ASSESSING THE ROLE OF THE PRIVATE SECTOR IN DELIVERING DRINKING WATER IN RURAL AREAS: A CASE OF ANGLICAN DIOCESE OF UPPER SHIRE (ADUS)

MASTER OF SCIENCE IN WATER RESOURCES MODELLING AND GOVERNANCE

TIONE NGWIRA DZUWA

UNIVERSITY OF MALAWI

June, 2022

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DECLARATION

I, Tione Ngwira Dzuwa, hereby declare that this thesis is my original work and has not been presented for any other awards at the University of Malawi or any other University.Where other people's work has been used, appropriate acknowledgements have been made.

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Full Legal Name

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Signature

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Date

CERTIFICATE OF APPROVAL

We, the undersigned certify that this thesis represents the student's own work and effort and has been submitted with our approval.

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DEDICATION

My passion is on rural water users considering the challenges they face in accessing safe drinking water. I have desired for a long time to understand the operations of rural water schemes in terms of providing safe drinking water to their clients. Finally, the opportunity has been found through my course of study in Water Resources Modelling and Governance. Hence, I dedicate this work to all beneficiaries of rural water schemes.

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ABSTRACT

The importance of safe drinking water on human life needs no emphasis. In view of this, several legislations, guidelines and policies have been developed at international and national level to improve the delivery of safe drinking water in the world. However, many studies have found that most rural areas of the world whose water is supplied by private investors have a challenge in accessing safe drinking water. Therefore, this study was aimed at assessing the role of the private sector in delivering drinking water in rural areas, case study of the Anglican Diocese of the Upper Shire Water Scheme at Malosa in Zomba District, Malawi. The study took a mixed research design approach. A total of 103 participants (42 males and 61 females) were interviewed in order to obtain their perception on the safety, acceptability and management of water supplied by the water scheme. A water quality test on bacteriology was conducted on water samples collected from the water scheme's distribution system following standard procedures to validate peoples' perception on the safety of the water. The study findings show that 87% of the study participants were not satisfied with the colour of the water supplied by the institution. Results on microbial analysis indicated microbial contamination on the water samples collected before chlorination. Interviews with the key informants also show that the water scheme was facing some operational and management challenges and lack of monitoring by relevant authorities due to policy issues. The results are in line with findings from other studies. This study therefore, recommends the revision of the Water Resources Bill of 2012, currently in force, to empower District Water Offices to monitor the operations of privately owned rural water schemes.

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LIST OF ACRONYMS

ADUS	Anglican Diocese of Upper Shire
ANT	Actor Network Theory
CMA	Community Management Approach
DMM	Delegated Management Model
DWO	District Water Office
FGD	Focus Group Discussion
GoM	Government of Malawi
HEP	Hydro Electric Power
MDGs	Millennium Development Goals
MMM	Municipal Management Model
MoH	Ministry of Health
MoIWD	Ministry of Irrigation and Water Development
POMA	Privately-Owned Management Approach
PRWS	Privately - owned Rural Water Scheme
RWS	Rural Water Supply
SRWB	Southern Region Water Board
UN	United Nations
UNICEF	United Nations Children's Fund
WHO	World Health Organisation
WUA	Water Users Association

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Every person is entitled to safe, sufficient and physically accessible water for personal and domestic use. In addition, it is recommended that water for domestic use should be acceptable and affordable. These five key a reasconstitute a fundamental human right (UNDESA, 2014; Scanon, *et. al.*,2004). In this regard, effective management of water supply entities is crucial at any level and in any community considering the significant contribution of portable water in people's lives.Water for domestic use is considered safe when it is free from pathogenic agents, harmful chemical substances, unpleasant taste, colour and odour (Park, 2011). Lack of access to safe, clean and affordable water has a significant impact on economic and human development (Pannu, 2012).Unsafe drinking water and poor sanitation have a profound negative impact on the health of people and the socioeconomic development of any nation.

Globally, 2.2 million people die every year from water borne diseases. In addition, at any given period, about 5% of all hospital beds are occupied by patients suffering from water related illnesses (WHO/UNICEF, 2010).It has also been estimated that about 443 million school days are lost each year due to water related illnesses (WHO, 2010).

Nevertheless, it has been reported that there are still some areas in the world that are lagging behind in the access to safe drinking water despite the fact that potable water is one of the fundamental human rights (UNICEF/WHO, 2015;United Nations, 2010). It is argued that the rural areas of developing countries are the most greatly affected and the challenge is even greater in water schemes that are privately owned (United Nations, 2005; WHO/UNICEF, 2012; Hunter *et al.*, 2011).Globally, by 2015, 663 million people did not have access to clean drinking water and half of them lived in the rural sub-Saharan Africa (WHO/UNICEF, 2015). In view of this, several legislations, guidelines and policies have been developed at international and national level to improve the management of drinking water in the world (Akpor & Muchie, 2011). At the international level, the United Nations (UN) has taken several initiatives to alleviate the water problem.

In the year 2000, at the Millennium Summit, UN member states committed themselves to halving the number of people without access to safe drinking water and sanitation by the year 2015 by adopting Millennium Development Goal (MDG) target 7c (United Nations, 2010; WHO/UNICEF, 2012). Water providing agencies worldwide started to work towards this target.In 2015, the UN developing agenda introduced Sustainable Development Goals (SDGs) to replace the MDGs in order to achieve universal and equitable access to safe and affordable water to all including the management of rural water supply by the year 2030 (WHO, 2017). At national level, the Government of Malawi (GoM) developed several policy frameworks and legal documents in its quest to effectively provide safe drinking water to its population.

The Malawi Vision 2020, the National Water Policy and the Malawi Growth and Development Strategy (MGDS) are some of the documents that were formulated to achieve the goal (Chidya *et al.,* 2019).The objectives of the MGDS as stated by Government of Malawi (2005) reflect those of the Millennium Development Goals (MDGs).The efforts of increasing access to safe drinking water yielded some results. In 2010, the United Nations under WHO/UNICEF joint Monitoring Programme for Water and Sanitation (JMP) projecting the desired outcome of 2015 announced that it was on track to achieve its goal of reducing by half the number of people accessing unsafe drinking water by the year 2015. Almost 6.1 billion (89%) of the world population had gained access to improved water sources between 1990 and 2010 (WHO/UNICEF, 2012). However, the process encountered some challenges. For instance, there have been major inequalities between and within countries. Only two-thirds of people in sub-Saharan Africa have access to clean water, and the figure is considerably lower in rural areas (UNICEF/WHO, 2015a).

A number of factors are responsible for the poor accessibility of potable water in rural areas. These factors, among many others include neglect by central and municipal government authorities to supply water to rural areas (Kalulu & Hoko, 2010).It is reported that government utility agencies are less willing to provide potable water to rural areas due to the unfavourable terrain of most rural areas. Investors are also less willing to supply potable water to rural areas due high upfront financial and infrastructural investments with no guarantee of cost recovery due to high poverty levels among the rural populace (Kalulu & Hoko, 2010; Adams & Zulu, 2015).

To address this challenge, some countries such as Kenya, have decided to recognize private investors as developmental partners in the provision of potable water to rural areas (Mehta, *et al.,* 2007). In Malawi, the National Water Policy of 2005 recognizes the role of private partners in the provision of safe drinking water. For example, section 3.3.5of the policy promotes public and private sector participation in water resources management, development, supply, and conservation. Section 6.2.2.11 of the National Water Policytalks of promoting private sector participation in the delivery of goods and services for rural water whereas section 6.1.2.11 of the policy talks of promoting and instituting economic incentives and opportunities to encourage theparticipation of small-scale water and sanitation service providers among other factors (GoM, 2005). Hunter *et al.,* (2011) attests that, a considerable number of rural people in both industrialized and developing countries are relying on small community water supplies for their everyday basic needs, most of which are privately owned. However, the contribution of these water schemes to the achievement of the human right to drinking water is understudied.

Studies available reveal that these community water supplies encounter a number of challenges which reduce their effectiveness in the provision of potable water to their beneficiaries (Charrois, 2010; Hunter, 2011). Operation and management challenges are some of the factors hindering many small private water supplies from discharging their duty effectively. The available literature shows that as a consequence, water supplied by these privately owned rural water schemes (PRWSs) is often associated with microbial contamination (Charrois, 2010).

Lack of properly trained personnel, financial constraintsand lackof access to expert assistance is also some of the factors affecting the smooth running and management of PRWSs world-wide (Charrois, 2010). Literature on the contribution of PRWSs in the achievement of the human right to drinking water in the Sub - Saharan Africa is also scanty. The few studies available show mixed results of successes and failures due to policy issues in the quest to improve access to potable water in rural households of the region (Naiga,2015). For instance, in Mozambique a pro-poor rural water strategy that was implemented to improve water access in some areas had not met the intended purpose (Ducrot & Bourblanc, 2017). On the other hand, donors and governments in many developing countries such as Kenya are increasingly recognising the importance of small-scale water providers as partners in the work to extend and improve water service delivery in low-income households and dispersed populations of rural and peri-urban areas (Mehta, *et al.*, 2007).

In view of this, further gaps remain in understanding the role of private small-scale rural water providers in the delivery of drinking water to rural areas. It is against this background that the study was set out to assess the role of one of thePRWSs in Malawi, the Anglican Diocese of the Upper Shire (ADUS) Water Scheme at Malosa in Zomba District.

1.2 Problem Statement

Realising the importance of safe and acceptable drinking water on humanity, several interventions have been put in place globally as well as locally to address the challenge of lack of access to safe drinking water (Quin, 2010).

This includes recognition of the private sector as developmental partners by central or municipal governments in the provision of drinking water to rural areas. Nevertheless, it has been reported that access to safe and acceptable drinking water still remains a challenge in many rural parts of the world. The impact is profound in water schemes where water for household use is supplied by private water investors in these rural areas (Akpor & Muchie, 2011; Hunter *et al.,* 2011; Kalulu & Hoko, 2010). Furthermore, the contribution of these privately owned water schemes in terms of the achievement of the human right to drinking water is understudied. The few studies available show mixed results of successes and failures of these water schemes due to policy issues (Naiga,2015). To this effect, the study was set to assess the contribution made by one of thePrivate Rural Water Schemes (PRWSs) in Malawi; ADUS water scheme at Malosain terms of acceptability and quality of the water supplied by the water scheme.The area supplied by the scheme was in 2016hit by diarrhoeal and typhoid outbreak that was generally associated with drinking water quality (Weekend Nation, 13 July, 2016), yet there are no studies to validate the claim. It is against this background that the study was therefore carried out.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of the study is to assess acceptability and quality of drinking water supplied by a privately owned rural drinking water schemes using the case study of the Anglican Diocese of Upper Shire (ADUS) Water Scheme in Zomba, Malawi.

1.3.2 Specific Objectives

(i) To analyse arrangements for water management at ADUS Water Scheme.

(ii) To explore people's perceptions on the acceptability of water supplied by ADUS Water Scheme.

(iii) To examine microbial safety of water supplied by ADUS Water Scheme for domestic use.

1.4 Justification of the Study

Most rural communities in Malawi, as is the case world-wide, are faced with the challenge of access to safe drinking water. The situation occurs in the midst of many policies at the international, regional as well as local level that have been put in place to ensure access to potable water. The water supplied by the scheme under study (Anglican Diocese of Upper Shire [ADUS] Water Scheme) had been associated with diarrhoeal outbreaks in the recent past. Therefore, findings from this study will fill gaps in how PRWSs should be managed to ensure that the rural populous have access to safe drinking water. Assessment of the role of privately owned rural water scheme in the delivery of drinking water became crucial in uncovering this knowledge. The study examined the extent to which PRWSs like ADUSmanage service delivery to ensure that acceptability and safety aspects among the five key areas of the right to water as advocated by the UN and WorldHealth Organisation are adequately met.

The study was also crucial in that its findings contribute to strengthening the basis for improving policy and strategies targeting rural water supply schemes thereby helping in the attainment of Sustainable Development Goal (SDG) number 6 of achieving 'water for all' while ensuring the sustainable management of water resources (UNDESA, 2018).

1.6 Outline of the study

This study is outlined as follows: chapter one has highlighted the importance of water for domestic use a fundamental human right in that it should be accessible, affordable, sufficient, safe and acceptable. The emphasis has been put on safety and acceptability of water meant for household use as per the objective of the study. The chapter also explains the study problem statement, objectives and significance hence setting the scene of the study. Chapter two discusses literature and theoretical frame work relevant to the study. In particular, the chapter discusses a number of issues namely: management challenges which rural areas and privately owned water schemes face in the quest to provide safe drinking water to people as advocated by the United Nations Organisation, the concepts of perception and acceptability in determining drinking water quality as well as efforts that have been put in place for providing potable water to the world population by the UN.

Lastly, the chapter discusses the rural water supply management models that exist in water governance and parameters for determining water quality. Chapter three discusses the methodology employed in the study whereas chapter four presents field findings on the contribution made by privately owned water schemes to rural households in terms of acceptability and safety. Specifically, the study assesses the effectiveness of the institutional arrangements involved in water quality management at ADUS water scheme, explores people's perceptions on the acceptability of water supplied by the Water Scheme and examines microbial safety of water supplied by ADUS Water Scheme for domestic use.Lastly, chapter five concludes by summarising the major findings of the study.

1.7 Summary

This chapter has provided a general background of the study and has broadly highlighted on the importance of safe and acceptable water for domestic use as recommended by the UN and the efforts that have been put in place at the international and local level to make water for household use a fundamental human right (safe and acceptable among other factors). The chapter has also discussed the role of privately owned water schemes in the provision of domestic water to rural household. It is within this framework that the study has presented the research problem, justification for carrying out this study. The chapter has also presented study objectives. The next chapter presents relevant literature and the theoretical framework of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is a review of some of the published scholarly articles on this topic. To provide a framework for understanding and analysing findings of the study, the chapter begins by examining the theoretical framework guiding this study.It then discusses the management challenges which rural areas and the PRWSs face in the quest to provide safe drinking water to people as advocated by the United Nations Organisation. The purpose of this review is to give a picture of the situation and to review some of the models used in the management of rural drinking water. The chapter is alsoa review of the concepts of perception and acceptability in determining drinking water quality. Acceptability has been defined by the UN as the state in which water for domestic use is acceptable to the users in terms of colour, odour and taste (Scanon, *et. al.*,2004).

2.2 Theoretical framework

2.2.1 The Actor Network Theory

The study employed the Actor Network Theory (ANT) developed by French Scholars; Michael Callon and Bruno Latour in 1980s to explain how the role of private water investors is recognized by the government of Malawi policy-wise but not practically on the ground. This scenario has affected the service delivery of private water schemes in rural areas.

ANT has been used by several scholars in various disciplines as follows: Latour (1996), Swatuk (2008) and Baiocchi, Graizbord and Rodriguez- Muniz (2013) and Oates *et al*. (2017).ANT isboth a theoretical and methodological approach to social theory. It explains that everything in the social and natural world exists in constantly shifting networks of relationships and that nothing exists outside those relationships. The theory believes in the existence of actors or actants who can be humans or nonhumans who have the capacity to act or participate in systems (institutions) or networks. An actant can be anything provided it is s source of action. According to this study, the government under MoIWD is as an actor whose actions has an impact on institutions (networks) responsible for water service delivery in the country.

