ISSUES AND CHALLENGES OF LIVINGSTONIA GRAVITY FED WATER SUPPLY SCHEME

Master of Science in Environmental Protection and Management (MSc EPM)

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By

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CANDIDATE'S DECLARATION

I declare that this research entitled, 'Issues and Challenges of Livingstonia Gravity fed Water Supply Scheme', is my own work. It is submitted in partial fulfilment of the requirements for the Master of Science Degree in Environmental Protection and Management at the Polytechnic, University of Malawi. It has not been submitted for any other degree to any University.

Name :

Signature :

Date :

CERTIFICATE OF APPROVAL

The undersigned certify that they have read and approved for acceptance by the University of Malawi, Polytechnic this thesis entitled, 'Issues and Challenges of Livingstonia Gravity fed Water Supply Scheme'.

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DEDICATION

To 'My Dear Better Half, Memory,' you spent sleepless nights to make sure your husband passes through this academic ladder. Wife! Here is your harvest, reap now! You may now talk and walk proudly for your husband has now climbed a step ahead in the academic echelons. To my son, Promise and daughters, Ellen and Immaculate, I really appreciate your patience for toiling in absolute poverty while your dad was trying to make it. From your dad, let it be known to you that **'It's not easy to come to the top, but heroes make it, anyway**.'

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ABSTRACT

The success of a water supply scheme depends on a complex mix of managerial, environmental, social, financial, and technical issues and the capabilities of the institutions and infrastructure designed to support it. Most water supply schemes in the northern region of Malawi have not been studied, Livingstonia is a good example. A study using a cross-section survey design was conducted in order to assess key issues affecting the performance of Livingstonia water supply scheme. The quantitative phase included the following hydrometrics: tap delivery rates, stream discharge rates, laboratory testing of water and physical inspection of water taps. The qualitative phase involved the characterization of water resource utilisation, facility management assessment of local understanding of catchment conservation and protection legislation, and practices through interviews, focus group discussions and questionnaires.

The study has shown that the scheme is meeting the water demands of the community except for few villages due to geographical and financial factors. The study has further shown that the scheme is contributing to the creation of employment. The scheme is run by a technical team which comprise of employed staff in addition to area mechanics. There is high water facility functionality in the scheme due to active community water committees. However, the quality of water is biologically substandard due to the encroachment of the water source by wild animals and people.

In terms of practice, the study has shown that although there are efforts by various players on protecting the water source, there is massive destruction of forest cover by education institutions for energy purposes and cultivation of buffer zone of the water source. In terms of legislation, the study has shown inadequate knowledge and awareness on policy and standards in community committees in managing water and environment. The study has also indicated the lack of legal status of local committees and failure of the government to ratify fiscal incentives as stipulated in EMA 23 cap vii section 31(a) as crucial factors affecting the promotion of environmental compliance in the catchment area of the scheme.

To address the challenge of unequal coverage of water in the study area the study recommends the use of alternative water supply technologies especially boreholes for safety purposes rather than springs. The study recommends chemical treatment of water before usage to safeguard user's health. On the same, the study recommends collaborative water quantity and quality monitoring programs with various stakeholders in the area. On environmental impacts, the water conduits should be covered to avoid overflows and contamination, the study further recommends rehabilitation of aprons to improve water point hygiene. Legislatively, the government should facilitate implementation of incentives for friendly users of environmental resources. Enforcement of rules and regulation by a non- legal entity is very difficult because of many freedoms that the new political dispensation in Malawi has brought. This study, therefore, recommends government support to local institutions and committees to attain legal status through legal registration. Most of them have written constitutions and by-laws but more often they are challenged by deviant community members due to lack of legal authority.

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ABBREVIATIONS AND ACRONYMS

CBRNM	:	Community Based Natural Resources Management
CCAP	:	Church of Central Africa Presbytery
CPC	:	Catchment Protection Committee
DANIDA	:	Danish International Development Agency
DFID	:	Department for International Development
DGMH	:	David Golden Memorial Hospital
DGs	:	Development Goals
DHS	:	Demographic Health Survey
EIA	:	Environmental Impact Assessment
GDP	:	Gross Domestic Product
GFS	:	Gravity Fed Scheme
GoM	:	Government of Malawi
HDI	:	Human Development Index
HHI	:	Household Income
IWRM	:	Integrated Water Resource Management
JMP	:	Joint Monitoring Programme
K-WATSAN	:	Khondowe Water and Sanitation Association
MASAF	:	Malawi Social Action Fund
MBS	:	Malawi Bureau of Standards
MDGs	:	Millennium Development Goals
MoWID	:	Ministry of Water and Irrigation Development
NEAP	:	National Environmental Action Plan
NEP	:	National Environmental Policy
NGO	:	Non-Governmental Organization
NIPDS	:	National Irrigation Policy and Development Strategy
NSO	:	National Statistical Office
NWDP	:	National Water Development Project
NWP	:	National Water Policy
O &M	:	Operation and Management
pH	:	Power of Hydrogen

SEP	:	Environmental Support Programme
SOER	:	State of the Environment Report
SSA	:	Sub Sahara Africa
SRWIHL	:	Sustainable Rural Water Infrastructure for Improved Health and Livelihoods
TA	:	Traditional Authority
UMCA	:	Universities Mission to Central Africa
UN	:	United Nations
UNCED	:	United Nations Conference on Environment and Development
UNDP	:	United Nations Development Programme
UNEP	:	United Nations Environmental Programme
UNICEF	:	United Nations International Children's Education Fund
UNILIA	:	University of Livingstonia
UNO	:	United Nations Organisation
USAID	:	United States Agency for International Development
WATSAN	:	Water and Sanitation
WBCSD	:	World Business Council for sustainable Development
WECD	:	World Commission on Environment and Development
WHO	:	World Health Organization
WPC	:	Water Point Committee
WRMPS	:	Water Resources Management Policy and Strategies
WSP	:	Water Sector Plan
WUA	:	Water Users Association

CHAPTER ONE: BACKGROUND INFORMATION

1.1 Introduction

Malawi Government has made commendable progress in the development of water resources in the country. However, there are several issues relating to development, utilisation and management of rural piped gravity water resources that the country should address as a matter of urgency in order to conserve resources from further degradation and depletion (United Nations (UN), 2009). Extensive gravity water studies have not been conducted across the country after the 1986 studies, which were carried out to contribute to the preparation of the National Water Resources Master Plan (Government of Malawi (GoM), 1998). Unless countrywide studies are undertaken, to assess the current quantity and quality of water supplied by the gravity fed schemes, it will be difficult to understand how the water resource in these schemes has changed with change in time (UN, 2009). It was, therefore, the purpose of this study to assess the status and management of the schemes based on empirical data by analysing information from the water committees, households, physical inspection of water facilities, conducting water hydrometrics and laboratory testing of water. This study was guided by Integrated Water Resource Management (IWRM) concept which defines water services' approach that takes poor people's multiple water needs and their priorities as a starting point of the planning and design of new infrastructure or rehabilitation and sustainable management institutions, (Mulwafu, 2002). The concept was supported by the critics to the Information- gap decision theory presented by Ben-Haim (2001) which among other things argues that lack of knowledge can be considered a critical gap in the information required to make suitable decisions in sound management of natural resources.

1.2 Malawi Gravity Fed Water Supply Schemes

One of the strategies by Malawi government to address water supply shortages in rural areas was the introduction of gravity fed water supply schemes which date back to 1968 (Msukwa and Louis, 1986). The Malawi Rural Piped Scheme Program refers to the activities of the Malawi government in building gravity schemes to provide drinking water to the rural population (Kleemeier, 2000). Most drinking water supplies in rural Malawi use point sources such as wells or boreholes. However, there are many places in which people live near hills containing perennial springs and streams (Appendix 1). Here piped water supplies, usually flowing by gravity or in some cases pumped, have become more appropriate.

The Malawi rural piped schemes had its origin in a small scheme constructed by the government in 1968 on an experimental basis. However, the projects expanded countrywide by various NGOs and donors (Gileme, 1983; Warmer, 1986). Malawi has now over 80 rural piped schemes serving a design population of almost two million people (Apollo, et al., 2002). The schemes vary widely in size: one serves over 350,000 people through thousands of kilometres of a pipe, whereas others serve one or two thousand people with less than twenty kilometres of pipe. Most are designed to serve fewer than 50,000 people (Kleemeier, 2000).

