doc [Accessed 23rd October 2016]

WGEKN (2007) Women and Gender Equity Knowledge Network 2007. Unequal, Unfair, Ineffective and Inefficient Gender Inequity in Health: Why it exists and how we can change it Final Report to the WHO Commission on Social Determinants of Health. (Online) Available from http://www.who.int/social_determinants/resources/csdh_media/wgekn_final_report_07.pdf [Accessed on 15th June 2016]

WHO (1997). Guidelines for Drinking Water Quality. Surveillance and Control of Community Supplies. (Online) Available from: www.who.int/water_sanitation_health/dwq/gdwqvol32ed.pdf [Accessed: 10th May 2014]

WHO (2003). The Right to Water. (Online) Available from http://www.who.int/water_sanitation_health/en/righttowater.pdf [Accessed on 20th August 2012]

WHO (2006). Global Health Workforce Alliance. The World Health Report, 2006. Health Workforce and Data Statistics. Health Workers for all and all for health workers. (Online) Available from; http://www.who.int/workforcealliance/knowledge/data/en/ [Accessed on 5th December 2016]

WHO (2010) Zimbabwe Statistical Factsheet. WHO Regional Office for Africa. *Factsheets of health statistics.* (pdf) Zimbabwe_Statistical_factsheet.pdf [Accessed online on 5th July 2014]

WHO (2013) Diarrhoeal disease (Online) Available from: www.who.int/mediacentre/factsheets/fs330/en/ [Accessed on 13th August 2016]

WHO (2013b). Zimbabwe. (Online) Available from http://www.who.int/maternal_child_adolescent/epidemiology/profiles/neonatal_child/zwe.pdf [Accessed on 15th November 2015]

WHO (2014).*Shigella.* (Online) Available from: www.who.int/topics/shigella/en/ [Accessed: 1st December 2014]

WHO (2015) Yip, W. and Hafez. R. Improving Health System Efficiency. Reforms for improving the efficiency of health systems: lessons from 10 country cases. (Online) Available at http://apps.who.int/iris/bitstream/10665/185989/1/WHO_HIS_HGF_SR_15.1_eng.pdf?ua=1 [Accessed on 29th October 2015]

WHO (2015). World Health Organisation. *Water and sanitation health (WSH). Content of the human right to water.* (Online) Available from http://www.who.int/water_sanitation_health/humanrights/en/index2.html [Accessed: 4th March 2015]

WHO, (2003) Heterotrophic Plate Counts and Drinking-water Safety. The Significance of HPCs for Water Quality and Human Health. IWA Publishing, Alliance House, 12 Caxton Street, London SW1H 0QS, UK. Online. Available at

http://www.who.int/water_sanitation_health/dwq/HPCFull.pdf [Accessed on 22nd October 2016]

WHO. (1997). Guidelines for drinking water quality. Volume 3 Surveillance and control of community supplies. (Online) Available from; http://www.who.int/water_sanitation_health/dwq/gdwq2v1/en/index2.html [Accessed on 17th April 2014]

WHO. (2007) World Health Organization. Rotavirus vaccines. Weekly Epidemiological Record 2007; 32:285-296. (Online) Available at http://www.who.int/wer/2009/wer8451_52.pdf [Accessed 19th December 2013]

WHO/UNICEF (2013) Progress on Sanitation and Drinking-Water: 2012 Update. World Health Organization/United Nations Children's Fund, Geneva. (Online) Available at: http://apps.who.int/iris/bitstream/10665/81245/1/9789241505390_eng.pdf (Accessed 28th August 2014).

Williams, S. L., Williams, D. R., Stein, D. J., Seedat, S., Jackson, P. B. and Moomal, H. (2007). Multiple traumatic events and psychological distress: The South Africa stress and health study. *Journal of Traumatic Stress* 20(5): 845-855.

World Health Organisation (WHO, 2012). Chapter XX: External causes of morbidity and mortality (V01-Y98). Sequel of external causes of morbidity and mortality (Y85-Y89). (Online) Available from: http://apps.who.int/classifications/apps/icd/icd10online2007/index.htm?navi.htm [Accessed 15th February 2013]

Yaziz, M. I., Gunting, N., Sapari, N. and Ghazali, A. W. (1989) *Water Research* 23 (6). p.761-765.

ZEPI (2014) Zimbabwe Expanded Programme on Immunisation. Comprehensive Multi-year Plan. 2015-2019. (online). Available at www.nationalplanningcycles.org/sites/default/files/country_docs/Zimbabwe/zimbabwe_epi_cmyp_2015_-_2019.pdf [Accessed on 13th August 2016]

Zimbabwe (2011). Government of Zimbabwe *National Disaster Risk Management Policy. (Draft)* (Number 1, revised 19th August 2011) Unpublished, Government of Zimbabwe, Harare.