2.2.1.1 Institutions and actors for rural water supply in Malawi

Institutional arrangements can be defined as humanly devised constraints or social structures that shape human behaviour and interaction (North, 1991; Harris, Jones & Kooy, 2011). Institutions can exist formally or informally. Institutional arrangements play a crucial role in water governance in that they shape water-related decision-making and policies. Actors on the other hand, can be defined as humans or nonhumans who have the capacity to act or participate in systems or institutions, (Hassenforder & Barone, 2018). According to Baumann and Danert, (2008); Lockwood and Kang, (2012) and Chowns, (2014), the central government is the formal institution that is responsible for rural water supply at national level in Malawi. The local government is responsible to central government, districts or Non-Governmental Organisations (NGOs). The NGOs work hand in hand with communities in the rural water sector who are the key actors.

The communities also have their own informal institutions or arrangements for water governance under traditional leadership. This set up is in line with the community Management Approach (CMA).

2.2.2 The Political Economy Analysis

The Political economy analysis is a framework that helps to explain how various governance arrangements and institutions operate at various scales. It also explains the way in which power and resources is distributed among key actors thereby affecting service outcomes (Jones, 2015; Franks & Cleaver, 2007; Mollinga, 2008; Harris *et al.,* 2011). It is argued that the poor performance of any institution is attributed to technical or managerial factors as well as political and economic factors (Fritz et al., 2009; Hudson & Leftwich, 2014). In Malawi, the political economy framework has helped in identifying the underlying factors hindering water service delivery (Oates & Mwathunga, 2017). It is also believed that such analysis can also be useful in identifying potential entry points for policy intervention among other factors (Booth & Golooba-Mutebi, 2009). It is against this background that this framework was chosen to help in addressing the gap that exists on the role of private water investors in the delivery of drinking water to rural areas.

2.3 Efforts in providing potable water to the world population by the UN

Water is an important natural resource on earth necessary for the survival of all living organisms and a catalyst for economic development (GWWater Security for Development, 2010; Shafiq et *al.,* 2013). Several scholars have agreed on the importance of water quality and quantity in determining human well-being (Younnes & Bartram, 2001; Pund & Ganorkar, 2013; Mahendra, *et al.,* 2018).

There has been a shift from the emphasis on quantity of water to an emphasis on acceptability (acceptable drinking water quality standards) categorised as physical, chemical and bacteriological (De Zuane, 1997; Karn & Harada, 2002).United Nations Organisation recommends that institutions that are responsible for provision of water for domestic use should ensure that the water supplied is safe and of acceptable colour, odour and taste (Scanon, *et. al.,* 2004). Inefficient management of bacteriological and chemical examination by water schemes results into the transmission of communicable diseases such as diarrhoea, cholera, dysentery, typhoid, and guinea worm (Nweke& Sanders, 2009; Aditi *et al.,*2017). Diarrhoea is the second greatest cause of childhood death in the world, taking the lives of over half a million children per year (UNICEF, 2016).

Studies have shown that contamination of formal water supply systems supplying drinking water to people discourages water users from patronising such water points thereby forcing them to resort to other unsafe water sources (Karn & Harada, 2002; Haylamicheal & Moges, 2012). WHO estimates that about 663 million people put their health at risk by using unimproved drinking water sources (WHO/UNICEF, 2015).In response to this challenge, the United Nations (UN), in the year 2000, at the Millennium Summit, committed itself to halve the number of people without access to safe drinking water and sanitation by the year 2015 by adopting Millennium Development Goal target7c (United Nations, 2010: WHO & UNICEF, 2012).In 2010, the United Nations under WHO/UNICEF Joint Monitoring Programme (JMP) for Water and Sanitation announced that it was able to achieve its goal of reducing by half the number of people accessing unsafe drinking water by 2015.

Almost 6.1 billion (89%) of the world population had gained access to improved water sources between 1990 and 2010 (WHO /UNICEF, 2012). However, there were still some challenges in the access to safe drinking water (Clasen, 2012; UN Millennium Project, 2005). Severalscholars have argued that the way progress was measured, did not fully address water quality and access which are the key components to the water target and fundamental to human health (Clasen, 2012; Rabies & Curtis, 2006; Ejemot *et al.,* 2008; Pickering &David, 2012). It has also been observed that the claim by the UN that it had reduced by half the number of people accessing unsafe drinking water was met with some disparities (De Albuquerque, 2012). There were some areas of the world enjoying improved water services whereas a lot more others could not (The PLOS Medicine Editors, 2009). In the same year that UN claimed to have met the target, there were still over 780 million people that were still unable to access clean water most of who were from the sub-Saharan Africa and Oceania (WHO/UNICEF, 2015).

Only 61% of the people in the sub-Saharan region gained access to improved water sources most of who were in the urban area, making it difficult to meet the (MDGs) of ensuring (environmental sustainability, improving health and eradicating extreme poverty of the rural majority living in the developing world (United Nations, 2005; WHO/UNICEF, 2012).To this effect in 2015, the UN developing agenda introduced Sustainable Development Goals (SDGs) to replace the MDGs in order to eradicate the discrimination and inequalities still existing in rural water supply that was inadequately addressed by the MDGs (UNDESA, 2018). The SDGs' focus is on achieving universal and equitable access to safe and affordable water to all including the management of rural water supply by the year 2030 (WHO, 2017).

2.4 Rural Water Supply

2.4.1Definition of rural area

There are a number of ways of defining rural areas. One of the ways is the use of population density. Using this approach, rural areas are defined as those areas with lower populations than urban areas (Satterthwaite & Tacoli, 2003). A rural area is also characterized by dispersed patterns of settlement exhibiting a mix of small towns, rural growth points, villages and hamlets (Moriarity, *et al.,* 2013). The use of service provision criterionis another way in which a rural area is defined. Using this approach, a rural area is defined as the area not expected to be served by the main service provider in charge of urban areas (Aguasan workshop, 2008). Going by these definitions, ADUS water scheme is located in one of the rural areas in Malawi; Malosa in zomba district. In general, rural areas play a vital role in the economic growth of many countries.

It is projected that over and above half of the sub-Saharan Africa's population is expected to remain rural in 2050 (UNDESA, 2018).Therefore, poor management of any scheme supplying water to this population will significantly impact on the general socioeconomic status of the nations within the region including Malawi where the study was conducted.Rural water supply can be traced to the declaration of the Decade of Drinking Water Supply and Sanitationby the UN in the 1980swhich aimed at improving public health, spurring economic development and poverty reduction; through the provision of universal access to clean water and sanitation in developing countries (Chowns, 2015; Montgomery *et al.*, 2009).

The decade is also characterised by decentralisation in the water sector with the introduction of the Community Based Management (CBM) model which focused on community ownership of projects including management of water systems (Harvey & Reed, 2007; Baumann & Danert, 2008).

2.4.2 Challenges faced by the rural water supply sector in the delivery of potable water

Poor rural water service delivery is related to several issues. Studies show that most rural areas lag behind in infrastructural development (Montgomery, *et al.,* 2009). It is also a common trend for rural areas to trail behind urban areas in water supply including its management. Studies on water access indicate a progress on drinking water supply by most countries. However, a challenge still remains in the management of water used for domestic purposes in the rural areas of both developed and developing countries (Kayser *et al.,* 2015). The challenge is greater in sub-Saharan Africa (WHO/UNICEF, 2012). In the year 2011, the use of improved sources of drinking water had increased in some parts of the world such as Latin America, Asia and the Caribbeanfrom 62% to 81% in 1990(WHO, 2015). However, a huge gap remained in the sub-Saharan Africa as only 61% of the people gained access to improved water source with the rural areas lagging behind (WHO/UNICEF, 2012).

In 2015 the proportion rose to 91% (WHO, 2015). However, the proportion of the rural population using an improved water source remains substantially lower than in urban areas (Bain, *et al.*, 2014). Furthermore, studies conducted by WHO/UNICEF reported that only 4% of the global urban population uses unimproved sources of drinking-water while 19% of the rural population lacks access to potable water.

This trend in inequality is consistent globally but profound in rural sub-Saharan Africa (WHO/UNICEF, 2015a). In Malawi it was estimated that only 65% of the population had access to safe drinking water of which 85% was in the urban and 15%in the rural areas (Mandowa, 2005). Lack of access to potable water in rural areas has forced people to turn to alternative sources such as; dug wells, unprotected surface water sources such as lakes and rivers and some informal private- vendor or small water systems (Kjellen, 2006). A study conducted in Balaka, a rural area in Malawi showed that people were obtaining drinking water from unsafe sources due to lack of access to safe water (Mkwate, *et al.,* 2016). In rural Africa, groundwater which is also a source of domestic water is reported to be compromised by microbial contamination.

The use of pit latrines which is a common form of sanitation in the region, solid waste disposal and animal droppings pollute groundwater quality in the region (Bello, *et al.*, 2013). In this regard, a study conducted in Mahikeng, South Africa, on the quality of groundwater found physico-chemical and bacteriological contamination (Palamuleni & Akoth, 2015). There is a need therefore, to have a strong management system to effectively manage domestic water in this region. Several factors are responsible for the lack of access to safe drinking water in rural areas. Lack of interest by central and municipal government authorities to provide water to rural areas is one of the factors (Kalulu & Hoko, 2010). It is argued that water providing companies and institutions are less willing to provide potable water to rural areas due to high operational costs as a result of the unfavorable terrain of most rural areas coupled with low population densities.

These high operational costs plus low population densities for targeted populations, does notguarantee cost recovery to the water providers (Adams & Zulu, 2015; Pannu, 2012). Inefficient management in water service delivery by rural water governance institutions is another challenge faced by rural water supply systems. These challenges occur at both global and regional level. It is reported that the UN which is the world's governing water body, is strong in setting priority goalsand guidelines for the global community (Gupta *et al.,* 2013). Nevertheless, it is considered weak in governance frameworks due to the presence of multiple and fragmented institutions (Gupta *et al.,* 2013). Consequently, a policy gap in water governance exists in many countries including some developed nations. For instance, fragmentation of water-related tasks across ministries and agencies was reported in various developed nations (OECD Water Governance Survey, 2010 in Gupta *et al.,* 2013).

The Government of Malawi has succeeded putting in place institutions for water governance as is the case with most African countries {Table 1} (GoM, 2012). Nevertheless, Oates and Mwathunga (2018) concur with Gupta *et al.*, (2013) by stating that the existence of incoherent policies and regulations in water governance has a negative effect on the management of potable water to rural areas of Malawi. Additionally, they state that there are no well-defined roles and responsibilities for water service delivery in the country. It is often unclear as to which department within the ministry is accountable for what, or to whom. This scenario has resulted into a weak regulation and monitoring system of water resources in the country. A study conducted on water quality governance in Brazil, Ecuador, and Malawi substantiates the findings by Oates and Mwathunga, (2018); and Gupta *et al.*, (2013).

The study identified similar challenges namely: insufficient data sharingand coordination between government offices, lack of monitoring andenforcement of water quality laws and unclear federal policies for surveillanceof water quality among other findings (Kayser et al., 2015).Financial challenge is another factor crippling management of the rural water sector in both developed and developing nations. Unstable or insufficient revenue undermines effective implementation of water responsibilities and policies in many countries (Gupta *et al.*, 2013). Globally, Malawi is ranked as one of the least developed countries in the world. The country's poor socio-economic status negatively affects the country's water sector infrastructural development (Ferguson & Mulwafu, 2004).

Further to this, scholars on water governance in Malawi have noted that the Ministry of Agriculture, Irrigation and Water Development (MoIWD) has limited direct control over the devolution of finances and functions to districts (Oates & Mwathunga, 2018). As a result, the ministry has inadequate resources for its functionality and little influence on decision-making on issues pertaining to performance.Additionally, the water sector in most countries of the world, Malawi inclusive, experience shortage of well-developed human resource capacity compared toother sectors (Gupta*et al.*, 2013; Oates & Mwathunga, 2018). In Malawi, the gap is partially filled by development partners who supplement government efforts in terms of human and financial support (Ferguson & Mulwafu, 2004). The country has also adopted the use of area mechanicsas part of service delivery to address the gap between Water Point Committees and Water Monitoring Assistants so as to improve the maintenance and sustainability of water points.

However, these efforts have managed to solve challenges existing in community managed water points established by the government under WUA and not in small-scale private water schemes which are beyond its jurisdiction. As a result, small-scale privately owned water schemes are denied the opportunity of their operations being monitored by MoIWD; a scenario which has the potential to affect the effectiveness of these water schemes in supplying potable water to their beneficiaries.

Table 1 Formal institutions for Rural Water Governance in Malawi

INSTITUTION	RESPONSIBILITIES
The central and Local Government (Ministry of Irrigation, water and development).	Policy making, monitoring, assessment, planning, development and coordination of rural water supply and sanitation services. .
WATER BOARDS	Planning. Development and coordination of water supply and sanitation services in the country.
PRIVATE SECTOR such as NGOs	Water supply to rural areas.

Source: GoM, 2012

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2.5 Privately owned Rural Water Schemes (PRWSs)

In developed countries, a larger portion of the rural population gets its drinking water from private water schemes also referred to as 'private water supplies'. These water schemes have been classified into; small and very small water supplies (Hunter *et al.,* 2011). According to Hunter *et al.,* (2011) small water supplies are those water facilities that provide water to not less than 5000 people while very small water supply systems are those water facilities that supply drinking water to less than 50 consumers. ADUS Water scheme is an example of a small rural water supplier in Malawi. The main source of the water in private water supply schemes is groundwater. In developing countries privately owned rural water schemes are scarce due to financial costs that are incurred in the operations of the facilities (Kalulu & Hoko, 2010).Despite this, POWSs are still part of rural water service delivery. However, their role varies in space. This probably relate to variations in management models governing rural water supply.

2.6Rural Water Supply Management Models

A difference exists between urban and rural water supply systems. Urban water supply usually relies on piped networks whereas rural water supply system is drawn from a range of technologies. The technologies are categorised into; boreholes fitted with hand pumps, wells and small piped networks relying on ground or surface water (UNICEF/WHO Joint Monitoring Programme, 2015a). There are also various situations governing access to water resources in rural areas which dictate the type and performance of management models to be followed. As a result, four main models in rural water governance have been identified.

These include; the community management approach (CMA), the municipal management approach (MMA), the delegated management approach (DMA) and the privately owned management approach (POMA) (Aguasan workshop, 2008). This review examines three of them (the CMA, DMA, and POMA) on how they affect the management of privately owned rural water schemes.

2.6.1 The Community Management Approach (CMA)

The 1990s saw a reform in the management of the rural water sector (Chowns, 2015). This resulted into many countries adopting various policies and strategies to ensure a sustainable rural water supply system (Black, 1998; Harvey & Reed, 2004). One of the strategies that were introduced by low-income countries was the replacement of state-led centralised service provision with decentralised community management approach (Harvey & Reed, 2006; Lockwood & Smith, 2011; Nicol *et al.*, 2012). The aim was to have an improvement on technical and financial performance in the rural water sector following the introduction of the International Decade of Drinking Water Supply and Sanitation in the 1980s (Schouten & Moriarity, 2003; Chowns, 2015). The idea behind the adoption of the community management approach was that communities should have a sense of ownership over their water supply systems by participating in the operation and maintenance of the supply systems unlike with the state-led centralised service delivery system (Schouten & Moriarty, 2003; Moriarty *et al.*, 2013).

Under this approach, infrastructure for the delivery of potable water is delivered through community-managed water points in a form of; bore holes with hand pumps, protected springs and piped gravity-fed systems (UNICEF/WHO Joint Monitoring Programme, 2015a).A water point committee comprising of a small group of villagers (usually 6 -10) is elected by the community to oversee the operations of a water point (Chowns, 2015). However, the state plays a role of facilitating the installation of new water points directly or indirectly through development partners. It also provides support to committees where necessary (Schouten and Moriarty 2003). It has been argued that CMA has been successful in ensuring the sustainability of water supply facilities (Lockwood, 2004; Quin *et al.,* 2010) despite having some shortfalls such asinformality of the system and voluntarism (Hutchings, 2015).