Rural gravity water schemes in Malawi are characterised by the absence of treatment systems and community participation in both construction and management. The government only plays a limited supporting role through the Ministry of Water and Irrigation and local assemblies. The water department designed some forms for recording, monitoring and reporting information about the performance, issues and challenges in the management and operation of the schemes. However, according to Warmer (1986) the monitoring system only worked fairly in the beginning, a United States Agency for International Development (USAID) mission in 1990 found out that information on the forms was inadequate and the system almost collapsed. In the absence of appropriate and complete information from these monitoring assistants, the water authorities and stakeholders exchange a misleading picture of the condition of the schemes. Monitoring assistants who happen to be the backbone of government in information generation and relay besides maintenance of the schemes some were found in Kleemeier (2000) studies not performing. In addition, in some cases, they were providing the services in varying extents. In 1990, the Ministry engaged consultants to evaluate the performance of the rural piped water schemes in all the three administrative regions of Malawi, however, the effort was unfruitful because the monitoring assistants' reports on the whole could not provide the detailed reliable information needed to do the analysis (Kleemeier, 2000).

Despite this plethora of literature and research from both local and global scale, relatively little is known about a number of key aspects of gravity water resources. In particular, knowledge is scarce about the long-term trends and changes in gravity fed water systems in most parts of the world (Thompson, 2000). Consequently, the dynamics and determinants of pipe borne water use remain only partly understood. Among the regions of the world, the research gap is most acute for sub-

Saharan Africa, a region whose population has the least access to improved water supply (Rijsberman and Cosgrove, 2001).

However, regional and district level basis is important for rational planning in order to effectively manage the country's gravity water resources, to sustain the water demand, improve water allocation and equitability. Not only that but it also helps to improve community resilience to climate change and variability accurate and reliable updated information on the status and management of water facilities on a country. Details of the status and management of water facilities should be looked into if remedial action is to be taken (Warmer, 1986). In Malawi, the absence of this information has been identified as one of the major constraints in water sector development (GoM, 2001). In part, the reason for this scenario is that there was a decline in government budget for rural water supply schemes (Water Sector Plan (WSP), 2002). These have resulted in deteriorating levels of both quantity and quality of water supply services in rural communities.

1.3 Problem Statement

In order to get a good understanding of the current situation and constraints for a specific scheme, information on the scheme development, history of management structures, supporting partners, and policy context development should be documented (Shams, 2010). However, to the contrary, despite its long history, Livingstonia gravity fed water supply scheme has not been studied. There have been significant changes in the landscape which include an increase in water demand due to the establishment of institutions such as the university, a secondary school and the technical college. Apart from changes in the natural setting, socially the ownership and management of the scheme has also changed in response to the current national decentralisation policy. The study was therefore, preliquisite to the exposition of issues and challenges affecting the performance of the Livingstonia water supply scheme.

1.4 General Objective

The aim of this study was to characterise the Livingstonia gravity fed water supply scheme in Rumphi district and examine its performance against the opportunities and challenges surrounding its use.

1.4.1 Specific Objectives

Specific objectives of the study were:

a. To characterise accessibility and utilisation of water, state of water and water facilities, and scheme management.
b. To assess the socio-economic and environmental impact of the water supply scheme in the area.
c. To analyse the impact of the existing conservation and legislation practices on water source catchment area of the scheme.

1.5 Significance of the Study

The study is significant in a number of ways. Firstly, the study has generated information to academicians on gravity fed water supply which will be used for comparative purposes. The study fills in critical gaps in gravity fed water studies in Malawi which for a long time have been concentrated in Southern Malawi and very little work has been done in northern and central Malawi (Klemeier, 2000). Rumphi has different physiographic, socio-cultural climatic and economic characteristics which may influence scheme management dissimilar to those in the southern region. In addition, most cases, researchers studying water supplies in Malawi make much reference to shallow wells and boreholes or just study them altogether at the expense of particular focus on gravity fed water supply systems. In the long run, interested and affected parties fail to appreciate the importance played by these schemes in their own geographic settings.

Secondly, the study has generated information which may be used in the decision-making by water resource managers, researchers, government and donors in the developing and evaluating rural gravity fed water supply schemes.The research results form an information database upon which gravity water supply schemes in the country and elsewhere for monitoring programmes. This study may serve as a spring board and eye opener to other schemes in Rumphi district from which various lessons may be drawn from as there is no such or similar current work conducted in the district to identify crucial issues related to management of water, water facilities and catchment area. In addition, the study exposes several points requiring interventions from other players in order to improve the supply of portable water and enhance time and financial savings on water collection. Consequently, it opens a wide door to long-term increased labour production in agricultural and other income generating activities in the study area and the country at large.

Finally, the study can assist the local people in Livingstonia to understand better the effects of their interaction with their physical environments affect water quality and quantity in water source catchment areas. They may be well informed of the dangers of deforestation activities in water sources. This study will provide information on how human activities have contributed to water contamination at water point and their sources. Eventually, the local people may appreciate the problems and be more willing to rehabilitate catchment areas.

1.6 Problems and Limitations of the Study

The major problem experienced in this study was resource limitation. The costs for analysing some other water quality parameters were very high as such only few parameters were analysed. Secondly, due to the poor hilly terrain which posed a lot of challenge on accessibility to some water points, water samples were taken and analysed at different times. In view of this, it was considered to have a profound effect on the standard reporting of results from a cross section study of this nature and that was solved by increasing the sample from 40 to 50 taps. Lastly, weak information recording system at Khondowe Water and sanitation (K-WATSAN) and Rumphi District Water Office was another limitation. Precisely, the historical developments and transitional ownership of Livingstonia gravity water supply system from the missionaries to Rotarians and to K-WATSAN at last.

Nevertheless, these limitations have not significantly affected the comprehension of the subject matter, the quality of the study and the conclusions drawn herein, owing to the comprehensive literature search and triangulation of methods used.

1.7 Organization of the Thesis

This thesis contains five chapters. The present chapter mainly provides the context of the research problem, states the objectives, problem statement, significance and limitations of the study. Chapter Two is the literature review where information to back up the study with the present state of knowledge on the subject is presented. Chapter Three gives some background information to the study area and methods applied to examine the problem. Chapter Four presents the results, interpretation and discussion. The conclusions and recommendations are given in Chapter Five.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Although the subject of gravity water supply schemes in Malawi has thus been considerably studied, no comprehensive local assessments from 2000 to this date have been carried out at Livingstonia gravity water supply scheme. To come up with a well-balanced literature review on social, natural and biophysical dimensions of a water supply scheme a variety of scholarly materials such as local and international journals, government white paper sand primary data from both water users and managers of Livingstonia gravity fed water supply schemes were analysed. The criticisms of the information-gap decision theory and integrated water resource management concept was used as scholarly lens of this chapter but with less focus on numerical data rather a larger consideration of programs, processes, and activities that have been used in formulating and guiding successful solutions to problems affecting water resource management and gravity fed water supply schemes in particular.

2.1.1 Application of the Critics of the Info-gap Decision Theory to this Study

Information-gap theory was invented to assist decision-making when there are severe knowledge gaps and when probabilistic models of uncertainty are unreliable, inappropriate, or unavailable (Ben-Haim, 2001).Information gaps are looked at as severe forms of uncertainty and occur often in practice. In many innovative technological projects, very little that should be known in order to make wise and reliable decisions is actually known (Zadeh, 2003). In environmental planning, in industrial management, in social and economic decision-making, in medical diagnosis, and in other areas, quite often the gap between what we know and what we need to know is substantial (Fang, Hipel, and Kilgour, 2003). Since the formulation and choice of an info-gap model depend on the type of initial information critics, argues that such non-probabilistic models still for them to be a meaningful need to be fed with preliminary basic information (Goicechea, Hansen, and Duckstein, 2002). To such case, the importance of information about a resource cannot be substituted by either probability or non-probability theories. In this scholarly review, initial information is being presented as information from other scholars on the same or similar subject while "what we need to know information" are natural, managerial, policy, socio-economic and biophysical changes in the Livingstonia scheme including its catchment areas. It was anticipated that information generated from these thematic areas would provide the scientific underpinning to help in the present study.