Zimbabwe Country Analysis Report (2010). Government of Zimbabwe - United Nations Country Team. (Online) Available at http://www.zw.one.un.org/sites/default/files/Country%20Analysis%20Report%20for%20Zimbabwe%202010.pdf [Accessed on 13th June 2014]

ZIMSTAT (2012) Zimbabwe Statistical Office Population Census 2012. (Online) Available at http://www.zimstat.co.zw/sites/default/files/img/National_Report.pdf [Accessed on 12th April 2014]

ZIMSTAT (2012b) *2011 Child Labour Survey Report*. (Online) Available from: www.zimstat.co.zw/dmdocuments/Childlabour.pdf [Accessed: 16th July 2014]

ZIMSTAT (2012c) Provincial Report Matabeleland South Census 2012. (Online) Available from http://www.zimstat.co.zw/sites/default/files/img/publications/Census/CensusResults2012/Mat_South.pdf [Accessed: 16th July 2014]

ZIMSTAT (2013). *Women and Men in Zimbabwe Report 2012* (Online) Available from: www.zimstat.co.zw/dmdocuments/Gender/Report2012.pdf [Accessed: 16th July 2014]

ZLLM, (2016) Zimbabwe Latitude and Longitude map (Online) Available from: http://www.mapsofworld.com/lat_long/zimbabwe-lat-long.html [Accessed online 13th June 2016]

Zuma, B. M., Luyt, C. D., Chirenda, T. and Tandlich, R. (2012). Flood disaster management in South Africa: Legislative framework and current challenges. International Conference on Applied Life Sciences (ICALS 2012). Turkey, September 10-12 2012. (Online) Available from: cdn.intechopen.com/pdfs-wm/39883.pdf [Accessed on 13th November 2012]

Zvidzai, C., Mukutirwa, T., Mundembe, R. and Sithole-Niang, I. (2007) Microbial community analysis of drinking water sources from rural areas of Zimbabwe. African Journal of Microbiology Research Vol. 1 (6) pp. 100-103 (Online) Available from:

http://www.academicjournals.org/article/article1380098120_Zvidzai%20et%20al%201.pdf
[Accessed 26th February 2016]

6 APPENDIX 1 QUESTIONNAIRE

Candidate: Tatenda Grace Chirenda

Student Number: 607c3455

Degree: MSP

Faculty Pharmacy

Division: Pharmaceutical Chemistry

Research Field: Environmental Health and Biotechnology Research.

Title: The assessment and monitoring of Microbial water quality in water tanks in Harare using simpler alternative methods and the public health implications of the results thereof.

Supervisor: Dr. Roman Tandlich and Prof Sunitha C. Srinivas

Water Reticulation System employees Questionnaire

Section A: Demographics

Name:----------

Place of employment:----------

Job Description:----------

Duration of Employment:----------

Section B: Water Quality

Employee Section

Which reservoirs are currently being supplied with water from this reticulation system?

Have there been any problems recently with the supply network to these reservoirs? Yes/ No

If yes, please describe them.

What kind of analytical tests are done at this Water reticulation system?

How often are these tests done and who conducts them?

Is the person responsible for the testing procedures trained to do so? Yes/ No.

If yes do they receive continuous training for such testing procedures? Yes/ No

Are there records available of prior microbial water quality testing at the site? Yes/ No

If yes, could I have please have access to them?

Tap Water Users Questionnaire

Section A Demographics

Name/ Zita:----------

Location/ Kwamunogara:----------

Source of water/ Pamunotora mvura yenyu yekunwa:----------

Please tick the appropriate answer.

Makai pane mhinduro yenyu

Section B Water Supply

1. Do you have adequate access to clean water in your household? Yes/ No

   Munowana mvura yakachena yokushandisa yakakwana here pamba penyu? Hongu/ Kwete

2. How often if at all do you experience water cuts?

   Kana muchishandisa mvura yemupombi, inoenda kangani?

Weekly	Monthly	Never
Svondo rega rega	Mwedzi wega wega	Haiendi

3. Are there times when your water is not appealing to drink? If yes, describe what it looks like during those times.

   Pane nguva here yekuti mvura yemupombi inenge isinganwiki? Hongu/kwete

   Kana mati hongu, tsanangurai kuti inenge ichitaridzika sei?

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4. Have there been any reports of pipe breaks recently in your waterlines? Yes/ No

   If yes, how long after the breaks were they repaired?----------
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Pane mapaipi akatsemuka here anounza mvura kwamuri murukisheni rwenyu panguva shoma yakapfuura? Hongu/ Kwete

Akazogadzirwa pava nenguva yakadii kubva pazvakaitika?----------
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5. Have there been any outbreaks due to water-borne diseases recently in the area? Yes/ No

   If yes, how long ago was this? ----------

   Pakamboita kuparirira kwezvirwere zvinokonzerwa nemvura yakasviba here mukati memazuva mashoma apfuura? Hongu/ Kwete

   Pava nenguva yakadii kubva pakazviitika? ----------

Water tank Users Questionnaire

Section A Demographics

Name/ Zita: ----------

Location/ Kwamunogara: ----------

Source of water/ Pamunotora mvura yenyu yekunwa: ----------

Please tick the appropriate answer.

Makai pane mhinduro yenyu

Section B Water Supply

1. How often do you use water collected in the tank per week and for what purposes?

   Munoshandisa mvura yemutank kangani pasvondo uye kuita mabasa api?

   ---

2. Do you chemically treat your water? Yes/ No

   If yes, with what chemicals?----------

   Pane mushonga here wamunoshandisa mutank kuti mvura yenyu ichene? Hongu/ Kwete

   Kana iripo, mungandipawo mazita ayo here?----------
   ---

3. Do you boil your water before using it for domestic purposes? Yes/ No

   Kana muchishandisa mvura kumwa munombotanga maikwatisa here? Hongu/ Kwete

4. Which source supplies the water in your tanks?

   Mvura yenyu yemutank inozadzwa nemvura ipi yacho?

Rainwater	Tap water	Other
Inonaya	Yemupombi	Imwe

5. If other please specify.----------

Kana ichizadzwa neimwe nzira, inzira ipi? ----------