Following the introduction of CMA, over 25% of the global population gained access to potable water between 1995 and 2010 (WHO and UNICEF, 2012). Despite the CMA being the most widely used model in Rural Water Supply (RWS), it leaves some gaps in the management of rural water schemes that are privately owned due to the fact that the set-up is different. In view of this, POWS in rural areas require a different approach from the widely used CMA in the management of rural and peri - urban water supply.

2.6.2The Privately owned Management Approach (POMA)

In this kind of model, a private investor decides to build and operate a water point or small piped water network to serve a neighbourhood that does not have access to any kind of water supply (Aguasan workshop, 2008).

These private investments can occur spontaneously or as a result of government's intervention in areas where it cannot provide the required water services. Privately owned management models are also applicable in peri-urban contexts, where they offer an alternative service to the main service water provider (Mehta, *et al.,* 2007). Under this approach, both the supply and management of the water are in the hands of the owner of the water scheme. Regulating bodies such as the central government of municipal councils are not involved in the operation of the water schemes. Thus their management may not be regulated by legislated policy. Consequently, the service delivery of POMAs is likely to be compromised. It has been argued that private drinking water supplies are often associated with microbial contamination due to financial challenges which affect the operations of such facilities.

To this extent, a number of small water scheme lack facilities of a conventional water scheme. *Escherichia coli* and human enteric pathogens are some of the common microbial contaminants predominant in these water schemes (Charrois, 2010). Microbial contamination occurs as a result of changes in seasonality and rainfall patterns as well as infrequent monitoring of drinking water sources (Charrois, 2010). Mehta, *et al*., (2017) observed that resistance from formal public utilities, lack of legal status or tenure, and failure to provide regulated services in terms of price and qualityare other factors affecting the service delivery of small-scale private drinking water supplies. The absence of a governing authority (the central government or local council) responsible for the regulation of drinking water laws, further compromises efficiency in the management of most private water schemes. The result of which is the frequent outbreak of microbial contamination in these water schemes (Charrois, 2010).

However, this problem cannot be generalised to all privately owned schemes because rural water governance varies across sites (Aguasan workshop, 2008). In order to address access challenge, it is therefore important to understand how this operates at specific localities. Gaps remain in our understanding on how POWSs operate in many specific localities of the sub-Saharan Africa in the achievement of acceptability and quality standards for drinking water.

2.6.3 The Delegated Management Approach (DMA)

This kind of model involves different forms and levels of management delegation. The model involves partnership which is usually in form of a contract between the owner of a water system (the delegating authority) and a privately managed entity (Aguasan workshop, 2008). The owner of the water system in most cases comprises of the central or municipal government or a Water User Association (WUA). The contract often stipulates the allocation of responsibilities between the delegating authority and the operator. It is argued that this kind of management model has been effective in the case of small towns and piped networks. This is because it takes advantage of the capacity of the private sector to boost access and manage services in a dynamic way. A good example of this model is the Mauritanian RWS.

2.7 The role of people's perceptions and acceptability in drinking water supply and service delivery

Until the early 1990s water quality standards were the only accepted form of scientific yardstick (Fawell & Miller, 1992). It has been however discovered that the society as a whole has a role to play in the judgment of safetyor what is to be considered as an acceptable level of risk in any particular time (WHO, 2004; DEFRA, 2005 in Doria, 2010). A combination of different factors, including changes in the social role of science contributed to the emergence of the general public as an important player in water management (Doria, 2010). It is in this context that some authors suggested the inclusion of perception especially when it comes to the quality of drinking water (Sheat, 1992 in Doria, 2010). Public perception on drinking water should have standards based on the protection of human health and consumeracceptability (IWA, 2004).

Studying public perception on drinking water quality is crucial for the management of water resources, generation of water quality standards as well as surveillance of the drinking-water quality (Ochoo *et al.,* 2017). Such studies are rare in the sub-Saharan Africa especially for privately owned schemes. The WHO recognizes the importance of public participation in the surveillance of drinking water quality. This is because the public being the primary beneficiary of clean and safe water supplies is the first to experience the consequencesof deteriorating water quality (WHO, 2011).

Ignoring suchperceptions can lead to public discontentment and implementation problemswhereas, a better understanding of the processes involved in public perception of water quality, may help to improve consumer satisfaction, promote cooperation and prevent conflict between the users and water service providers (Barraque, 2003; Doria, 2010).Public perceptions of risks related to water quality also play a greater role in influencing health-seeking behaviour and practices (Slagle *et al.*, 2015). This may involve avoiding the use of contaminated drinking water points. The role of perception in drinking water is very important because it is influenced by the same cognitive-emotive processes that affect risk perception in general, one of which is aesthetic appeal (Doria, 2010; Doria *et al.*, 2005; Haylamicheal & Moges, 2012). The attributes that are of great concern by the public in determining drinking water quality include; taste, odour, colour and turbidity. These factors determine service satisfaction, willingness to pay and the selection of water sources (Warren, 1996; Jardine *et al.*, 1999). It is with this background that the study explored perceptions of ADUS water users.

2.8 Water Quality Parameters

Water quality and the risk to waterborne diseases are critical public health concerns in many developing countriesincluding Malawi (Mwendera, 2006; Haylamicheal & Moges, 2012). The effect is even greater in most rural water supply schemes (Brikke, 2002; Schouten & Moriarty, 2003). It has been found that about 80% of diseases are directly or in directly connectedto contaminated water sources (Adebayo et al., 2011; Sadallah& Al-Najar, 2015). Ensuring good quality drinking water is not only a basic factor in guaranteeing public health but also the protection of the environment and for sustainable development (Rajini *et al.*, 2010).

Ideally, water for domestic purposes should be free from any organisms, tasteless and colourless (Pavendan *et al.,* 2011). However, water is not always found pure (Sasikaran *et al.,* 2012). Faecal material, agricultural runoff, domestic and industrial sewage are some of the pollutants of natural water (Madema *et al.,* 2003; Geldreich, 1990). Physical, chemical and biological parameters are used to determine the safety of water for domestic use (Karn & Harada, 2002). Chemical and biological parameters are mostly established through field or laboratory tests whereas physical parameters such as colour, taste and odour are determined by the general public through their own sensory evaluations (Thoradeniya & Bulathsinhala, 2015). The physical, chemical and microbiological parameters that are often tested include; temperature, pH value, electrical conductivity, turbidity, nitrate and calcium content, as well aspresence of *total coli form* and *E-coli* (Palamuleni & Akoth, 2015;Wedgeworth *et al.,* 2014; Sasikaran *et al.,* 2012).Of recent, the chemical quality of drinking water has deterioratedconsiderably.

Studies show that quality has been greatly compromised due to the presence of toxic elements from water pollution andinefficient water quality management strained by increased population demand for potable water (Ikem *et al.,* 2002). WHO has permitted countries to establish drinking water standards based on the maximum permissible levels of different constituents (Sasikaran *et al.,* 2012). The standards vary from one country to another but the objective is to reduce the possibility of spreading waterborne diseases (Edama *et al.,* 2001). To this effect, Malawi follows drinking water quality guidelines based on WHO and Malawi Bureau of Standards (MBS) guidelines (Chidya *et al.,* 2019).

2.8.1Microbial contamination in drinking water

It has been observed that alarge portion of the population in developing countries suffers from health problems associated with scarcity of potable water due to the presence of microbiological contamination (Kanth *et al.,* 2018; Pal *et al.,* 2018). Microbial contamination through human or animal excreta, particularly faeces happens to be the most common and widespread health risk associated with drinking water (WHO, 2017). It is therefore, recommended that where resources are not enough for water quality treatment, microbial treatment should be prioritised over physico - chemical treatment (Bharti & Katyal, 2011; WHO, 1996). It is argued that the health risks due to toxic chemicals in drinking water differ from that caused by microbiological contaminants. Physico-chemical parameters can only lead to acute health problems through massive accidental contamination of water supply sources or after consuming such type of contaminated water for a longer period of time unlike those associated with microbial contamination whose effects are rapid (WHO, 1996;Talebi & Safigholi, 2007).

Furthermore, in the eventuality of massive accidental contamination of water supply sources by physico-chemical parameters, the water becomes unacceptable to the users due to a change in the taste, odour, and appearance of the water. In this case; users can easily tell that the water's quality has been compromised unlike in the case of microbial contamination (WHO, 1996). Faecal contamination of drinking water by animals or human beings may introduce a variety of intestinal pathogens such as *Salmonella*, *Shigella*, *Vibrio cholera* and *E. coli* (Choudhury*et al.,* 2016; Smruti & Sanjeeda, 2012).

These pathogens may cause diseases such as; dysentery, diarrhoea, cholera, typhoid, hepatitis, giardiasis and varieties of other bacterial as well as fungal, viral, and parasitic infection (Nwachukwu& Ume, 2013; Wanda, 2006 in Choudhury *et al.*, 2016; Crown, 1986).In view of this, potable water is tested for the presence of organisms such as *coli forms*, *Escherichia coli*and*Pseudomonas aeruginosa*that are very commonly found in the human or animal gut (Choudhury*et al.,* 2016).According to U. S. Environmental Protection Agency (EPA), the presence of such organisms in drinking water is a good indicator for evaluating water quality in terms of faecal pollution in water sources (Choudhury *et al.,* 2016). WHO/UNICEF (2015) presents national estimates on water quality which are averaged. Disaggregated by source at tiny scale that is, informal-privately owned water schemes help in understanding the contribution of privately owned schemes in the provision of safe water. However, such studies are limited in developing countries especially in sub-Saharan Africa.

2.8.2 Microbial Water Quality Analysis

There are standard operating procedures and protocols that need to be observed in determining the level of microbial contamination in drinking water. The standard procedures are applied during water sample collection, transportation and microbial analysis in the laboratory to avoid cross contamination and alteration of the water samples (MBS, 2002; APHA, 2011). In accordance with the standard guidelines; the wearing of gloves, surgical mask and the use of sterile collecting bottles are a must in water sample collection to avoid cross contamination of the water samples (Sanders, 2012).Sterile125 or 150 ml plastic specimen bottles are recommended for water sample collection. The specimen bottles should be rinsed thrice on site with the sampled water from the sources.

Furthermore, water samples should be collected in triplicate, from the selected points aseptically and bottled in sterile specimen bottles to the volume of about 100 mlto ensure an adequate representation of the specimen.Caremust be taken when collecting the samples to avoid contaminating the sterile bottle or its cap.Once the samples have been collected, theyshould be labelled and placed immediatelyin a cooler at a temperature of 1 - 4°C with ice for delivery to a reputable laboratory for Microbiological Water Quality Analysis within a period of 24 hours(U.S. EPA, 2013; APHA, 2011; Pillai, 2009).The spread plate method and the membrane filter method are some of the procedures that are employed in determining microbial contamination in drinking water (WHO, 2011; Senior, 2007).

In order to isolate bacteria from the water samples, serial dilution of the sample is made in sterile water which is then cultivated in triplicate on nutrient agar such as the m-endo agar les (MEA), the plate count agar (PCA) and the MacConkey agar. The plate count agar (PCA) is used for determining a general count whereas the MacConkey agar is for the detection of Gram - negative bacteria count such as *E. coli* in water samples (Pant *et al.,* 2016; Adogo *et al.,* 2016; Atlas, 2010).The nutrients usually include reagents that resist the growth of non-target organisms and make the target organism to become easily identifiable, mostly by a colour change in the medium (Fawole, 2001; Burnett, 2001).The samples are thenincubatedin a petri dishat around37 °C for 24 hours under aerobic conditions (Aditi *et al.,* 2017; Fawole, 2001; Burnett, 2001). After incubation, bacterial isolates can be identified through colony morphology, Gram's staining, and biochemical properties (Pant, 2016). The bacterial colonies are then enumerated and expressed in colony forming units {cfu/ml} (APHA, 2011).

2.9Summary

This review has discussed the importance of understanding people's perceptions and acceptability in determining the quality of drinking water in accordance to World Health Organisation. The perception of water users in determining the quality of drinking water is very important because water users have a responsibility to assess the quality of the water they are using. As such, water users' perception becomes a tool that can be used in assessing the effectiveness of any water scheme. However, studies analysing drinking water acceptability and water quality in rural privately owned schemes are limited in sub-Saharan Africa. The chapter has also looked at theoretical frameworks that can help in understanding how institutions and policies affect the delivery of drinking water supplied by private investors. Finally, the chapter has also reviewed literature on water quality parameters with emphasis on microbial contamination in that health effects of using microbial contaminated water sources for household use has been discussed as well as the procedures for analysing microbial water quality.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this chapter, the study design, place, population as well as the sample size and sampling technique have been described. In addition, conceptual framework, methodsas well as instrumentsthat were used in collecting and analysing data are discussed. Ethical procedures that were followed in collecting the data have also been described. Following the introduction, section 3.2 describes the research design, while section 3.3 describes location of the study; the procedure for microbial water quality analysis is described in section 3.4. Section 3.5 describe how sample size and sampling techniques for the study were determined while sections 3.6 and 3.7 describe how the study handled ethical issues pertaining to the study as well as the limitations that were encountered during the study respectively. The chapter ends with section 3.8 which is a summary of the chapter.

3.2Research design

The study took a case study design. Literature has shown that case study design can be used in both qualitative and quantitative research methods (Starman, 2013).This studyalso took amixed research approach employing both qualitative and quantitative research methodsconcurrently to assess the role of the private sector in the delivery of drinking water to rural areas using case study of ADUS water scheme.

Quantitative research methods were used to analysestudy objectives which had numerical data whereas; qualitative research methods were used in analysing objectives which had non-numerical data. To this effect, specific objectives 1 and 2 were analysed using both the qualitative and quantitative approach because they yielded both qualitative and quantitative data. Objective number 3 was analysed using quantitative approach only as it was purely numerical in nature.In addition, quantitative research methods were also used in the study to validatequalitative results thereby generating comprehensive and reliable results (Hennink et al., 2011). In this regard, the Pearson's Chi-square test was conducted to validate data on people's perceptions. Qualitative research methods included; focus group discussion, observations, and bench/desk review.

Quantitative research method involved one-on-one interview using a structured questionnaire. Figure 1 depicts a schematic view of the methodological approach adopted by the study. The schematic view of the study shows the pattern or direction which the study followed to come up with the results, from which conclusions were drawn. Different methods of data collection and analysis were employed on each research objective that was formulated in order to adequately address the research topic. From the analysis, the study results were obtained and discussed. Thereafter, conclusions and recommendations were drawn.