2.1.2 Integrated Water Resource Management (IWRM) Concept

This approach according to Mulwafu (2000) focuses on water resource management at the lowest appropriate levels, users' participation, the inclusion of women, and financial and environmental sustainability. IWRM is defined as a water services approach that takes poor people's multiple water needs and their priorities as starting point of the planning and design of new infrastructure or rehabilitation and sustainable management institutions. This bottom-up approach has resulted in the communities being more active and aware of the usage and protection of water resources. It gives them a sense of ownership which is a single most important aspect of sustainability. The researcher looks at the approach as a starting point for assessing the interaction of social processes and water environment in the context of decentralisation and environmental legislation as reflected in scholar work of various authors.

2.2 The Status of Water and Water Facilities, Utilisation and Accessibility in Gravity Fed Water Supply Schemes

Several studies suggest that lack of water services in many areas is not due to lack of effort on the part of government agencies and aid organisations, but is the result of implementing unsustainable systems, in part because the user characteristics and water status are not fully understood (Ostrom, Schroeder and Wynne, 2003). The statuses of water resources, facilities, utilisation patterns and management systems have both direct and indirect impact on the performance and sustainability of a water supply system in any location. Therefore, it is critical to have updated information about them.

2.2.1 Water Quality Issues affecting Gravity Fed Water Supply Schemes

Our lives depend heavily on water that is free of toxic chemicals and pathogens but the majority of people in Malawi do not have access to safe drinking water. The National Environmental Policy (NEP) in 1996 emphasised on the improvement of service delivery in the area of water supply and sanitation and the Environmental Support Programme (ESP) in 1998 added that management of water as a natural resource, quality control in particular, is an essential requirement (Sajidu, Masumbu, Fabiano, Ngongondo, 2007). Despite various government efforts in addressing water issues in the country, very little work has been done on improving water quality, particularly in rural areas where most of the gravity fed water supply schemes exist. Most of the water projects since 1995 have concentrated mainly on improvement of water delivery (GoM, 2008b).

In rural Africa and other developing countries, scientific evidence is often lacking to guide the scaling-up of gravity fed water as the safest source of potable though in most times the water is not conventionally treated. Ground and surface water sources are often only tested for microbial, physical and chemical quality during construction by drillers, which is a contractual requirement commonly practised in Malawi (Kanyerere, Levy, Xu and Saka, 2012). This is undertaken to establish if the water is fit for human consumption. The Central Laboratory of Malawi performs the analysis as soon as the water source has been developed and before people start using the source (GoM, 2008b). However, this is not sustained on a regular basis. This is a common pattern in developing countries where more regular water sampling and analysis are considered too costly (MacDonald, Davies, Carlow, Chilton, 2005). Furthermore, groundwater is often tested only when pollution from industrial effluents or commercial farming activities is suspected (MacDonald, 2005). Therefore, it is not surprising that in areas such as rural Malawi, where there are no or few industries or commercial farming operations, studies regarding contamination of water are seldom performed. Studies that focus on abundance and spatial variation of contamination in water in gravity fed schemes are rare in Malawi (Kleemeier, 2000). However, such knowledge is vital for devising effective strategies to improve the quality of drinking water for rural populations, especially those who have low purchasing power for effectively treating drinking water at home.

According to some water quality studies, a typical water problem in the country is unpleasant smell due to high concentrations of sulphur in the bedrock and high salinity caused by evaporative concentrations in shallow water tables (Dzwairo, Hoko, Love, Guzha, 2006). High levels of iron are also notable throughout the country, especially in the basement aquifers. Other studies, for example, Wright (2004) blames high iron concentrations on pipe corrosions. Many catchment areas across the country are under pressure due to poor agricultural practices and deforestation. Agriculture is considered to be an important diffuse source of nutrients exported from catchments. Large losses of nutrients from agricultural land may be caused by intensive use of fertilisers. Stalnacke (2003) and several investigations have shown that concentrations of nutrients in water were strongly correlated to the percentage of agricultural land in the study basins (Grimvall and

Stalnacke, 2003; Sharpley and Withers, 1994). Other diffuse sources include atmospheric deposition, urban runoff, animal manure and fertilisers applied to cultivated fields, and runoff from livestock feedlots.

Some gravity fed water schemes have their sources from rivers which at many times are vulnerable to pollution. Nitrogen and phosphorus enter such rivers through several hydrological, geological and biological pathways depending on the natural and anthropogenic processes taking place in the catchment (McClain, 1998; Wassman and Olli, 2004). These processes are generally known from numerous studies of small catchments as well as from recent global and continental scale assessments of nutrient sources (Seitzinger and Harrison, 2005). The natural source of phosphorus is the weathering of phosphorus-containing rocks such as apatite (Chislock, Doster, Zitomer, and Wilson, 2013). Nitrogen is also present in igneous rocks at low concentrations but the main source of nitrogen for all biological activity is the atmospheric reservoir of gaseous nitrogen that is made available to ecosystems by fixation into a variety of oxides or reduced to ammonia as a result of fixation by microorganisms (Chislock, Doster, Zitomer, and Wilson, 2013).

The growth of human population and an increase in its capacity to alter the environment has increased the supply of nutrients to rivers and human activities in the watersheds are now important contributors of nutrients to water sources (Wassman and Olli, 2004). The major point sources of nutrients to water sources are sewage and industrial effluent discharges (Harper, 1996; Moyo and Worster, 1997). These play a major role in most severe cases of water source pollution depending on the population, or size of and type of activity discharging the waste, the capacity of the water body to dilute the discharge, and the ecological sensitivity of the receiving water body (Allott, McGinnity and O'Hea, 2005). Another concern in India about gravity multi-village water schemes is drinking water quality due to geological conditions (Sather and Smith, 1984).The (Sather and Smith, 1984) study identified more than 215,000 habitations (15% nationally) that have serious water quality problems related to excess fluoride, arsenic, salinity, iron or nitrate. Many of these water quality problems are caused by naturally occurring substances in groundwater and extend over large areas.

Table 1: Water Quality Hazards and Potential Impact on Users

CONTAMINANTS	HEALTH EFFECTS	SOURCES
Microbiological	Acute gastrointestinal illness dysentery, hepatitis, typhoid, fever, cholera, giardiasis, cryptosporidiosis, etc.	Human and animal fecal matter
Arsenic	Dermal and nervous system toxicity	Geological
Lead	Central and peripheral nervous system damage kidney effects; Highly toxic to infants and pregnant women	Leaches from lead pipes and lead-based solder, pipe joints
Nitrate	Methemoglobinemia ("blue baby syndrome")	Fertilizer, sewage, feed lots
Fluoride	Skeletal damage, dental fluorosis	Geological
Pesticides and herbicides	Nervous system toxicity cancer risk	Farming, horticultural practices
Trihalomethanes	Cancer risk	Treatment by-product
Radionuclides	Cancer	Geological

Source: (United Nations Education Scientific and Cultural Organisation (UNESCO), 2003).

The potential of water to negatively affect people's health is well documented for both developed and developing countries (Younes and Bartram, 2001; Wright, 2004). Water-related diseases continue to be one of the major health problems globally (United Nations Education Scientific and Cultural Organisation (UNESCO), 2003). It is estimated that 80% of all illnesses are linked to use of water of poor quality (World Health Organisation (WHO), 2002). One of the strategies for tackling this problem is the provision of protected sources or treating it which is not common in most Gravity Fed Schemes (GFS) in Malawi (Kleemeier, 2000). This situation, therefore, put peoples' lives at high risk of contracting water-related diseases. Other than health risks, water with poor quality affects the environment and the water infrastructure as indicated (Table 1).

2.2.2 Status of Water Facilities in Gravity Fed Water Supply Schemes

The water point mapping for rural water supplies, carried out by a number of sector players between 2004 and 2008 provides inventories of water sources, functionality and provides the basis for estimating coverage (Baumann and Danert, 2008). However, update mechanisms for this data are still weak and NGOs rarely report their new constructions to the district assemblies or district water offices, even though they may monitor facilities which they constructed. There seems to be no diagnostic data providing information why sources are non-functional or abandoned. The Village Health Book represents another data source but does not contain sufficient information for district planning (Baumann and Danert, 2008).