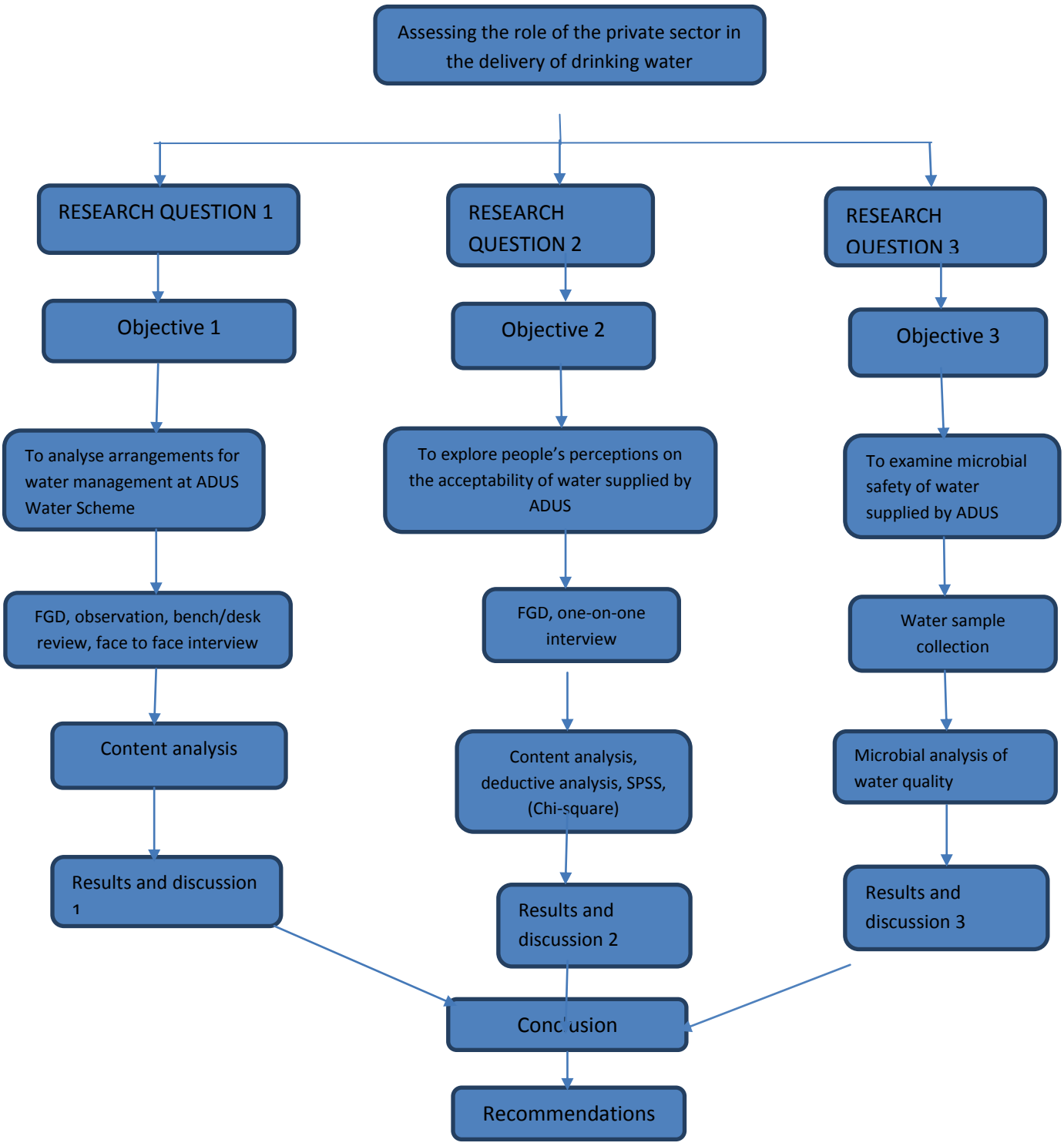

Figure 1: Schematic view of the methodological approach

Source: Study design (2018)

3.3 Study Location

The research was conducted at the Anglican Diocese of Upper shire (ADUS) Water Scheme catchment area in Malosa - Zomba District, in Southern Malawi (figure 2). The water scheme has a dam built on Likwenu River in the Malosa forest reserve.

The dam which was constructed in the early 1970s for hydroelectricity purposes has a capacity of about 230m^3. The scheme provides water to the following institutions: St Luke's College of Nursing, Anglican Diocese of Upper Shire headquarters, Malosa Secondary School, Chilema Ecumenical Lay Training Centre, St Luke's Hospital, Likwenu Primary School, Nsanjama Primary School and the surrounding villages, which include:Mndecha, Chipire, Malunga, Mtambo and Jauma (fig. 2).In total, the scheme provides water to a population of about 5000 people (ADUS, 2011).

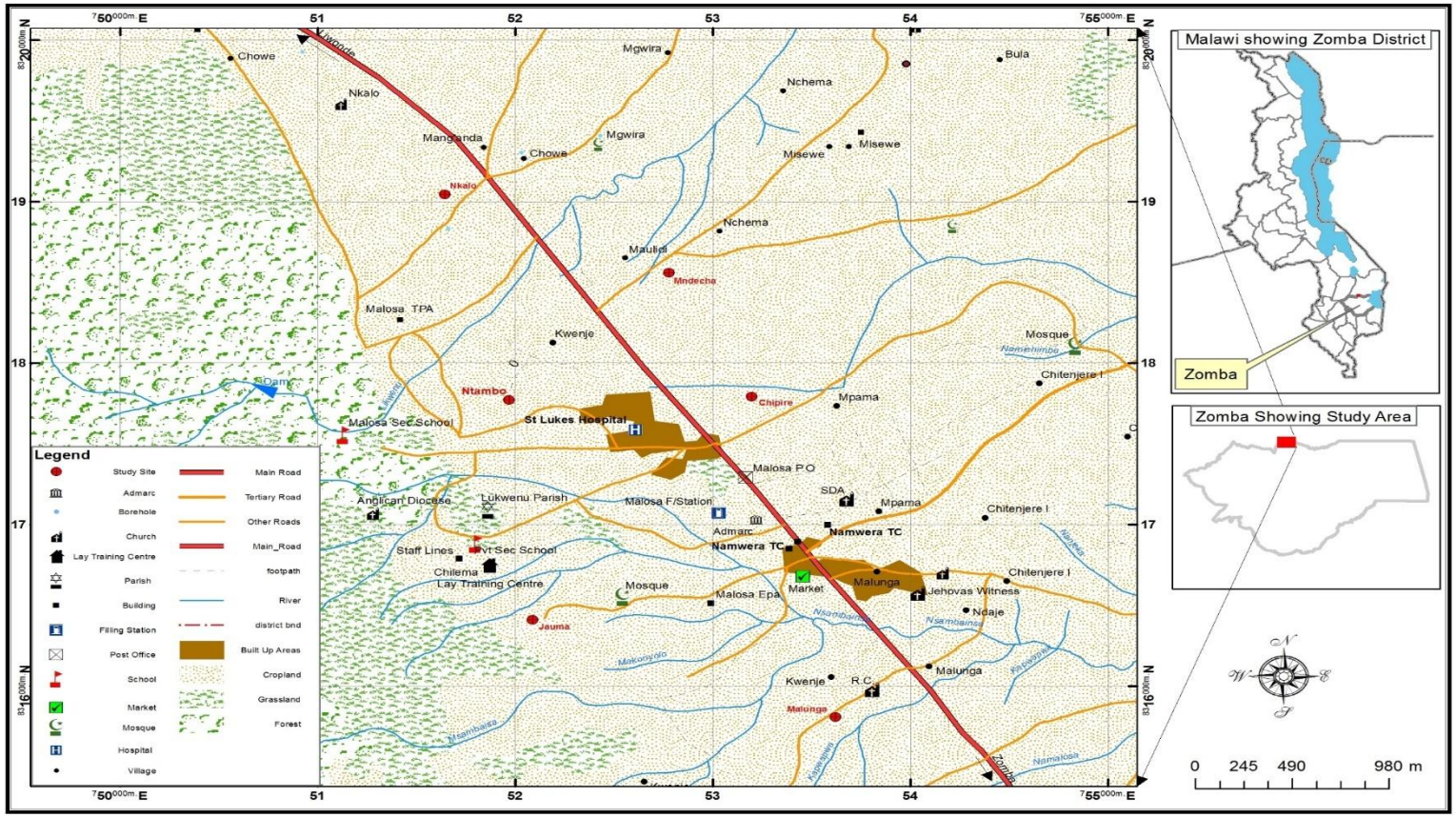

Figure2: Map showing catchment area of ADUS Water Scheme in Malosa, Zomba district of Malawi

Source: Survey data collection (2018)

Picture a: Water source(Likwenu River)

Picture b: Collection Dam

Picture c: Chlorination Tank

Figure 3: Pictures a to c are some of the units of ADUS water scheme

Source: survey data collection (2018)

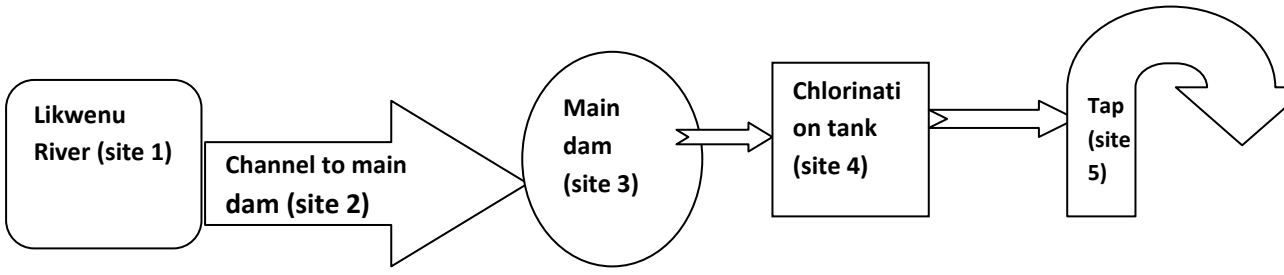

Figure 4: Diagrammatic presentation of ADUS Water Scheme

Source: survey data collection (2018)

3.4Microbial water quality analysis

3.4.1 Data collection and Analysis

In order to analyse the safety of water supplied by ADUS Water Scheme for domestic usein terms of microbial contamination, water sampleswere strategically collected in from the five points in the water distribution system of the scheme in order to identify at what point in the distribution system, microbial contamination may take place(fig. 5).Water samples were collected from the selected points twice, in the dry season and rainy seasons in order to compare the extent of microbial contamination in the two seasons.Standard procedures in accordance to the U.S. EPA, 2016; Sanders, 2012) were followed during water sample collection, preservation and transportation, to prevent cross contamination and degradation of the samples so as to ensure quality control. In line with this, water samples were collected in duplicate, gloves, surgical maskand sterile bottles were used during water sample collection. The samples were then bottled in sterile specimen cups to a volume of 40ml to ensure that there was an adequate representation of the specimen. The specimen cups were rinsedthrice on site with the sampled water from the sources.The water samples were then placed in cooler boxes maintained at 4 °C with ice packs.Collected samples from the sites were then immediately transported to the microbiology laboratory, University of Malawi, Chancellor College for subsequent microbial analysis.

3.4.2 Dilutions

This part of the procedure was conducted in a sterile lamina air flow in the microbiology laboratory to prevent microbial contamination of the water samples (Sanders, 2012; Staneck& Roberts, 1974; Ogilvie & Jones, 1971). Field samples were vortexed using a vortex mixer prior to sub sampling.

A subsample was then drawn from the 40 ml field sample using sterile pipette tips. Precisely, 100µl of the water was drawn using a pipette, and poured into a sterile test tube containing 900µl of sterile water. The test tube was labelled, and contents mixed thoroughly and 100µl of the mixture was drawn from the test tube and poured into a second sterile test tube containing 900µl of sterile water. The procedure was repeated to create five-fold serial dilution for each sample in a progressive manner (Standard Analytical Procedures for Water Analysis, 1999).

3.4.3 Bacterial Load

The prepared water subsamples were then mixed with ringer solution double strength and left at room temperature for 2 hours prior to plating on various culture media. Counting the total number of microbes in the water was done using total viable counts (IS 1622: 1981; Chauhan *et al.*,2017). The 1^{st}, 3^{rd} and 5^{th} dilutions were picked using stratified sampling and were plated on sterilized nutrient media. The nutrient media used for this study were nutrient agar, VRBA, and Endo-Agar Base prepared with fuchsin. During plating, 500µl of the various dilutions were drawn using a pipette and were poured on triplicate plates for all the nutrient media(Pant *et al.,* 2016; Adogo *et al.,* 2016; Atlas, 2010).Sterile swabs were used to make streaks in the petri plates.

The plates were then incubated at 37^{o}C for 24hrs after which individual colonies were counted in each Petri dish (Aditi *et al.,* 2017; Fawole, 2001; Burnett, 2001). Isolates were then grouped based on morphological and biochemical characterization. The process of biochemical characterisation involved inoculation of test tubes containing nutrient broth of lactose with water samples as described by Cowan and Steel's Manual for the identification of Medical Bacteria.

Representative isolates were then sub-cultured for sub-sequent western blotting to confirm microbial identities (Pant, 2016; IS: 5887 {part -1}, Reaff. 2005). The results were compared with the Malawi Bureau of Standards (MBS) and WHO guidelines for water quality.

3.5ADUS water users' perceptions

3.5.1Samplesize andSampling techniques

The study used a sample size of 103 (42 males and 61 female) respondents. These respondents were 98 ADUS water users and five key informants namely: two technicians and the water scheme committee chairperson from ADUS, an engineer from Southern Region Water Board and the District Water Officer for Zomba. The study's sample size was determined through the use of published tables and the application of formulas (Israel, 1992). The study used a published table according to Yamane (1967:886). The value on the table was verified mathematically using a formula by the same author.

A Simplified Formula for Proportions

$$n = \frac{N}{1 + N(e)^2} = \frac{5000}{1 + 5000\,(0.1)^2} = 98$$

Where n is the sample size, N is the population size and e is the level of precision (Yamane, 1967).To arrive at the sample size (n) of 98 ADUS water users; the population size (N) of ADUS Water Scheme which is at 5000 is calculated at 10% level of precision (e).

3.5.1.1 Sampling techniques

Three sampling methods were used to identify sample subjects during the study. These sampling methods are systematic stratified sampling, random sampling and purposive sampling.

Systematic stratified sampling and random sampling

Systematic stratified sampling method was used to select subjects (males and females aged from 18 to 57) into the study. This age range was chosen on purpose in order to capture the views of both the young and elderly water users on the quality of water supplied by ADUS. In addition, the age range was chosen because it is a productive age group (GoM, 2017) and it is frequently involved in domestic chores which mostly require the use of water. The participants came from ADUS water catchment area namely: St. Luke's Nursing College,St. Luke's Hospital and Malosa Secondary School and the three surrounding villages namely: Malunga, Mtambo and Chipire. Thereafter, the study participants were pre-sorted into two age groups: youths (18-35 years) and adults (36-57 years) in accordance with the African youth charter (African Union, 2006). The study used systematic stratified sampling method in order to come up with a representative sample size (Habib, 2014). Thereafter; Simple random sampling method was employed to select respondents from the two strata into the sample. This resulted into a sample size of 98 water users.

Purposive sampling

Purposive sampling was used during the study to identify key informants. Purposive sampling was chosen because the population was too small for a random sample (Gentles, *et al.,* 2015). To this extent, five key informants participated in the study.

Purposive sampling method also helps to involve participants who have had relevant experiences into the study based on the researcher's judgment (Moule& Goodman 2014; Sandelowski, 2000). This knowledge therefore, guided the researcher to recruit only those participants with targeted traits. In the case of this study, the desired targeted trait wasthe knowledge in the management and supervision of the dam.

3.5.2Data collection methods

The data was collected through focus group discussion (FGD) and face-to-face interviews. Sixteen people participated through FGD (6 females and 10 males). The participants for the FGD were purposively sampled from the 5 institutions of ADUS water scheme. Two participants were drawn from the 8 strata that were formed using a 5-year age interval of the study's productive age group. The reason was to ensure a good representation of the participants' responses (the youth as well as the elderly).Eighty - two people (27 males and 55 females) participated through one to one interview using a structured interview guide. Self-administered questionnaires were employed to collect data from key informants: three ADUS water scheme workers, the District Water Officer and the SRWB engineer.

Areas of focus during the FGD and face-to-face interviews with water users covered areas of acceptability where ADUS water users were interviewed to give their opinions on how they perceive the quality of water supplied by ADUS. The areas of acceptability focused on colour, taste and odour. ADUS water users were sampled from 3 ADUS institutions namely: Malosa Secondary School, St. Luke's College of Nursing and ST. Luke's Hospital and the villages of Chipire, Malunga and Mtambo. FGD was audio-recorded, transcribed and translated into English and then analysed.

ADUS Water Scheme employees were interviewed to obtain information on factors affecting water quality at the institution.An engineer from Southern Region Water Board and the District Water Officer for Zomba district were interviewed as controlling officers of the water scheme. In order to improve the quality of information collected through the research instruments, pre-testing was done at St. Luke's Hospital, to evaluate ability of the instruments to collect desired data. Improvements were then made accordingly. Some questions were modified while few others were removed from the questionnaire. Clients included in the pretesting did not participate in the actual study. As part of ensuring consistency, all data was collected by the researcher herself. Other methods that were employed in generating data in the study included: check list and desk/ bench review methods which were used to obtain secondary data on the operations of the ADUS Water Scheme by going through the reports of the water scheme.

3.5.3 Data management and analysis

Quantitative data was processed and analysed using Microsoft Excel and Statistical Package for Social Sciences (SPSS). Charts and tables were used where necessary to present study findings. SPSS helps to add a visual aspect to quantitative data (Field, 2018). Data that was analysed using SPSS was that which was generated through the one-to-one interview with ADUS water users. The questions were based on acceptability. The researcher wanted to know people's perceptions on ADUS water in terms of colour, taste and as odour. This was done by rating their level of satisfaction and registering the results in percentages. The data was then represented visually through charts and tables using SPSS software tools. Results on people's perception were validated with a significance test (Pearson's Chi square).

To this effect, independent variables such as age, gender, level of education and length of stay were analysed against dependent variable (taste, colour and odour) in terms of level of significance at 0.05 level of confidence. Depending on the outcome of the results, a significant relationship or lack of significant relationship was established basing on the level of significance. Where the values were above 0.05, no significant relationship was established among the variables while a significance level below 0.05 indicated a significant relationship among the variables. A Paired t-test was conducted on microbial results on water samples collected in both the dry and wet season to establish if there was any relationship between the results of these samples based on a 0.05 level of confidence. A deductive approach was used to analyse the qualitative data from the FGD and one-to-one interview.

Themes and sub themes to be analysed in the study had already been identified through literature review. In addition, content analysis was also used to analyse qualitative data in the study. Preference was given to the method because it is one of the best methods for exploring large volumes of documented information (Gbricks2007).In this approach, similar data was then put into same group or category for coding according to Polit and Beck (2010). Data was then transcribed back to Chichewa as a way of testing and ensuring that original content and meanings were not lost. Colaizzi's approach which applies seven steps to analyse data was also used. This method incorporates result validation by re-consulting the study participants (Polit and Beck, 2010). The steps include:

1. Arrangement of field data according to the interviews.
2. Translation of data from Chichewa to English.

3. Summarising data according to themes and then subthemes presented as results.
4. Readingof data several times and coding line by line.
5. Identification of data into distinct units, grouping and re-grouping similar and dissimilar units.
6. Relabeling of categories and validation of the analysed data.
7. Grouping of similar responses together into themes.

3.6Ethical considerations

A permission to conduct the academic research at ADUS Water Scheme was sought from the Committee Chairperson of the water scheme (the Principal of St Luke's College of Nursing). A letter of consent from Chancellor College (appendix 2)was presented to the water scheme chairperson. All key respondents were also informed about the study, its aim as well as its importance prior to the actual exercise. Participants were assured that their views would be treated with confidentiality. In addition, they were also asked to give an informed consent about their participation in the study.

3.7 Limitations of the study

The study faced a few challenges during the fieldwork. The main challenge was lack of financial support since the study had no external funding. This affected the smooth running of the study. There were some instances when the study could almost come to a standstill due to financial challenges. For example, at one point in time, the researcher failed to collect and analyze data in good time because of financial challenges (laboratory costs).

The researcher also experienced some resistance from study participants during data collection because the participants were used to receiving some handouts upon participating in a research. The challenge was overcome by explaining to the participants that the study was an academic one which had no funding. Some participants therefore agreed to participate in the study. Lastly, the officials at ADUS were reluctant at first to release all the information pertaining to the study because they were afraid that it might be used to tarnish the image of the water scheme to the public. The researcher had to explain properly the aim of the study to them and they were eventually cooperative. The death of a key technician in the course of the study was also a big blow to the study. However, the researcher managed to overcome all the challenges.

3.8 Summary

This chapter has presented the methodologies employed in the research. The chapter begins by describing the location of the study area, research design and the schematic view of the methods employed in the study. Then it outlines the methods that were used in collecting and analyzing data for the study. The study used a mixture of qualitative as well as quantitative methods. The data collection methods include: FGD, one-on-one interviews, observation as well as desk review. Content analysis, deductive analysis as well as SPSS and Microsoft Excel are some of the methods that were used to analyzestudy findings. The study usedsystematic stratified sampling method, random sampling as well as purposive sampling to identify study participants. Lastly, the chapter has presented ethical issues as well as the limitations of the study. Chapter four presents the results and discussion of the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings of the study which was conducted to assess the role of the private sector in the delivery of drinking water to rural areas using the case study of the Anglican Diocese of Upper Shire (ADUS) Water Scheme in Zomba District. The study aimed at analysing the institutional arrangements operational at ADUS water scheme in the delivery of safe and acceptable drinking water to its users as advocated by WHO. The study also explored the perceptions of ADUS water users on the water supplied by the water scheme. A microbial water quality test was conducted on water samples collected from the water scheme to validate study findings. The results of the study have been presented by intertwining data and interpretation according to themes and sub-themes to illustrate important points. The chapter has five sections following the introduction. Section 4.2 provides a description of the study's respondent's demographic data. Sections 4.3 and 4.4 provide information on the institutional arrangements for water management at ADUS Water Scheme and respondents' perceptions on the quality of ADUS water respectively. Section 4.5 discusses microbial analysis of ADUS water while section 4.6 presents chapter's summary.

4.2 Respondents demographic data

A total of 103 people participated in the study (42 males and 61 females). Eighty - two (82) people participated through one to one interview, five (key informants), through a self-administered questionnaires and sixteen (16) people participated through FGD. This section presents the demographic data of the respondents that participated through one to one interview. Socioeconomic characteristics of the water users such as gender, age, education and length of stay in the study area of the participants were employed to determine the perceptions of the water users towards the water supplied by the scheme in terms of aesthetic appeal (turbidity/ colour, taste and odour) {Table 2}.

Table 2: Demographic characteristics of ADUS Water Users

Source: Survey Results (2018)

Characteristics of ADUS Water Users	Number of ADUS Water Users	Percentage Representation of Sample
Males	27	33
Females	55	67
Age (18 – 35)	45	55
Age (36 – 57)	37	45
Level of Education (none)	15	18
Level of Education (primary)	22	27
Level of Education (Secondary to Tertiary)	45	55
Length of stay in the study area (0 – 9 years)	17	21
Length of Stay in the Study Area (over 10 years)	65	79
Had used water from Other Sources	74	90
Had used ADUS water only	8	10

The educational level of the participants ranged from none to post graduate. The participants' level of education was classified in order to see if level of education has an effect on the perception of water users. These socioeconomic characteristics have been found to have an effect on consumer's perceptions on safe drinking water (Thoradeniya & Bulathsinhala, 2015; Abedin, Habiba & Shaw, 2014). Age of participants was another independent variable used in this study to explore water users' perceptions on the water supplied by the water scheme. An age range of 18-57 was chosen on purpose in order to capture the views of both the young and elderly water users on the quality of water supplied by ADUS. The age range was chosen because it is a productive age group (GoM, 2017) and it is frequently involved in domestic chores which mostly require the use of water.

The study also wanted to see if there are variations in terms of perception between young and elderly water users. In this regard, age was classified into two brackets. The first bracket was for the youth with age ranges of 18 - 35, and the other age bracket catered for adults, ranging from 36 –57 based on the Youth Charter (African Union, 2006). The period for length of stay of the study participants in the area was another demographic factor that was explored in order to assess the perceptions of the water users'. In order to see if length of stay of the study participants in the study area had any effect, the period of stay in the study area was classified into two: those that had stayed in the study area for a period of 0 years to 9 years and another category of those that had stayed in the study area for a period of over 10 years.

Finally, the study also wanted to see if there is any difference between waters users that had never used water from any other source apart from ADUS and those that have been exposed to other sources of water as regards to their perception on the acceptability of ADUS water in terms of aesthetic appeal. Information from the demographic data reveals that there is a mixture in the patronage of ADUS water in terms of sex, gender, level of education and length of stay in the study area. In terms of gender, the number of female participants in the study was higher (67%) than that of men (33%) {Chi-square = 11.56, df = 1, p = 0.0007} though the sample size was randomly selected. This means that females had an upper hand in terms of giving responses on the acceptability of ADUS water than males. Many scholars have observed that women play a central role in the provision, and management of water considering their substantial involvement in domestic and agricultural responsibility placed on them (Khandker*et al.,* 2019; UNDP, 2006; UN report 1992).

However, not much is understood on this complex relationship between women's lives and access to water (Ray, 2007). Wahaj and Hartl (2007) adds that when it comes to framing policies and programs, women perspectives and roles in water management are also rarely taken into consideration. To this extent, the higher percentage of female respondents in the study has a significant impact.

In terms of level of education, the study found that 55% of the participants had attained secondary school as well as tertiary education whereas 18% and 27% of the respondents had no formal education and primary school education respectively. It was also found that 79% of the respondents regardless of their age, gender and education, they had stayed in the study area for a period of over 10 years. The fact

that majority of the respondents had attained formal education and that they had lived in the study area for a good number of years, gives confidence about the credibility of their responses on the acceptability of the water offered by the water scheme. Similar studies in Sri Lanka and Bangladesh reveals that such socioeconomic characteristics have an effect on consumer's perceptions on safe drinking water (Thoradeniya & Bulathsinhala, 2015; Abedin, Habiba & Shaw, 2014). The fact that all the respondents were 18 years old and above, suggest that the respondents were capable of making informed decisions (GoM, 2017). However, the responses were dominated by the youth (55% against 45% of the adult water users).

4.3 Institutional arrangements for water management at ADUS Water Scheme

The government of Malawi through its decentralisation reforms; recognises the importance of the private sector's contribution in rural water service delivery. The National Water Policy, the Water Resources Bill and the Water Resources Act are some of the government's documents highlighting the types of institutions (and their structures) created by the reforms to facilitate delivery and management of water services, their institutional roles and regulatory arrangements.

For instance, section 6.2.2.11 of the National Water Policy (2005) promotes private sector participation in the delivery of goods and services for rural water supply and sanitation whereas the Water Resources Bill (2012) highlights the institutions with their corresponding roles in ensuring the provision of potable water to rural areas. Precisely the bill states that, the central government through the local government (DWO) is responsible for monitoring, assessment and coordination of rural water supply and sanitation among other functions. The Water Boards have been entrusted

with the role of coordinating water supply and sanitation services in the country including private water schemes. The bill also recognises the responsibility of the private sector in the provision of potable water to rural areas. It is against this background that the first objective of the study was set to examine the arrangements for water management at ADUS Water Scheme as a private institution in line with government efforts.

The study found that ADUS water scheme is a small private rural water scheme according to the definition by Hunter *et al.,* (2011) and is owned by the Anglican Church in the Diocese of Upper Shire. According to literature on formal institutional arrangement for rural water supply in the country, the operations at ADUS water scheme are supposed to be regulated by the local government through the DWO and the Southern Region Water Board (SRWB). An interview with a water quality technician at the water scheme revealed that the water scheme is within the jurisdiction of the SRWB as stipulated in the Water Resources Bill of 2012.

In addition, the study also found that the water scheme also reports to the Ministry of Health through Zomba District Health Office and ST. Luke's hospital; public health unit. However, information collected from ADUS Minutes file of 2011, revealed that the water scheme experiences infrequent and irregular supervision by the two institutions contrary to what is stipulated in the National Water Policy and the Water Resources Bill. An interview with the water scheme's technician and the water quality officer from SRWB corresponds with the information from the minutes file that supervision is irregular and mostly carried out when there is water-borne-outbreak

related to the facility. The diarrheal-out breaks experienced in the catchment's area in 2016 (appendix 1) can be linked to inadequate supervision by the relevant authorities.

The Water Resources Bill has also assigned the responsibility of monitoring, assessing and coordinating the operations of rural water supply schemes to the central government through the local government (DWO). However, an interview with the District Water Officer for Zomba revealed that their office does not render any service to the institution being a private entity as it is not within its jurisdiction. The DWO only supervises public water providing institutions. This is another grey area in the two documents. Related to this, the study found several management challenges at the water scheme which requires financial as well as technical assistance from the government though the DWO. For instance, the study found that ADUS water scheme is unable to employ qualified water quality technicians to manage the water scheme.

One-on-one interview with the water quality technician at the water scheme revealed that the technician had a formal training in water quality which he obtained during a 3 days training at the institution organised by the SRWB. In addition, ADUS also employed a full-time technician whose highest level of academic qualification was a Primary School Leaving Certificate and had a formal training in water quality obtained at Zomba Works Training Centre with a work experience of 42 years. The duties of the technicians include: cleaning of the dam, chlorination of the water as well as the maintenance of the distribution system. Looking at the academic and professional qualifications of the staff members managing the water scheme, it suggests that the staff members may be lacking in important water quality

management skills. In this case, it is very likely to compromise the core function of the scheme which is to supply potable water to its beneficiaries effectively.

Further interview with ADUS water quality technicians revealed that the water scheme lacks several facilities of a conventional water scheme such as screening, coagulation, flocculation and filtration due to financial challenges. The water scheme also lacks an electric chemical pump for dosing (instead they use a 20l bucket to estimate the volume of water for chlorination). An interview with an engineer from SRWB also confirmed the absence of these facilities at the institution. The technicians also reported that the water scheme is trespassed by charcoal burners who often carry out their ablutions in the river (the source of water for the water scheme) due to lack of a fence at the facility.

A water quality test was therefore important to check for faecal contamination in the water supplied by the water scheme. In terms of informal institutional arrangement, the study also found several management challenges as well. The study found that the Water scheme has a Management Committee comprising of representatives from the institutions that are supplied by ADUS water scheme and the operations of the water scheme are coordinated by the Bishop who happens to be the proprietor of the Diocese. Below the Bishop is the chairman of the water scheme (the Principal of St. Luke's College of Nursing), representatives from institutions in the Diocese as well as traditional leaders. Figure 5 shows the structure of ADUS water scheme management committee.