Ministry of Irrigation Water and Development (MoIWD), (2008) states that “theft and vandalism of water facilities are a major setback to water and sanitation services delivery”. It points to the need to intensify public awareness and dialogue on the problems and effects of this, and “instil ownership”. In relation to the same subject, Kleemeier (2000) gives out a report of water department study of gravity fed schemes in southern Malawi as indicated in (Table 2).

Table 2: Changes in Functionality Rates of Piped Water Schemes

DATES	SURVEY/STUDY	FINDINGS
1982-83	Water Department survey of five piped water schemes	Water available at the observed taps for 85% to 99% of days over a one- year period
1983-84	Analysis of monitoring assistant reports for three schemes	Selected taps had water for 80% of the days
1984	Study of eight schemes	Selected taps provided water 97% or more of the days. Breakages repaired in two days of less in 91% of cases.
1998	Study of 17 schemes	66% of the taps supply water for a minimum of 50% of the days over the past three months
2007	National water point mapping	49% of the GFS taps were not working

Source: Warmer (1986)

Kleemeier (2000) observed that from 1982-83, water was available at the observed taps between 85% and 99% of the days over a period of one year and that in case of breakdown, was restored within five days. The following year, her analysis of the reports submitted by the monitoring assistants for three schemes showed that selected taps had water 80% of the days Kleemeier (2000). A similar study in 1984 (Warner et al., 1986) found that selected taps in eight schemes provided water 97% or more of the days, and in the other scheme, 91% of the days. Breakages were repaired in two days or less in 91% of the cases, and in only 5% of the cases did it take more than three days (Warner et al., 1986).Though access to improved water supplies in rural areas is relatively high in Malawi, there is a major problem with respect to functionality (Kleemeier, 2000). Water point mapping report (GoM, 2007) indicates that 31% of water points are not working and that this reduces the effective rural coverage to 55% (Table 2).

Table 3: Water Facilities' Functionalities and Population Served with Improved Water in 2007

Water source	**Number of sources**		**Percentage of sources**	
	Total	Functional	Total	Functional
Borehole fitted with hand-pumps	24,679	19,404		79%
Gravity Flow schemes (GFS) Standpipes/taps (for 82 schemes)	12,456	6,050		49%
Average			69%	
Water source	**Number of people served**		**% of people served**	
	Total	functional sources	Total	functional sources
Borehole fitted with hand-pumps	6,169,750	4,851,000		
Gravity flow schemes (GFS) Stand-pipes/Taps (for 82 schemes)	1,499,720	726,000		
Average			75%	55%
Assumption: A borehole fitted with hand-pump serves 250 people, a GFS tap serves 120 people. Rural population is 10,174,802.				

Source: GoM (2007)

Gravity water supply is a capital-intensive mode of water delivery which requires costly investments in infrastructure such as taps, pipes, storage tanks, dams etc. These fixed assets need to be maintained. Most major infrastructure, such as roads, sewers and sidewalks, requires some form of asset management, and water supply is no exception. Asset management is "the combination of management, financial, economic, engineering and other practices applied to physical assets with the objective of providing the required level of service in the most cost-effective manner" (National Asset Management Steering Group, 2006). In practice, to keep a water point functioning depends on a complex mix of managerial, environmental, social, financial, and technical issues and the capabilities of the institutions and infrastructure designed to support the community (Harvey and Reed, 2004; Mukherjee and Wijk, 2002; Sugden, 2003). Studies have shown that operation and maintenance of water supplies, with many government-provided-schemes in particular, fail after a short period of time because of poor operation and lack of effective maintenance (Butterworth and Sousa, 2001). Delay or negligence in Operation and Maintenance (O&M) of water facilities negatively impacts the credibility of the investments made, the wellbeing of rural population and advancement of further projects (WHO, 2000).

There are different causes that lead to failure in water supply systems such as physical constraints that are not well looked into during planning, for example, poor aquifer with limited storage, engineering problems i.e. use of systems that are expensive to operate and maintain, institutional or management failure, corruption, rising water demands, gender, financial, political, community, and social and environmental factors (Butterworth and Sousa, 2001; WHO, 2000). This is supported by the findings of Abika and Carrethe (undated) that technical complication is one of the problems associated with piped water facilities. This is particularly true when there is the absence of technical assistance and community capacity building in the process of installing and operating of water facilities in the rural areas. Harvey (2003) reports that piped water supply services are a financial burden to locals because of high costs associated with their O&M. The perceived water quality and distance to an alternative water source are also important factors influencing community's willingness in operation and maintenance of water facilities (Harvey, 2003).

A Ugandan study revealed that taps easily breakdown as a result of huge pressure due to the fact that some of them serve more than 1000 people (Trevett, 2001). While another study in Madagascar observed that lack of community water boards' meetings on regular basis, inadequate monthly tariff to cover routine maintenance and lack of an operator designated was responsible for maintenance, as problems related to broken hand pumps (Harvey, 2003). The other reasons for vandalism are political or tribal differences; disagreements over the location of the water point; loss of livelihoods for water vendors; envy between communities without and communities with taps; the use of pump parts for other purposes and preference for technologies which are not complex (Harvey and Kayaga, 2003).

Vandalism in Malawi accounts for so many dry taps because people frequently steel pipes, thereby cutting off water supply to groups of taps (Kleemeier, 2000). Although thieves steal all kinds of pipes, their predilection for taking steel pipes to make hoes has the biggest impact per theft, as steel pipe is almost inevitably on the main line serving many taps. In addition to theft, some pipes are apparently cut just for malicious or frivolous reasons (Msukwa, 1990). In four schemes studied by the University Centre for Social Research of the University of Malawi, the findings showed evidence of supply problems due to consumers operating gate valves in order to direct water to their taps, and thereby depriving other taps of water (Msukwa, and Chirwa, 1981 as cited in Kleemeier, 2000). In addition to problems identified by preceding studies, several other scholars provide evidence of a gradual deterioration in scheme installations and capacity (Glennie, 1982). While another study in Malawi pointed out problems originating in the design phase as the major contributing factor to high rates of non-functionality of water facilities (Msukwa, 1990).

2.2.3 Water Utilization and Accessibility in Gravity Fed Water Supply Schemes

Access to safe drinking water is the proportion of people using improved drinking water sources such as household connection, public standpipe, bore hole, protected dug well, protected spring and rainwater (WHO, 2010). About 94 % of the urban population of developing regions uses improved sources while only 76 % of rural populations have access to improved sources. Poor or absence of safe water may lead to many unfavourable consequences, such as more time and energy consumption for collecting and carrying water and insufficient water to maintain good hygiene practices (Hunter, 2010). WHO and United Nations International Children’s Education Fund (UNICEF), (2014) report that in 2012, approximately 884 million people around the globe as indicated in Figure 1 below lacked access to improved water sources, while 2.6 billion people lacked adequate sanitation services. Unfortunately, these figures mask the extent to which these problems affect rural communities: 84 percent of people lacking potable drinking water and 70 percent of people lacking improved sanitation services reside in rural areas (WHO and United Nations International Children’s Education Fund (UNICEF), 2014).

Providing sustainable potable water systems for rural areas in resource-limited nations remains at the forefront of national and international agendas. According to the World Bank, the only way to overcome poverty in rural regions is by addressing the specific root causes such as water provision (World Bank, 2010). International reports identify Malawi as one of the Southern African countries likely to experience absolute water scarcity by 2025 (Ohlsson, 1995 as cited by Hunter, 2010). However, this estimation appears to reflect infrastructural and distributional problems more than actual scarcity (Chipofya, Kainja, and Bota, 2012). The country has an extensive network of rivers and lakes, with water bodies covering more than 21% of its territory.