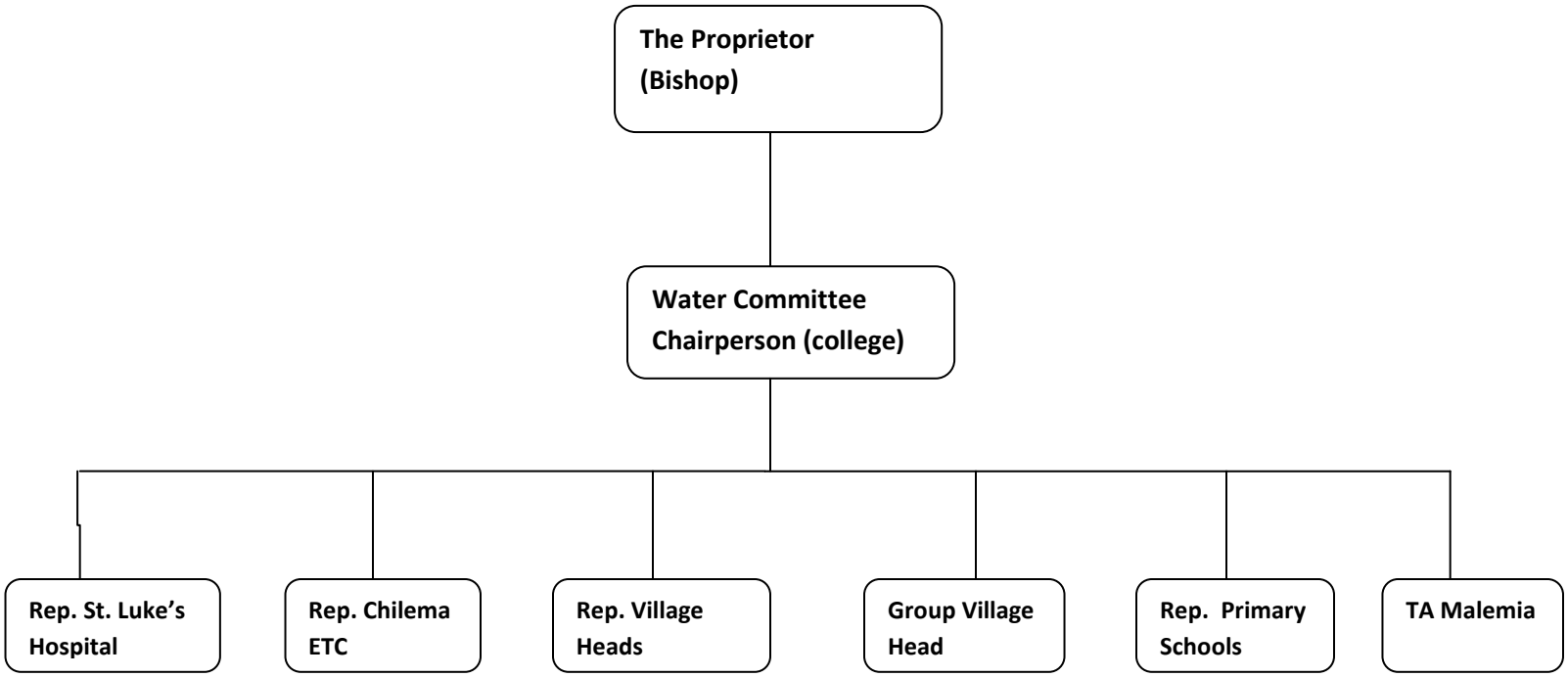

Figure 5: Organogram of ADUS Water Scheme Management Committee

Source: Survey Results (2018)

This kind of set up is in line with the POMA system of rural water supply as stipulated in the Aguasan workshop (2008) where a private investor decides to build and operate a water point or a small piped network to serve a neighborhood that does not have access to any kind of water supply. The study found that despite the water scheme having this informal arrangement in place, the role of most actors in the institution is passive. For instance, an interview with the water committee chair person revealed that despite the water scheme having a Management Committee, decision making and general running of the scheme is controlled by the Bishop of the diocese who is referred to as the proprietor of the institutions in the diocese including the water scheme. The role of the other actors namely: heads of institutions and village heads is often negligible. The study found that the role of the actors in the water scheme is to simply take communications from the proprietor to their subjects and nothing more than that.

Moriarty *et al,* (2013) & Jones *et al,* (2006) validates the study findings that it is a common practice in privately owned water schemes for supply and management of water to be in the hands of the owner of the water scheme. The study findings suggest that such a bureaucratic set up may have some implications. For instance, it could lead to a delay or lack of action from the water providers despite receiving concerns from water users on the quality of their water which then might lead to loss of trust in the safety of the water by the users.

Several scholars have observed that loss of trust in drinking water by the users may discourage them from patronising a facility and cause them to seek for alternatives which may endanger their lives with water borne diseases (Kjellen & Mc Graham, 2006); Karn & Harada, 2002; Haylamicheal & Moges, 2012). The study findings are in line with the literature above. This is what the respondents had to say during the FGD:

> *"the trend in this water scheme has been that the water becomes very dirty towards the end of the dry season (the months of September and October) and throughout the rainy season. The level of sedimentation in the water increases during the rainy season in that the water comes out with a lot of sediments (mud), algae, as well as insects such as tad poles and worms at times. As such, we prefer to use water from the borehole or rain water in the wet season rather than water supplied by ADUS.*

The challenges encountered by ADUS water scheme are in line with the findings of other studies conducted in Kenya, Canada and other parts of the world (Mehta *et al.,* (2007); Charrois, (2010); WHO, (2012), where it was found that PRWSs encounter several operating and management challenges emanating from lack of properly trained personnel, financial constraints and lack of access to expert assistance among others. Mehta *et al* (2007) argues that many governments have for a long time not taken private or small-scale water providers as developmental partners. This is because small-scale water providers have been regarded as short term water suppliers who often offer inferior services.

This could be one of the reasons why the government of Malawi does not render financial support and supervisory role to PRWSs despite the National Water Policy recognising private water investors as developmental partners.Literature shows that there are some countries where the role of PRWS in the delivery of drinking water is being recognized formally by local and central governments. For instance, the Kenyan government has carried out several interventions to assist the small-scale private water providers in the country by partnering with them through a basic legal and regulatory framework (Mehta, et al., 2007). It is reported that the private water providers work with regional water boards which own water service assets to help them gain legal status as companies or associations. Thereafter, they operate as independent service providers under Kenyan law. Consequently, development partners have joined in funding and managing pilot programs that are supporting these small-scale private water providers.

with reference to the study findings on the institutional arrangements for water management at ADUS, this work suggests to the water sector, research and academia community the need to model, improve and/or develop the existing water policy so that it recognizes private water investors in the country as developmental partners by introducing some reforms into the policy like what the Kenyan government has done. The Kenyan RWS has incorporated some elements of the DMA in the management of the rural PRWSs unlike in most parts of the world including Malawi, where they are using the CMA in rural water supply which does not recognise the role of PRWS in its set up.

4.4 Respondents perceptions on quality of ADUS water

In line with the second objective, the study explored people's perceptions on the acceptability of water supplied by the Water Scheme. Several scholars have agreed on the importance of public perception on drinking water quality (Doria et al., 2005; Doria, 2010; Ochoo et al., 2017; Haylamicheal & Moges, 2012). The study explored people's perception on ADUS water in terms of aesthetic appeal (turbidity/ colour, taste and odour) to determine the quality of water supplied by the facility. The results would reflect on how the water scheme manages its water. The questionnaires for collecting this information were designed in such a way that the data on the perceptions of ADUS water users could be analysed in terms of their age, gender, sex, level of education, length of stay in the study area as well as their experience with water supplied by other institutions. The study wanted to find out if these factors had any effect on how ADUS water users perceive the taste, colour and odour of water supplied by the water scheme. The results were validated using Pearson's Chi-square test.

4.4.1 Respondents perceptions on the Taste of water supplied by ADUS water scheme

The study found that the level of satisfaction or dissatisfaction of ADUS water users in terms of their taste on the water supplied by the water scheme did not depend on their age, gender or level of education. According to the Chi-Squared tests, ADUS water users' level of satisfaction or dissatisfaction with the water in terms of taste was not statistically related to their age (Pearson Chi-Square =1.654, df = 2, p = 0.437).

In the same way, there was no relationship between the responses given by the water users based on gender and level of education with the taste of water supplied by the water scheme (Pearson chi-square = 1.305, df = 2, p = 0.521 and Pearson Chi-Square = 9.112, df = 6, p = 0.167 respectively). The participants' level of satisfaction or dissatisfaction was also rated in terms of comparison between ADUS water and water from other sources namely: Water Board, WUA and Borehole water. The results show that there was no relationship between the level of satisfaction with ADUS water and previous use of water from other sources (Pearson Chi-Square = 1.893, df = 2, p = 0.388) {Table 3}.

Table 3: ADUS water users' perceptions on the taste of water supplied by the water scheme

Source: Survey Results (2018)

Variables	**Total (n) = 82 (100)**	**Satisfied n (%) = 58 (70.7)**	**Not satisfied n (%) = 11 (13.4)**	**Very satisfied n (%) =13 (15.9)**	**P – value**
Gender	82 (100)	58 (71)	11 (13)	13 (16)	0.521
Male	27 (32.9)	17 (62)	5 (19)	5 (19)	
Female	55 (67.1)	41 (75)	6 (11)	8 (15)	
Age	82 (100)	58 (71)	11(13)	13 (16)	0.437
18 – 35	45 (55)	30 (67)	8 (18)	7 (16)	
36 – 57	37 (45)	28 (76)	3(8)	6 (16)	
Length of stay	82 (100)	58 (71)	11 (13)	13 (16)	0.024
0 -9 years	17 (20.7)	12 (71)	5 (29)	0 (0)	
10+ years	65 (79.3)	46 (71)	6 (9)	13 (20)	
Level of education	82 (100)	58 (71)	11 (13)	13 (16)	0.167
None	15 (18.3)	9 (60)	4 (27)	2 (13)	
Primary	22 (26.8)	14 (64)	3(14)	5 (23)	
Secondary	27 (32.9)	20 (74)	1(4)	6 (22)	
Tertiary	18 (22)	15 (83)	3 (17)	0 (0)	

Other sources	82 (100)	58 (71)	11(13)	13 (16)	0.388
Yes	74 (90.2)	54 (73)	9 (12)	11 (15)	
No	8 (9.8)	4 (50)	2 (25)	2 (25)	

The fact that the chi-square test could not establish relationship between the socioeconomic indicators of the water users mentioned above and the taste of the water supplied by the institution suggests that their responses on the taste of water supplied by the institution were not determined by those indicators. In other words, their perception on the taste of ADUS water was the same regardless of their socioeconomic background. In general, 71% of respondents across all the independent variables registered satisfaction with ADUS water in terms of taste. Sixteen percent of the respondents indicated that they were very satisfied with the taste of the water whereas 13% of the participants were not satisfied with the water in terms of taste. Those who had no objection with the taste of the water indicated that the water is tasteless and not salty as is the case with borehole water.The small percentage (13%) that had problems with the water indicated that the water has the taste of mud because of poor sedimentation process.

The study also established a statistic relationship between length of stay of the study participants and taste (Pearson Chi-Square = 7.49, df = 2, p = 0.024 (Table 3). This suggests that the perception of ADUS water users in terms of taste is dependent on the period of stay in the study area. To this effect, the respondents that have stayed in the study area for more than 10 years can relate to the taste of the water supplied by the water scheme unlike those who have stayed in the study areas for less than 10 years. Basing on this, it can be concluded that 79 % of the water users have stayed in the study area for over 10 years. Out of this percentage, 91% of the respondents indicated that they had no problems with the taste of water supplied by the water scheme. Even though the results show that there is no relationship between the respondents who have stayed in the study area for a period of less than 10 years and the taste of the water supplied by the water scheme statistically, the results indicate that 71% of the respondents were satisfied with the taste of the water supplied by the water scheme.

In general, it can be concluded that majority of ADUS water users have no problem with the taste of the water regardless of their socioeconomic status basing on the statistics of the study participants as well as from the results generated from the FGD. The respondents from the FGD had this to say:

> *"the taste of ADUS water is very good. It is not salty and hard as water from the borehole. We actually spend more soap when washing clothes using water from the borehole unlike when we are using ADUS water.*
>
> *The taste of ADUS water is even better because the water is cool as it comes from the mountain, unlike in borehole water".*

4.4.2 Respondents perceptions on the Colour of water supplied by ADUS water scheme

The study found that there is no relationship between the perceptions of the respondents on the colour of water supplied by ADUS and their gender having the level of significance (Pearson Chi-Square = .554, df = 2, p = 0.758). Likewise, there was no relationship between the colour of ADUS water and the age of the water users (Pearson Chi-Square = 2.192, df = 2, p = 0.334). The study could not also establish a statistic relationship between the level of education and length of stay of the respondents in the study area and their responses on the colour of the water supplied by the water scheme (Pearson Chi-Square = 7.648,df =6, p = 0.265 and Pearson Chi-Square = 0.829, df = 2, p = 0.661 respectively).

A statistic relationship could not also be established between the respondents' perceptions on the colour of ADUS water and their experience with water from other sources (Pearson Chi-Square = 6.971, df = 6, p = 0.323). The absence of statistic relationship means that the responses of the water users on the colour of water supplied by the institution was not determined by their age, level of education, length of stay nor experience with water from other sources. In other words, their perception on the colour of ADUS water is the same regardless of their socioeconomic background. To this effect, the findings show that majority of the respondents were not satisfied with the colour of ADUS water regardless of their gender, age, level of education, length of stay in the study area as well as exposure to other sources of water.

Figure 6 shows the level of satisfaction with ADUS water in terms of colour. Out of the 82 participants that were interviewed through one-on-one, 10 participants (12.2%) indicated that they were satisfied with the colour of the water, 1 participant (1%) was very satisfied while 71 (87%) were not satisfied with the colour of the water.

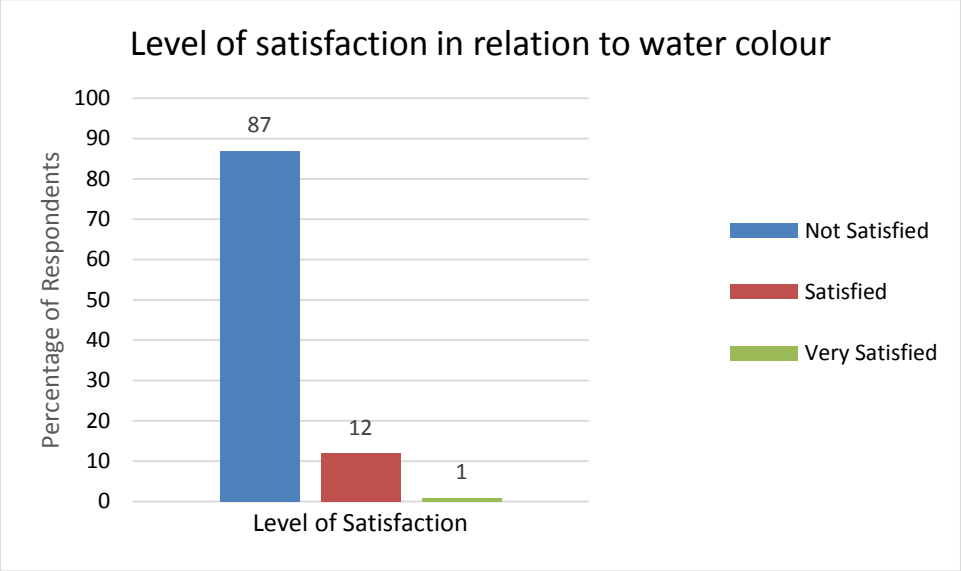

Figure 6: Respondents perceptions on quality of ADUS water in terms of Colour

Source: Survey Results (2018)

The results of the study (as shown in fig.6) indicate that majority of the interviewees across all the independent variables that were interviewed were not satisfied with the water in terms of its colour. They considered the water to be muddy. The main reason put forward by the respondents is that they feel sedimentation process at the water scheme is poor. As a result, the water is dirty (has unappealing colour). Further clarification was obtained through FGD where respondents indicated that:

> *"the water becomes very dirty throughout the rainy season. Towards the end of the dry season, the level of sediments in the water increases.*

During the rainy season the water from the tap comes out with a lot of sediments (mud), algae, as well as living organisms such as tad poles and worms at times".