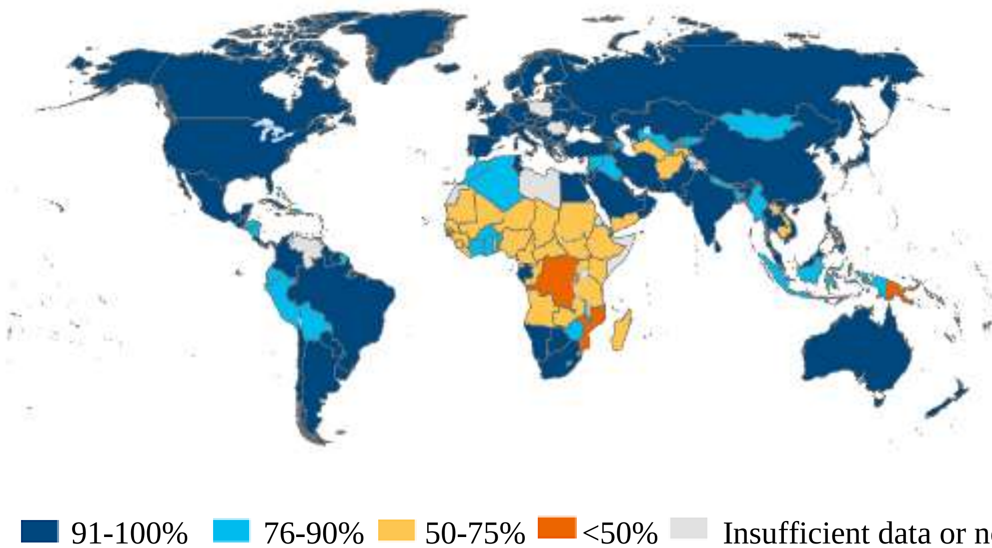

Figure 1: Global Population Using Improved Drinking Water Sources in 2012

Source: Joint Monitoring Programme (JMP) (2014)

The Country Situation Report on Water Resources in Malawi according to Kaluwa, et al. (1997) indicates that despite the fact that the renewable freshwater resources in Malawi are about 3,000 cubic metres per capita per year, the distribution across the country is irregular and varies by season and year. Therefore, access to water remains limited. In relation to country water accessibility situation analysis (GoM, 2010), the new Water Resources Management Policy and Strategies (WRMPS) reports that:

> The existing urban and rural water supply schemes and systems provide access to potable water facilities for up to 54% of the country's population, which reduces to 32% with access to potable water at any one time due to breakdowns, drying up of sources and other operational and maintenance problems.

However, whereas expanding improved water infrastructure is necessary, that alone does not guarantee safety and adequacy of water to its users: Access is an intermediate output and has to be combined with the favourable demand to generate desired outcomes among users (Larson, et al., 2006). Recent evidence from empirical research for example, (Kleemeier, 2000; Vasquez et al..,

2009) also indicate that improved water supply schemes in many developing countries are not functioning properly hence an obstacle on accessibility. In sub-Saharan Africa, for instance, it is estimated that 35 percent of all rural water systems are not functioning (Baumann, 2005). Other authors also cited drinking water safety and reliability as key problems even when the basic water delivery systems are in place (Vasquez et al, 2008). Thus, "in addition to increasing access through the implementation of improved water supplies, it is also necessary to ensure that both new and existing water systems are sustainable, so that access to safe water is sustained for all" (Harvey, 2008).

Unfortunately, lack of water services in many areas is not for lack of effort on the part of government agencies and aid organisations, but is the result of implementing unsustainable systems, in part because the user characteristics are not fully understood (Ostrom et al., 2003). The Government of Malawi with the assistance of donor funding rolled out a Sustainable Rural Water Infrastructure for Improved Health and Livelihoods (SRWIHL) which targeted five districts namely; Rumphi, Nkhotakota, Ntcheu, Mangochi and Phalombe. The project first phase ended in 2013 with a focus on rehabilitation and expansion of existing twelve Gravity Fed Schemes in the project districts (GoM, 2014). Among other reasons, the five districts were selected because of their low water supply coverage, which is less than 70%. However, other studies, for example, Nicol (2000) and suggests that increasing of water coverage alone does not increase accessibility since there are a number of factors especially in the rural areas which may challenge community members from using improved water sources such as distance, financial constraints, non-functionality of water facilities, gender, terrain, water quality, water quantity and many others.

2.3 Socio-Economic and Environmental Impacts of Gravity Fed Water Supply Schemes

The project activities related to water supply have both negative and positive effects on the environment during, before and after scheme establishment. The environment according to Braun (1990) classification comprises of the natural, social and economic features of the project area.

2.3.1 Socio-Economic Impacts of Gravity Fed Water Supply Schemes

Inadequate water supply, insufficient sanitation and unsafe hygiene cause and reinforce poverty and deepen the disparity between rich and poor (Nicol, 2002). It is the rural and urban poor communities who are mostly impacted by inadequate water supply and sanitation services both socially and economically and thus lead them into a vicious cycle of abject poverty. To unlock this poverty cycle in order to achieve socio-economic development for the vulnerable group in the society, various factors have to be taken into consideration by all stakeholders involved in water supplies and sanitation provision in rural areas. Sustainable water supply and basic sanitation services under community management system might change the existing situation (International Rescue Committee (IRC), 2003).

There is no doubt that water supply and sanitation services have an impact to other DGs such as poverty, hunger, education and child mortality to mention few (Figure 2). For the case of poverty, it is obvious that household livelihood security rests on the health of its members. Illness caused by drinking unsafe water and inadequate sanitation cause a health cost that claims a large share of poor household income which could have been used for other productive purposes. In terms of child mortality, improved sanitation, safe drinking water sources and availability of enough quantities of domestic water for washing reduce infant and child morbidity and mortality (United Nations (UN), 2005). By realising the importance of water and basic sanitation services and the links to the MDGs, Figure 2 below tries to provide an understanding of the situation in rural areas in Africa where the majority of poor people make their living.

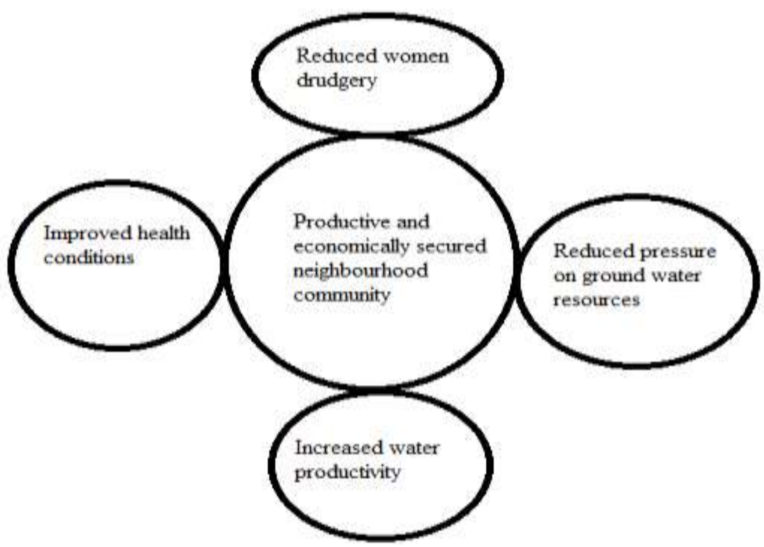

Figure 2: Socio-economic Importance of Water Supply Schemes

Source: (International Energy Agency (IEA), 2004)

Access to water supply services is an indispensable element of sustainable human development (IEA, 2004) and a pre-requisite for meeting the Millennium Development Goals (UN, 2005). Different sectors of society use water in a variety of ways. Wide variations also exist in the relative importance of water supply schemes in different countries, and therefore assessing how societies benefit from water use is very complex. In addition to economic criteria for assessing the importance of water supply schemes to society, other important criteria include human health, aesthetic and spiritual values, as well as some recognition of the intrinsic psychological and empowering value of simply having secure access to convenient water supply. Gravity Water Supply Schemes are known as one mode of providing water for both irrigation and domestic purposes towards the reduction of poverty in most developing countries (Bakis, 2007). The Malawi national water policy highlights the significance of water resource as put forward by GoM (2003) "the provision of clean potable water to all people so as to reduce the incidence of water-borne diseases and reduce the time devoted to water collection by individuals." Thus the objective puts emphasis on direct human consumption production and services sectors. On the other hand, the UN International Drinking Water Supply and Sanitation Decade adapted from Department for International Development (DFID), 2000) provide the following as objectives of water supply schemes in developing countries:

a. The provision of water for domestic consumption and personal hygiene in terms of the Water Services Authority's by-laws (government policy requires that a minimum of 25 litres per person per day be provided);
b. The improvement of the quality of the existing supplies (protection of the sources being the first consideration);
c. The improvement of the availability of water to the community (both reliability and accessibility);
d. Community involvement (acceptability) and commitment;
e. The improvement of public health;
f. The improvement of the living standards of the community;
g. The development of local technical, financial and administrative skills; and
h. The improvement of the economic potential of the community (e.g. small-scale agriculture and industries).

It is interesting to note that while domestic water needs are absolutely fundamental to our survival, the emphasis placed upon them within many water management strategies is rather low in developing countries (Katz and Sara, 2008). Unless it is an irrigation scheme by design, water allocations in most rural fed water supply schemes continue to be heavily weighted in favour of domestic usage, with often inadequate amounts being provided for economic uses such as agriculture. However, the sectoral distribution of water in Malawi (Mulwafu, et al., 2002) has been estimated to be 34% domestic, 17% industry and 49% agriculture and natural resources. Thus, agriculture and natural resources use about one-half of the country's water resources, mainly in the form of rainfall. Agriculture and natural resources deserve consideration not only because they are the largest user of water, but also because they are the largest sector of the economy generating about one-third of Malawi's gross domestic product. Moreover, for the foreseeable future, they are likely to remain a significant sector of the economy.

There are many issues to be considered in any quantification of the returns arising from the use of water, and these must not be identified using only economic criteria (Bartram and Balance, 1996). Most often in developing countries decisions about how water is managed, economic and political considerations are often given priority (Larson, Minten, and Razafindralambo, 2006). However, when assessing domestic water provision, a problem is encountered in defining appropriate measures of the returns on investments. Although monetary measures are appropriate for many criteria, certain important attributes of the value of domestic water cannot be measured in this way. For example, no definitive method of valuation has been agreed to quantify effectively the value of good health, or the lower child mortality rates normally associated with clean domestic water provision (Katz and Sara, 2008). While some progress has been made on the valuation of a range of natural resources (Katz and Sara, 2008) methods to value water supply functions and services are less developed, despite the ever-growing literature on this subject.

Looking at the returns from water supply schemes in rural areas by sector, it is observed that in some countries, different sectors play different roles in economic performance. As such, the use of water in these sectors may be a determining factor in the economic progress. The relationships between water availability, sectoral water uses, Gross Domestic Product (GDP) and the human development index can be examined using simple linear correlations in communities around gravity water supply schemes. For example, in the agriculture sector in poor countries there is some positive correlation between water use and the contribution of agricultural outputs to the overall household incomes of farmers, whereas, in richer countries, there appears to be no clear relationship (Chipofya, Kainja, and Bota, 2012). This is clearly an area of research that should be explored much further since it suggests that how water is managed within an economy can have a direct impact on the economic welfare of society.

A related issue, which merits further work, is the distributional impact (in society) of the ways in which water is managed, and how more effective water management can contribute to poverty alleviation. Examples of poor distributional impact can be seen in many of the GFS throughout the world that have been built for commercial irrigation. In many of these schemes the beneficiaries tend to be the richer members of society and/or the political elite, or male while those coping with the impacts of the scheme are often poor subsistence householders who not only do not have electricity but are also likely to lose important livelihood benefits provided by the schemes (Kalua and Chipeta, 2005). The value of water varies considerably from place to place and also from use to use. For a given quantity of water, the value derived from its use varies. For example in Malawi as of to date, the value of the water may be much higher if the crop grown is coffee than if it were maize. Crop selection has a big impact both on the use value of water and on the amount of water used from any scheme.

The establishment of gravity water supply schemes according to GoM (2010) was to reduce the distance to water points and increase productivity. Women and girls are largely affected by lack of access to water, as the (National Statistical Office (NSO), 2013) report shows that it is women who are largely responsible for collecting water (82% of females assume responsibility for domestic activities which includes fetching and handling water against only 18% of males; women spend over eight times more time than men fetching water and wood and girls spend over three times more time than boys on the same activities). This therefore relatively reduces their capacity to effectively contribute to Gross Domestic Product (GDP) and Household Income (HHI).

Unsafe water, inadequate sanitation and poor hygiene habits play a major role in child mortality in rural Africa. It is reported that about 43% of children in sub-Saharan Africa drink unsafe water and one in five die before their fifth birthday (WHO, 2010). Lack of clean water and basic sanitation is responsible for about 1.6 million preventable child deaths each year and millions more children suffer from water borne diseases such as typhoid, worms and diarrhoea (UN, 2005; UNICEF and WHO, 2005; UNICEF, 2005). The establishment of the Livingstonia gravity water supply scheme by Dr Robert Laws in 1904 was partly to increase productivity and maximize positive health returns through increased access, coverage and associated sanitation services (McCracken, 1994). According to the Ministry of Health, in Malawi, nearly 50% of all illness is related to water borne diseases (Kalua and Chipeta, 2005). Amongst many advantages of gravity fed water supply is its perceived good quality which is an important aspect contributing to combating of diseases and reducing both mortality and morbidity. Many scholars and reports allude to the correlation of availability of a water supply to positive health outcomes. WHO/UNICEF Joint Monitoring Program (JMP) (2013) argues that the rationale to support improved sanitation and hygiene interventions is to contribute to the reduction of the top leading causes of death among children under 5 years in Malawi which is diarrheal diseases (18%) and Malaria (14%). The JMP indicates that one of the strategies to achieve sufficient safe hygiene practices in rural areas is water infrastructure development including GFS. A prospective study by Lindskog and Lindiskog (2006) at Likangala gravity water supply scheme indicates the reduction of child mortality after the establishment of the scheme. This implies that access to clean water in itself may reduce mortality, but it is also a necessary pre-requisite for other intervention programmes to be efficient.

Gravity water supply schemes offer a wide range of opportunities including employment and training. Results from local studies confirm provision of employment opportunities by water supply scheme (Shams, 2010). Water monitoring assistants were deployed by Government to oversee scheme operations. In 1998 alone, 65 monitoring supervisors were employed by Government to assist in scheme major repair works (Kleemeier, 2000). The gravity fed schemes offer a wide range of training opportunities; typical are group dynamics, financial management, repair and maintenance (Shams, 2010). However, (Kleemeier, 2000) observes that the government water department due to lack of funding, training programmes have since been stopped in the 1990s. As of late, NGOs are in forefront providing capacity building training countrywide in order to maximise their efficiency in running the schemes.

2.3.2 Environmental Impacts of Gravity Fed Water Supply Schemes

The water supply projects in rural areas are classified as category 2 according to the Environmental and Social Assessment Procedures (World Bank, 2003). However, there are some notable significant environmental impacts one of which is land subsidy. This may occur on a large scale with a drop from 1 to 50 centimetres per 10 metres in the ground water level depending on the thickness and compressibility of the water bearing formations (Hinnawi and Hasbmi, 1982; UNEP, 1989 cited by Msilimba, 2000). For example, impressive cases of land subsidence have been reported in Beijing, in China, where an area of 600 square kilometres of land dropped during the period 1966-1983 (Gui and Zhong, 1989 as cited by Holmes, 2005).In Malawi, it has been suggested that the 2000 Nyankhowa landslides were caused by the leakages and overflows from the Livingstonia water supply scheme (Manda, 1999; Msilimba, 2002; and Msilimba and Holmes, 2005). It was observed that as the slump mass on sloppy hill sides bordering the sedimentation tank in the catchment area became saturated with water, pore pressure increases, initiating a failure.

Water supply projects have also a significant impact on land use (World Bank, 2003). The construction of small scale piped water supply and sanitation project may require; land for digging pipe line works, storage tanks, spring boxes, well drilling as well as sanitation facilities such as latrines and septic tanks. Such requirements end up consuming valuable acreage of productive land which could be used for farming or other activities. Furthermore, Environmental Science Discipline (2009) observes that destruction of flora and fauna is common during the construction phase of water supply projects. Concurring with Environmental Science Discipline report, Zoraki, Amaxidis, Skoulikidis and Ikolaidis, (2004) observed that drying of plants in the catchment regions could be increased due to the reduction in the moisture and or water coming to their roots from the water table.