Among the respondents (12.2%) who reported that they were satisfied with the colour of the water, there were also some who indicated that the water becomes dirty towards the beginning of the rainy season but they had no problems with that because it was just for a short period. The fact that there were some respondents that had not used water from other sources apart from ADUS but they still they were not satisfied with the colour of ADUS water suggests that the water has turbidity problem as water users were able to tell that ADUS water is not aesthetically appealing even without a comparative experience with water from other sources. As a result of being dissatisfied with the quality of water at ADUS, majority of respondents from the FGD stated that:

"we prefer to use water supplied by Water Board and WUA to that of ADUS. The water supplied by the two institutions is cleaner and does not contain impurities like ADUS water. We would love if the management at ADUS would be 'sieving' its water properly".

According to ADUS water quality technician, the water scheme's problem of turbidity is a result of lack of conventional facilities for a water scheme. The fact that the water scheme was initially constructed for HEP generation and not to supply water for human consumption is sufficient rationale why the water scheme was not able to supply potable water.

The fact that 87% of the respondents that were interviewed through one-on-one and through FGD recommended that the institution should improve on the sedimentation process so that the water comes out clean is strong evidence that aesthetically, the water has unappealing colour. Thus many water users do not accept the standard of water provided by the water scheme. Unappealing colour (turbidity) in water is caused by presence of suspended materials in water such as clay, silt, organic and inorganic matter among others; a high turbid measurement in drinking water is usually an indication of inadequate water treatment (Shittu et al., 2008). Turbidity also affects the process of water disinfection. The presence of suspended particles in water shields microorganisms from disinfectants thereby reducing the efficacy of the disinfection process drastically. This leads to an increase in chlorine demand (Le Chevallier, *etal.*,1981). This could also be the case with ADUS water in that higher turbidity levels might have a negative impact on water treatment at some point in time. This could be the reason for intermittent diarrhoeal outbreaks reported prior to this study in 2016 (refer to appendix 1).

Several scholars have observed that loss of trust in drinking water by the users may discourage them from patronising a facility and cause them to seek for alternatives which may often endanger their lives with water borne diseases (Kjellen, 2006; Karn& Harada, 2002; Haylamicheal&Moges, 2012). In the case of ADUS the study has found that people prefer the use of borehole water which is free of charge unlike WUA water. However, due to the non-functionality of borehole pumps in the area as is the case with most bore holes in the country (Harvey and Reed, 2006; RWSN, 2010) the people have a challenge in terms of access to potable water.

As a result, they may resort to wells, rivers and other unclean sources. The study found that the catchment area has very few boreholes and some were not functional during the time of the study.

4.4.3 Respondents perceptions on the Odour of water supplied by ADUS water scheme

In order to know the perception of ADUS water users on the water supplied by the institution in terms of odour, the study carried out one-on-one interviews as well as FGD. The study findings show that 84% of the respondents (69/82) interviewed through one-on-one interviews across all the independent variables (of age, gender, level of education, length of stay and experience with water from other institutions) were satisfied with the water. Only1% (1/82) of the respondents was very satisfied indicating that the water has no offensive smell. However, 15% (12/82) of the respondents were dissatisfied with the water due to odour indicating that water has the smell of mud. It can therefore, be concluded that a larger percentage of ADUS water users feel that the water has no offensive smell. Figure 7 summarises the levels of satisfaction of ADUS water users in terms of odour.

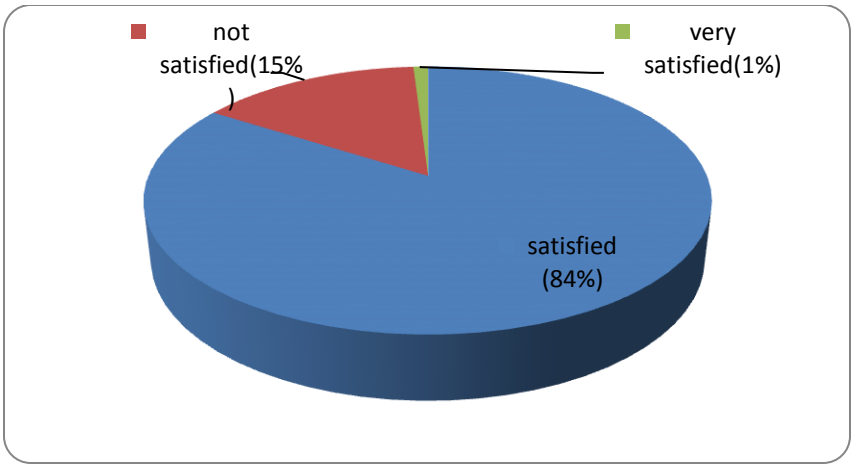

Figure 7: Respondents perceptions on quality of ADUS water in terms of Odour

Source: Survey Results (2018)

In order to validate the perceptions of the water users, Pearson's Chi-square's significance test was conducted on the responses generated through the one-on-one interviews. The findings show that there is no relationship between gender (Pearson Chi-Square = .940, df = 2, p = 0.625) age (Pearson Chi-Square = 1.743, df = 2, p = 0.418), and level of education of ADUS water users with the odour of the water (Pearson Chi-Square = 5.702, df = 6, p = 0.457). Likewise, the study found that there is no relationship between length of stay of study participants in the area and their perception on the water supplied by ADUS in terms of odour (Pearson Chi-Square = 4.107, df = 2, p = 0.128) as well as comparison of ADUS water with water from other sources in terms of odour (Pearson Chi-Square = 0.148, df = 2, p = 0.929). Results from FGD also reflected the same trend where all the 16 participants indicated that they were satisfied with ADUS water as it does not have any odour: *"we have no problems with the water we get from ADUS water scheme in terms of smell. The water has no strange smell'*.

A study conducted in Ontario, Canada on people's perception on their private water schemes shows a different trend to the findings of this study. Among the respondents in the Ontario study, 59.3%, 55.1% and 51.7% of the respondents were not satisfied with the taste, smell and colour of water from their private water supply respectively (Jones *et al,*. 2006). Most private water schemes in Canada and the rest of the world rely on ground water. This partially explains the difference in the results with those of ADUS whose source is surface water (river source). The taste, colour and smell of water from these two sources are therefore bound to be different.

In conclusion, majority of ADUS water users suggested that ADUS should improve on filtration in order to have water that is aesthetically appealing in terms of colour. Nevertheless, respondents commended the management of ADUS water scheme for supplying water of a good taste, with no objectionable smell which is also affordable and reliable compared to water from other sources. The respondents that had used water supplied by WUA indicated that apart from charging fair water bills (K500 per household, per month against K1300 by WUA), ADUS water is not intermittent as is the case with water from the two other institutions. They indicated that the water scheme is able to supply water to its customers throughout the year. Affordability and reliability are key issues in ensuring the right to water (IUCN and UNDP, 2004).

4.5 Microbiological quality of ADUS water

A microbial water quality test was conducted to validate water users' perceptions on the quality of water supplied by the water scheme which in turn reflects on the effectiveness of the institutional arrangements for water management at thefacility. In addition, the test was carried out because it has been proven that most diseases are directly or in directly connected to contaminated water sources (Adebayo *et al.*, 2011; Kanth *et al.*, 2018; Pal *et al.*,2018; WHO, 2017). Furthermore, it has been argued that private drinking water supplies are often associated with microbial contamination due to financial challenges which affect their operations (Charrois, 2010; Hunter 2011). To this regard, water samples from ADUS water scheme were collected for microbial analysis. Figure 8 shows the comparison of levels of microbial contamination on the water samples collected during the dry season as well as the rainy season before water treatment was administered to the water samples.

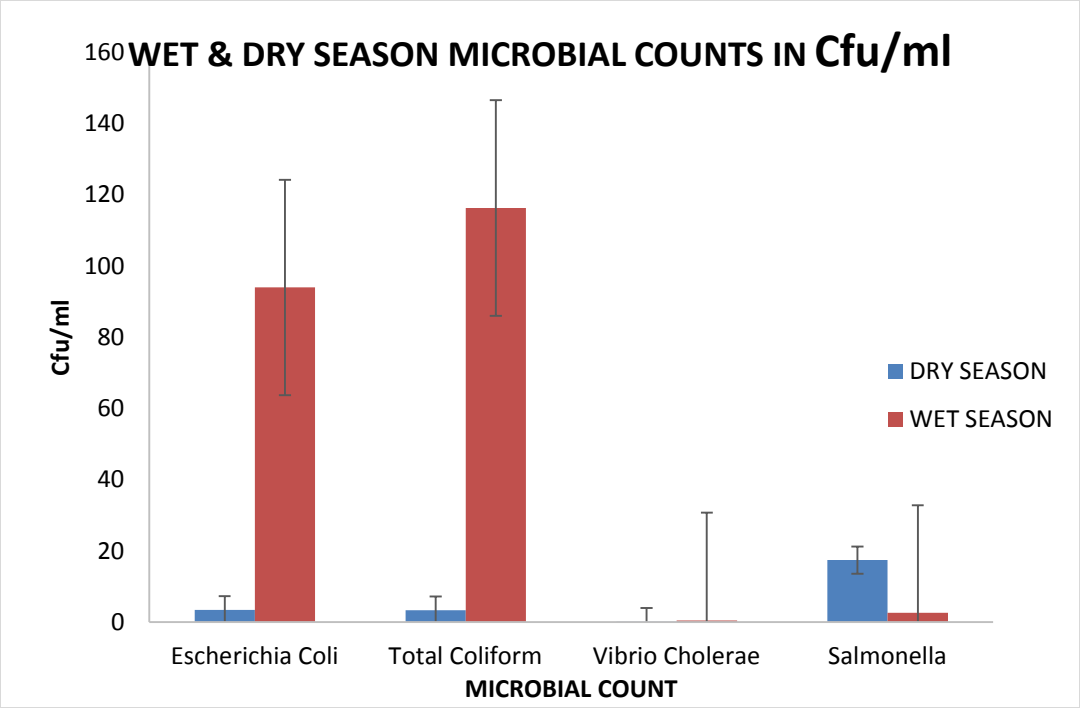

Figure 8: Level of microbial contamination of ADUS water before chlorination

Source: Survey Results (2018)

In general, water samples collected from the river source (site 1), the inlet channel leading to the collection dam (site 2) and in the collection dam (site 3) registered positive for *E. coli*, *Total coliform*, *Vibrio cholera* and *Salmonella* indicating that water from these points is unsafe for drinking (figure 4). However, water samples from the chlorination tank (site 4) and tap (site 5) had no trace of pathogens. This is because water treatment (chlorination) is carried out in the chlorination tank and the tap is the final water collection point for the consumer. The pattern was similar for both the dry and rainy seasons (table 4).

Table 4: T - Test on ADUS water sample results (at 95% confidence interval)

Variable	Wet season (mean)	Dry season (mean)	t-value	df	p-value
Escherichia coli	94. 00	3.40	-1.580	4	1.89
Total coli form	105.50	3.30	-1.489	4	0.211
Vibrio cholera	0.50	0.50	*	*	*
Salmonella	2.60	17.40	0.853	4	0.422

*The correlation and t could not be computed because the standard error or the difference was 0.

A Paired t - test was conducted on the results to establish if there was any relationship between them based on a 0.05 level of confidence. The mean and error margin for *E. coli* in dry season were3.40 and ±4.398 respectively where as the standard deviation, standard error mean and p-values were 5.017, 2.244 and 0.204respectively. The mean and error margin for *Total coli form* in dry season were3. 30 and ± 3.878 respectively, while 4.424, 1.979 and 0.171 were the standard deviation, standard error mean and p-valuesrespectively.The mean and error margin for *Vibrio cholera* in the dry season were 0.50 and ± 0.98 respectively, whereas 1.118, 0.500 and 0.374 were the standard deviation, standard error mean and p-values. Finally, the mean and error margin for *Salmonella* in the dry season were17.40 and ± 32.400 respectively.

The standard deviation, standard error mean and p-values for *Salmonella* in the dry season were36.965, 16.531 and 0.352 respectively. The readings for the same variables in wet season were as follows: 94.00 and ± 116.537 were the mean and error margin for *E. coli* whereas 132.951, 59.458 and 0.189 respectively was the standard deviation, standard error mean and p-value respectively. *Total coli form* had 105.50 as the mean and ±134.753 as the error margin, whereas 153.734, 68.752 and 0.189 was the standard deviation, standard error mean and p-value respectively. The mean readings for *vibrio cholera* and *salmonella* in the wet season were0.5 and 2.6 respectively whereas their error margins were ±0.98 and ±5.096; (1.118 and 5.814) were the standard deviations; and 0.5 and 2.6 were the standard error means; whereas 0.374 was the p-value for *vibrio cholera* and *salmonella* in the wet season.Basing on the statistics above, the study found that the levels of microbial contamination of dry season and those of wet season were not significantly different as summarised in (table 4).

In general, the levels of microbial contamination for wet season were higher compared to those of the dry season (figure 8). The trend could be attributed to surface run off that may bring in further contamination to the dam.The implication of this is that the chances of having high microbial contamination in both seasons are high. This means that at any point in time, the dry season might also have higher microbial contamination levels.Laboratory results, on the water samples collected in both the dry and wet seasons confirm the presence of faecal and microbial contamination in the distribution system of ADUS water scheme before treatment.The results in figure 9 indicate that the source of ADUS water is microbiologically contaminated rendering it unsafe for drinking.

To this effect, communities around the source of the water scheme need to be sensitised and made aware that water at source all the way before chlorination is unsafe for human consumption, a situation which may expose the users to several water-borne diseases (Nwachukwu& Ume, 2013; Wanda, 2006; Crown, 1986). The WHO (1997) water quality guidelines recommend that water for domestic purposes should be free from *Ecoli* or *Total coli form*. However, after chlorination (water from site 4 and 5) is safe for human consumption. To this effect, results in table 5 show that ADUS waters scheme's chlorination process is effective in eliminating pathogens from the water based on guidelines for drinking water (WHO, 1997) as there were no traces of pathogens after chlorination (in sites 4 and 5). The recommended levels of microbial contamination in drinking water by WHO, 1997 and MBS, 2002 is zero.A similar study was conducted in Abeokuta, Nigeria where water for drinking and swimming purposes was tested for safety.

Results showed that water samples collected from the river and stream had no objectionable smell but was aesthetically unappealing in terms of colour. In terms of bacteriology analysis, water samples collected from the river had the highest microbial load (Shittu, et al, 2010). This trend is the same with ADUS water where water from the river is aesthetically not appealing in terms of colour and highly loaded with microbes even though it has no odour. The study findings also show that ADUS water scheme relies on chlorination as the only means of water treatment.

Experiments that have been carried out on communities that are dependent on chlorination only as part of water treatment show that disinfection efficiency is negatively correlated with turbidity there by creating a chlorine demand (Shittu, et al, 2010). This is a major disadvantage of relying on chlorine as the only means of water treatment. In addition, administering chlorine to water that is aesthetically unappealing (especially in terms of colour) leads to loss of trust in the water by the users. As such, users may easily abandon the water facility. Results from one-on-one interviews show that 87% of the respondents were not satisfied with the water supplied by ADUS water scheme because of its colour. The trend was the same in the FGD where majority of the respondents also indicated dissatisfaction with the water supplied by the water scheme. Park (2011) emphasises on the importance of colour as an aspect of water quality.