Land pollution is also common with during the establishment of a water supply project (Carter, 1986). Land may be polluted by the materials which are used in construction works such as; oil, chemical materials, solid waste disposal, waste water of workers, and drilling of wells. Soil erosion may also be evident in the project site especially during operations and other construction and maintenance works may involve the removal of vast areas of vegetation. Removal of vegetation on catchment areas of water sources often causes soil erosion which may affect the recharge of the aquifer, and contaminate streams and drinking water supplies if silt and nutrient and pesticides laden runoff water enter them (Zoraki, Amaxidis, Skoulikidis and Ikolaidis, 2004).

Water supply schemes sometimes work as a catalyst for rapid industrial development and possible resultant population growth leading to excessive exploitation. Huabin, Gangjun and Weiya (2005) observes that withdrawing ground water from an aquifer in excess of the long -term rate of recharge may lead to depletion or lowering of local ground water tables. This may result into drying up or reduction of water yields of other water sources within the catchment area. Several studies have been carried out in different parts of developing countries concerning the rate of drop of the water table. For example; in Tamil Nadu in southern India the water table dropped 25 -30 metres in a decade (Davis, et al., 1989). In Yemen (Huabin, Gangjun and Weiya. (2005) groundwater levels fell by 20 metres in the 1970s; on the Sana's Plain as a result of the uncontrolled sinking of over 10,000 wells. One of the most obvious environmental consequences of stream water diversion is the drying up of once-perennial streams and rivers which are in hydraulic contact with the ground water that is being over drafted. Such being the case, when water yields from a catchment area fall down, the cost accessing portable water in a community increase dramatically.

2.4 Environmental Protection of Gravity Fed Water Supply Schemes' Catchment Areas

Encroachment of protected catchments, through deforestation, human settlement and cultivation of marginal lands is an issue of major concern in Malawi today. This nature of pressure exerted on the water resources brings about declining base flows, deterioration of water quality, and reduced groundwater recharge rates, increased turbidity of water in river and reservoirs and increased incidences of flood disasters (Chipofya, et al., 2009). The protection of catchment and aquifer systems that furnish rural schemes with raw water supplies is therefore clearly desirable. GoM (2003) further observes that expanding rural populations and peri-urban communities (with growth rates in the region of (12-15%) will not only increase demand, particularly for more groundwater exploitation but will also impose significant environmental pressure on local catchments and aquifers through deforestation, erosion and pollution. Therefore to maintain the hydro-environmental integrity of the existing surface and groundwater circulation, and thereby sustain the resource base, requires more comprehensive scientific understanding of catchment areas and legal protection of catchment and aquifers countrywide.

Comprehensive scientific understanding of catchment areas and appropriate policies and practices protection of catchment and aquifers involves a clear understanding of drainage systems and their landscape operations within a given watershed (Shaw, 1985). The physical approach to basin analysis also involves understanding the effects of changes in specific hydrological elements (Figure 3) on water flow (Mather, 1978 as cited in Savenije, 2002). This is because river systems have profound effects on various processes taking place in the catchment. Therefore, catchment analysis is crucial and requires scientific understanding because of its role in supporting water supply schemes (Savenije, 2002).

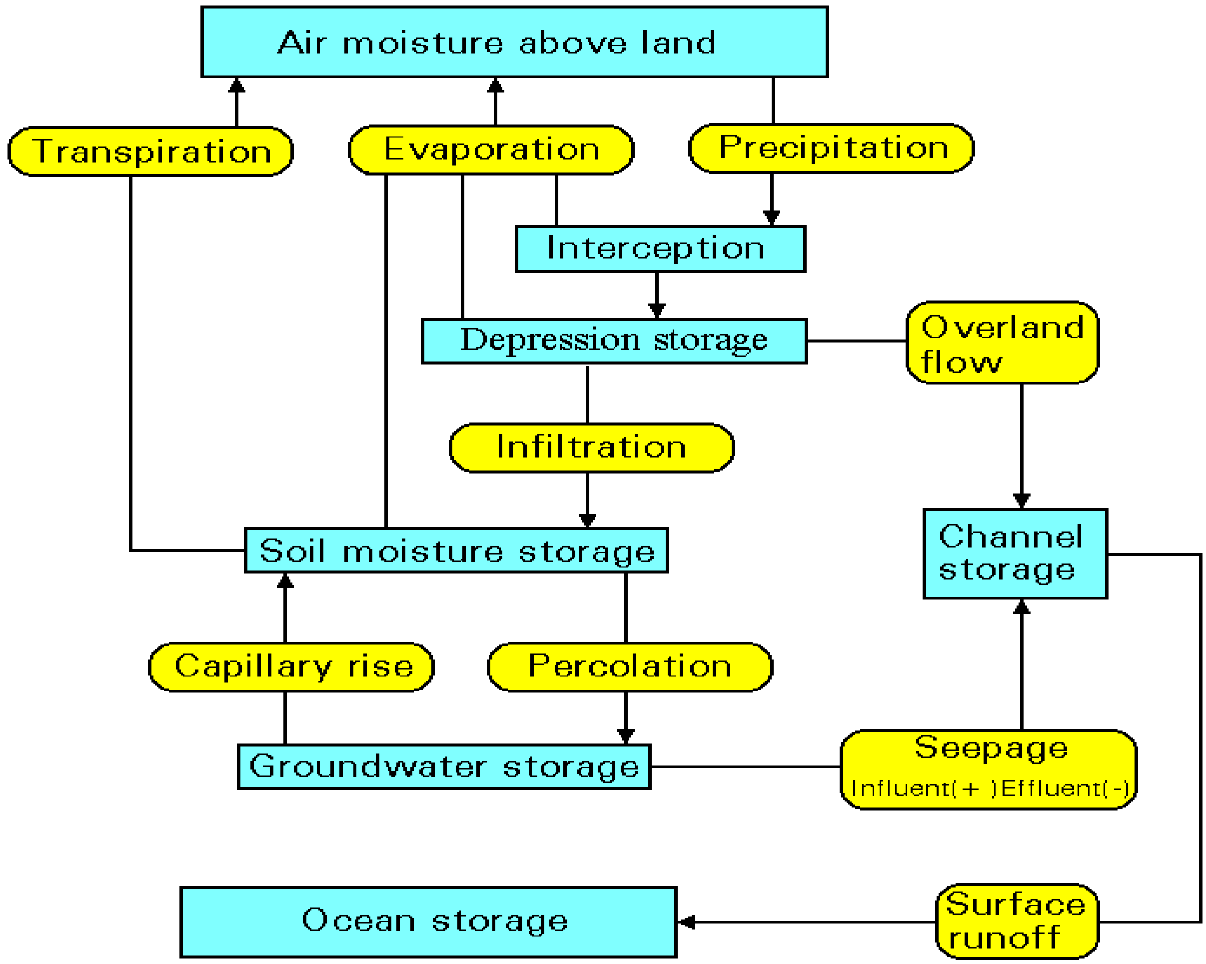

Figure 3: Catchment Area Hydrological System

Source; Savenije, and Laat (1999)

Observational studies on small watersheds in tropical, temperate and boreal region have shown that in general, a decrease in vegetation density (for example, from forest to grassland or crops) can be expected to increase annual mean water yield and discharge, while an increase in vegetation density tends to reduce water yield and discharge, consistent with alterations in total evapotranspiration and soil infiltration rates (Bosch and Hewlett, 1982). Removal of forest cover from a catchment area can result in significant hydrologic changes, including decreased evapotranspiration, decreased rainfall interception by surface litter and increased runoff volumes. Research has shown that the tree canopy can intercept 10-40% of incoming precipitation (commonly 10-20%) depending on factors such as tree species, density of stand, age of stand, location, rainfall intensity and evaporation during or after the rainfall event (Mbano, 2006).