As already pointed out in section 4.4.2 of this study, literature indicates that when water users are not satisfied with their water source, they turn to alternative sources such as; dug wells and unprotected sources which may expose them to water borne diseases (Kjellen, 2006). In the case of ADUS the study has found that people prefer the use of borehole water. However, due to the non-functionality of borehole pumps in the area, the people have a challenge in terms of access to potable water. The study found that the catchment area has very few boreholes and some were not functional during the time of the study.To this extent, the study findings show that ADUS water scheme as a PRWS is largely ineffective in the management of drinking water in terms of acceptability and quality.

4.6 Summary

This chapter has assessed a number of issues in relation to the role of the private sector in the delivery of drinking water in rural areas using the case study of Anglican Diocese of Upper Shire (ADUS). Specifically, the study analysed the effectiveness of the management arrangements at ADUS Water Scheme in ensuring the delivery of acceptable and safe drinking water to its users. The study also explored the perceptions of the water users on the acceptability of water supplied by the Water Scheme. Finally, a microbial water quality test was carried out to examine the safety of water supplied by the Water Scheme for domestic use. The test was also conducted to validate the perceptions of the water users on the quality of the water supplied by the water scheme in terms of microbial contamination. The major conclusion emerging from this study is that the management arrangements (both formal and informal) at ADUS Water Scheme are not effective as a result of lack of supervision by relevant authorities (DWO) as well as financial challenge typical of most PRWSs despite many efforts at both the local and international level to make private water investors governments developmental partners in the provision of drinking water to rural areas.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

This section provides conclusions and explains the implication of the study to the body of knowledge. In addition, the section also provides policy implications based on the research findings. Finally, the section suggests areas of further research.

5.1 Conclusion

In conclusion, the study aimed at assessing the role of the private sector in delivering drinking water in rural areas using case study of ADUS water scheme. Specifically, the study analysed the institutional arrangements for water management at ADUS Water Scheme, explored people's perceptions on the acceptability of water supplied by the Water Scheme and examined microbial safety of water supplied by ADUS Water Scheme for domestic use in terms of microbial contamination. The study conducted interviews with 98 sampled participants and 5 key informants. The study found that the institutional arrangements for water management at ADUS water scheme are not effective (in line with the first objective). This is largely because the water scheme does not receive support from the relevant authorities which in this case is the MoIWD through the DWO due to policy issues. The study found that the rural water supply sector in the country is governed by the CMA whose setup does not give room to governments to assist private water investors in rural areas contrary to government's efforts.

5.2 Implications of the study

Many governments are committed to improving the supply of potable water to rural areas. To this effect, most of them have adopted the CMA which has been associated with success in ensuring the sustainability of rural water supply. However; the study has found that the model is not an effective model in the management of some RWS systems and especially where the water supply system is privately-owned. There is evidence that PRWSs including those of developed nations have serious management issues preventing them from discharging their duties effectively. The challenges mainly arise as a result of using principles of the CMA on water schemes that are privately owned. The CMA has led to some restrictions on the governance of PRWSs to a larger extent because PRWSs are outside the jurisdiction of central or municipal governments policy-wise. This is a contradiction to what is stipulated in government's documents on recognising the private sector as a developmental partner in the provision of potable water to rural areas. The study therefore, suggests of a model that can incorporate elements of the CMA and the DMA to effectively help in the management of PRWSs. The management of small scale rural water schemes by the Kenyan government could be an example of this model.Finally, the study the study is in agreement with the findings of several scholars who have also noted the importance of public perception in determining drinking water quality.

Recommendations

Based on the study findings, the following recommendations are drawn.

- Central and municipal governments should explore the possibility of adopting a model that combines the aspects of the DMA and the CMA in the management of PRWSs rather than thecurrent ‘one-size-fits-all approach’ as observed by Moriarity*et a.*, (2013).
- A conventional water scheme is a requirement for every institution supplying drinking water to people including PRWSs in addition to the ongoing chlorination process. In the case of ADUS water scheme, the facility needs to be upgraded to a conventional one.
- In the event that a PRWS like ADUS does not have conventional water treatment facilities, they should explore the possibility of using natural coagulants for the removal of turbidity in drinking water in order to keep the water aesthetically appealing in terms of colour for the users. Natural coagulants have proved to be an excellent method for the removal of turbidity from drinking water. They are also cheaper and safe to human health; and also environmental friendly as they are bio degradable.

5.4 Area for further Study

- The study was done at a small scale (at one private water scheme), therefore, a similar study can be done at a larger scale in order to have a wider understanding on the role of private water schemes in the country and beyond.

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APPENDICES

'Reports on Zomba typhoid not yet out'

MERCY MALIKWA
STAFF REPORTER

Almost six weeks since Ministry of Health (MoH) declared a typhoid outbreak in Malosa, Zomba, reports into inquiries to ascertain the state of water in Likwenu Dam which is suspected to be the source of the outbreak is yet to be out.

District health officer (DHO) for Zomba Gift Kawalazira, speaking in a telephone interview on Thursday, said his office is still waiting for the reports from Southern Region Water Board (SRWB) and Central Health Science Unit (CHSU) so that they can discuss it with involved stakeholders.

"What we are waiting for is a formal report from Southern Region Water Board, they have completed with their investigations, and they are just compiling the report now. There are also other reports, which we are waiting for from Central Health Science Unit (CHSU), our laboratory in Lilongwe.

"When the reports come out we will discuss with [stakeholders in] Malosa and then map the way forward on how to monitor the treatment of the water then we will give a timeframe of 30 days, if we do not register any new cases within the 30 days then they can reopen the schools [St. Luke's College of Nursing and Malosa Secondary School]," said Kawalazira.

He said probably by the end of next week everything should be finalised "because the problem is, it is all science so it's methodical, there is need to carry out tests and investigate, and at the end of the day come up with a formal report."

Meanwhile, the Anglican Diocese of Upper Shire has disputed claims that the outbreak spurred from Likwenu Dam by saying the diocese has continued to strengthen and improve the dam since its construction in the early 1970s through upgrading and rehabilitation works in 2011 by Willie and Partners Engineering Company as consultants.

"You may wish to know that a new intake weir, storage and sedimentation tank was constructed in addition to the rehabilitation of the dam embankment and spillway.

"Recently the Diocese of Upper Shire acted on the recommendation of the authorities— Malawi Government, through the Ministry of Health—to improve the safety of the water by cleaning of the dam, upgrading of its chlorinator and procurement and installation of a backup chlorine tank," reads part of the statement signed by the diocese's bishop The Right Reverend Brighton Vita Malasa.

In a telephone interview on Wednesday, Malasa said life has come back to normal at Malosa as no new case has been witnessed over the last two to three weeks.

The Zomba tyhpoid outbreak dates back to July 2 this year when Zomba DHO was notified of an increase in the number of patients presenting to St Luke Hospital with fever, headache, vomiting, abdominal pain and general body weakness.

According to MOH, as of July 9 2016, 348 cases of typhoid, cumulatively, have been reported from Malosa Secondary School and St. Luke College of Nursing.

PHOTOGRAPH: NATION

Malasa: Life is back to normal at Malosa

'Solar irrigation schemes

Appendix 1

Principal
Dr Richard Tambulasi B.A, MA, PhD

Chancellor College,
P.O. Box 280, Zomba, Malawi.
Telephone: 265-1-52-42-22
Fax: 265 -1-52-40-46
27th September 2016

To whom it may concern

Dear Sir/Madam,

LETTER OF SUPPORT TO CARRY OUT RESEARCH

Tione Dzuwa is our Master's student in Water Resources Modelling and Governance. She is currently carrying out her research in water quality assessment in partial fulfillment of her Programme's requirement. The data collected will be strictly used for academic purposes. May you therefore offer her the needed support.

For further information, you may contact me on 0888300886

Sincerely,

M Joshua

Miriam Joshua
Senior Lecturer - Geography and Earth Sciences Department.

Appendix 2

QUESTIONNAIRE FOR ADUS WATER SCHEME WORKERS

I am Tione N Dzuwa, currently pursuing a Master's Degree in Water Resources Modelling and Governance at Chancellor College. As partial fulfilment for the award of the degree, I am conducting a research on the topic: **Management Effectiveness and Acceptability of Rural Drinking Water: Case study of ANGLICAN DIOCESE OF UPPER SHIRE (ADUS) Water Scheme**. The research is purely academic and the results will be treated with confidentiality. I therefore kindly ask for your assistance in completing the questionnaire.

Section A: Demographic Information

Answer this section by ticking ( ) the appropriate option or filling the blank spaces where necessary.

1. Gender 1. Male 2. Female
2. Age (in years).....
3. Your highest educational qualification

a. Primary school ( )
b. Secondary school ( )
c. College certificate or diploma ( )
d. College degree ( )
e. Post graduate degree ( )
f. Others (specify).....

4. Length of stay in the area (specify).....

SECTION B: WATER TREATMENT

1. Do you have any formal training related to your job?

   1. Yes ( ) 2. No ( )

      2. If yes, where did you get the training? Please specify

      .....

3. Is the water supplied by ADUS treated with chlorine?
   1. Yes ( ) 2. No ( )

4. If yes, at what point is the chlorination done?

5. Please specify.....

6. Justify the reason for your answer

   .....

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   .....

   .....

   .....

7. How often do you apply chlorine in the tank?

1. Once/day ( ) 2. Twice/day ( ) 3. Three times/day ( ) 4. Weekly ( )

5. Other (specify).....
8. If you answered question number 7, specify the amount of chlorine that is applied to the water

.....

9. Does any kind of cleaning take place in the collection tank?

   1. Yes ( ) 2. No ( )

10. If yes, how often? Please specify

1. Weekly ( ) 2. Monthly ( ) 3. Quarterly ( ) 4. Twice a year 5. Once a year ( )
6. Other (specify).....

11. If you have answered question 7, describe the kind of cleaning that takes place

    .....

    .....

    .....

    .....

    .....

12. Do you have a Water Catchment Committee?

1. Yes ( ) 2. No ( )

13. If yes, is it helpful to ADUS Water Scheme or not?

1. Very helpful ( ) 2. Helpful ( ) 3. Not helpful ( )

14. Please specify your answers in question 13

    .....

    .....

    .....

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.....

15. State the agency which ADUS Water Scheme collaborates with.

1. Ministry of Health ( ) 2. City Assembly ( ) 3.Water Board ( ) 4. Other

Specify.....

16. Does the Water Scheme under go any routine maintenance exercise?

1. Yes ( ) 2. No ( )

17. If yes, how often? Please specify

.....

18. What type of maintenance takes place?

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19. What challenges does the institution face?

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20. Does the institution consider Malawi Bureau of Standards requirements in its operations?

1. Yes ( ) 2. No ( )

15. Does the institution adhere to World Health Organisation's standards on Water Quality?

1. Yes ( ) 2. No ( )

21. Do you face any challenges with the water in the following seasons?

1. Dry season ( ) 2. Rainy season ( )

22. If you answered question number 21 , explain the challenges which are encountered in the seasons mentioned.

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23. How do you deal with the challenges encountered

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24. Suggest areas where ADUS Water Scheme needs improvement.

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Appendix 3

QUESTIONNAIRE FOR DISTRICT WATER OFFICER (ZOMBA)

I am Tione N Dzuwa**,** currently pursuing a Master's Degree in Water Resources Modelling and Governance at Chancellor College. As partial fulfilment for the award of the degree, I am conducting a research on the topic: **Management Effectiveness and Acceptability of Rural Drinking Water: Case study of ANGLICAN DIOCESE OF UPPER SHIRE (ADUS) Water Scheme**. The research is purely academic and the results will be treated with confidentiality. I therefore kindly ask for your assistance in completing the questionnaire.

Section A: Demographic Information

Answer this section by ticking ( ) the appropriate option or filling the blank spaces where necessary.

Gender: 1. Male ( ) 2. Female ( )

Age (in years).....

Your highest educational qualification

1. Primary school ( )

2. Secondary school ( )

3. College certificate or diploma ( )

4. College degree ( )

5. Post graduate degree ( )

Others
(specify).....

SECTION B: WATER TREATMENT

1. As an office, do you conduct inspections on water providing institutions in the district?

1. Yes ( ) 2. No ( )

2. If yes, how often?

1. Monthly ( ) 2. Quarterly ( ) 3. Twice a year ( ) 4. Once a year ( )

3. If No, why? Please specify

.....

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4. Which guide lines do you follow when conducting the inspections?

1. World Health Organisation ( ) 2. Malawi Bureau of Standards ( ) 3. Other ( ) specify.....

5. Is Anglican Diocese of Upper Shire Water Scheme within the jurisdiction of your control?

1. Yes ( ) 2. No ( )

6. If yes, do you supervise its operations?

1. Yes ( ) 2. No ( )

7. If no, please give reasons

.....

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8. If yes, how do you rate the level of performance of the institution in the provision of potable water to its clients in terms of:

A. colour

1. Meets the expected standards ( ) 2. Exceeds the minimum standards ( )

3. Does not meet the expected standards ( )

B. Taste

1. Meets the expected minimum standards ( ) 2. Exceeds the minimum standards ( )

3. Does not meet the expected standards ( )

C. Odour

1. Meets the expected minimum standards ( ) 2. Exceeds the minimum standards ( )

3. Does not meet the expected standards ( )

D. Microbial contamination

1. Meets the expected minimum standards ( ) 2. Exceeds the minimum standards ( )

3. Does not meet the expected standards ( )

9. Justify your answer in question number 8

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9. Do you have any other aspects about ADUS water scheme which you want to express but have not been captured by this questionnaire?

1. Yes ( ) 2. No ( )

10. If yes, please explain

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Appendix 4

HOUSEHOLD QUESTIONNAIRE

I am Tione N Dzuwa, currently pursuing a Master's Degree in Water Resources Modelling and Governance at Chancellor College. As partial fulfilment for the award of the degree, I am conducting a research on the topic: **Management Effectiveness and Acceptability of Rural Drinking Water: Case study of ANGLICAN DIOCESE OF UPPER SHIRE (ADUS) Water Scheme**. I therefore kindly ask for your assistance in completing the questionnaire.

Section A: Demographic Information

Answer this section by ticking ( ) the appropriate option or filling the blank spaces where necessary.

7. Gender 1. Male ( ) 2.Female ( )
8. Age (in years).....
9. Your highest educational qualification

g. Primary school ( )
h. Secondary school ( )
i. College certificate or diploma ( )
j. College degree ( )
k. Post graduate degree ( )
l. Others (specify).....

10. Length of stay in the area (specify).....

SECTION B: PERCEPTION OF THE ACCEPTABILITY OF THE WATER SUPPLIED BY ADUS

1. How satisfied are you with the water supplied by ADUS water scheme?

   1. Satisfied ( ) 2. Not satisfied ( ) 3. Very satisfied

2. Give reasons for your answer

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3. Have you ever used water supplied by other water providing institutions apart from ADUS?

1. Yes ( ) 2. No ( )

4. If yes, which institutions?

   1. Water Board ( ) 2.Water Users Association ( )

   Other ( ) specify.....

5. If you answered question 5, how do you compare the water supplied by ADUS with the water supplied by the institutions above?

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..... Do you have any suggestions on how ADUS can improve the water which it supplies to its customers?

1. Yes ( ) 2. No ( )

6. If yes, give reasons

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Appendix 5