On the other hand, withdrawal of water for irrigation leads to decreased inflow to the lake, increased salt and other pollutant discharge to the river system, and an increase in pollutant concentration in downstream river reaches (McKinney, 2001). Therefore, activities in communities within river catchments that withdraw water for various purposes need to be better understood by resource managers for proper management of the resource (Van der Zaag, 2002). Water resources engineers which are currently few in Malawi and other developing countries are primarily concerned with catchment yields and usually study hydrometric records on monthly basis (Savenije, 2002) to generate information which can guide resource planning, use and conservation. The analysis of existing data indicates that the volume of water used within gravity water schemes, for example, Lingoni catchment in Machinga district is not currently known and hence, the total volume of domestic water used within the catchment is also unknown (Wigginton and Raine, 2001). This is because there are no mechanisms for monitoring stream flow in catchment areas at present (King, 2000). The only fully operational gauging station in Machinga, for example, is on Shire River at Liwonde barrage (GoM, 2004).Many possible reasons for not having hydrometric data are available in various studies looking at water resources availability in river catchments of Malawi (Ngongondo, 2003). According to King (2000), stream discharge is the most important parameter of channel flow and its measurement usually involves consideration of both stage and velocity. Flow measurements, on the other hand, ensure maintenance of proper water delivery schedules, determination of the amounts of water delivered and estimation and detection of conveyance losses. Increased demand on available water resources, increasing the cost of conservation of the environment, demand that water be used economically and without waste, and experience shows that this cannot be accomplished without measurements of water flow (Nakapa, 2010).The most commonly used methods of discharge measurement are the velocity area technique, dilution gauging or tracers, volumetric gauging, the slope area technique, weirs and flumes, the rated section, floats and current meters (Rouen, George, Kelly, Lee, and Moreno-Ostos, 2005). Therefore, understanding the quantity of water in a catchment at different times of the year prevents its destruction from human activities such as unplanned water abstraction for various purposes.

Catchment areas of most GFS are under threats for various reasons which include encroachment for cultivation and settlement; uncontrolled bush fires, wanton cutting down of trees which is contributed by activities such as curios carvings, pit sawing, firewood collection and charcoal production (GoM, 2008). For example, the Lingoni catchment supplying Chagwa GFS in Machinga district experiences massive deforestation by charcoal burners and illegal cultivators on *Colophospermum mopane* (Tsanya) and Eucalyptus trees (Sabola, 2002; GoM, 2004). An estimated 40.067 people in Mposa and Chamba Traditional Authorities in Machinga district depend on the Lingoni catchment for their water needs (GoM, 2008b). With proper maintenance, Lingoni River can provide water that is relatively free from contamination, soft, clear and odourless; this water can be used for bathing, cooking, washing and gardening. It is therefore, important that all those using water from the catchment understand all the potential dangers of disturbing the catchment.

Before a GFS is established it is therefore important to quantify the amount of water in the spring or stream source and determine its quality in order to generate baseline data which may be used in future for purposes of monitoring its degradation or depletion (Scheltema, 2002 cited by Kleemeier, 2000). This is because no single factor is of great importance to the successful operation of a GFS than the evaluation of the adequacy of the water supply (Food and Agriculture Organization (FAO), 2002). Suitability of a water source for GFS depends on several factors such as legal constraints, quality of water (the amount and identity of suspended solids and dissolved materials in the water), and the ability of the water source to supply the total water requirement and seasonally varying requirements year after year. In case the scheme’s other main function is irrigation agriculture it is also important to determine the amount of water required when extending an existing scheme, changing the cropping pattern, designing new irrigation scheme, adding a second or third irrigation season, and switching from a crop of low water demand to a crop of higher water demand

The current Malawi National Environmental Policy emphasizes the promotion and support of the conservation and protection of forest ecosystems in catchment areas and the growing of trees by the individual companies, estates, local communities and authorities, including integration of forests and trees into the farming systems, soil conservation activities and land use systems (GOM, 2004b). This would ensure watershed conservation and sustainable socioeconomic development. Information on the impact of forest cover change on water source yields is essential for proper management of both forestry and water resources. The Environment Management Act (GoM, 1996b) deals with implementing sectoral regulations under it. Land use and management regulations were made in 1999 (GoM, 1999c) to control land use in environmentally fragile areas such as water source catchment areas. Unfortunately most of the GFS catchment areas in Malawi there are no government agencies to implement the legislation. For example, Nakapa (2010) gives the example of Lingoni catchment in Machinga district.

2.5 Summary of Literature Review

Several studies in this review confirm that safe drinking water supplies are critical to the well-being of the community and catchment protection is necessary to help avoid, minimise or manage risks to water quality. However, studies indicate that most rural gravity fed water systems in Malawi built 10-20 years ago are now experiencing a wide range of problems that prevent sufficient quantities of safe water to be equally distributed to the rural population (Kleemeier, 2001). The situation calls for a regular assessment of whether a sufficient combination of capacity and conditions is in place to enhance the likelihood of water supply system remaining functional over time in itself which will contribute to sustainability as gaps will become apparent and can be addressed. Other studies (Shams, 2010; Scheltema, 2002) lobby for scheme-based monitoring framework for GFS, which may be used to assess whether a sufficient combination of capacity and conditions is in place to enhance the likelihood of the system remaining functional over time. Such regular assessment at the local level in long run generates a consistent and comprehensive water resource information database which is valuable to effective decision making in water resource management.

Accurate and reliable information on the status of water supply and sanitation services on a community, district and regional basis is essential for effective planning and management. Such information can only be available if a water supply and sanitation monitoring system exists as an integral component of the sector's institutional structure. In Malawi the absence of such a system has been identified by a number of scholars as a major constraint to sector development (GoM, 2001). It has also resulted in progressively deteriorating levels of service and gravity systems have had to operate under capacity. All this has happened without the real scale of the problem being appreciated. In nutshell, the importance of water resource information in our present situation needs not to be overemphasised.

Finally, in relation to sustainability and best performance of gravity fed water supply schemes in Malawi reviewed literature support community based water resource management and local level IWRM (Chilima, et al., 2003). However, the Community Based Management (CBM) approach in the country is subject to a number of organisational challenges and problems that need to be addressed. These include problems of non-functional committees, non-functional water facilities, under- performing GFS, poor coordination, poor monitoring, failure to address gender issues, and poor recognition of community labour and time costs.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Introduction

Presented in this chapter is a description of methods used to generate samples, data collection and analysis and presentation. The chapter also covers the description of the study area and ethical considerations.

3.2 Research Design

This study was a cross sectional survey with two phases. The quantitative phase included hydrometrics thus water measurements in terms of tap delivery rates, stream discharge rates, laboratory testing of water and physical inspection of water taps. The qualitative phase involved the characterization of water resource and facilities management the villages serviced by the scheme. Based on the results from the two phases recommendations were proposed for improving the status and management system of the water facilities. The study used a mixture of data collection instruments. The research methods included; administration of a semi structured questionnaire to households, focus group discussions (FGDs), and key informant interviews (KIs) with water officers. Observations of water facilities, water quality experiments and hydrometrics were also used.

3.3 Research Study Area

Rumphi is one of the 28 districts in Malawi located in the northern region. It is bordered by Chitipa in the north, Karonga in the north east, Mzimba in the south and Nkhata-Bay in the south east. The district is approximately 70 kilometres from Mzuzu, the Northern Region’s commercial hub and 435 kilometres from Lilongwe, the capital city of Malawi. According to Rumphi district socio-economic profile the total land area of the district is 4,769 square kilometres making about 4.03 % of the total area of Malawi (118 484 square kilometres) and 5.05% of the country’s total land area (94 276 square kilometres) (GoM, 2008). The district is predominantly hilly with some few valleys. The study was carried out in selected villages in Livingstonia gravity water supply scheme catchment areas, Traditional Authority (TA) Mwalweni of Rumphi district. This TA is chosen because it is one of the oldest area in Rumphi which has benefited from missionaries’ gravity water supply projects its proximity to perennial springs along the border of Nyika plateaus. It is also an area among others where people rely on agriculture as a means of livelihood. This TA is almost identical with other TAs in the district with respect to its layout, ethnic composition and socio-economic status and is believed to be representative of other areas that rely on gravity fed piped water supplies in Rumphi.

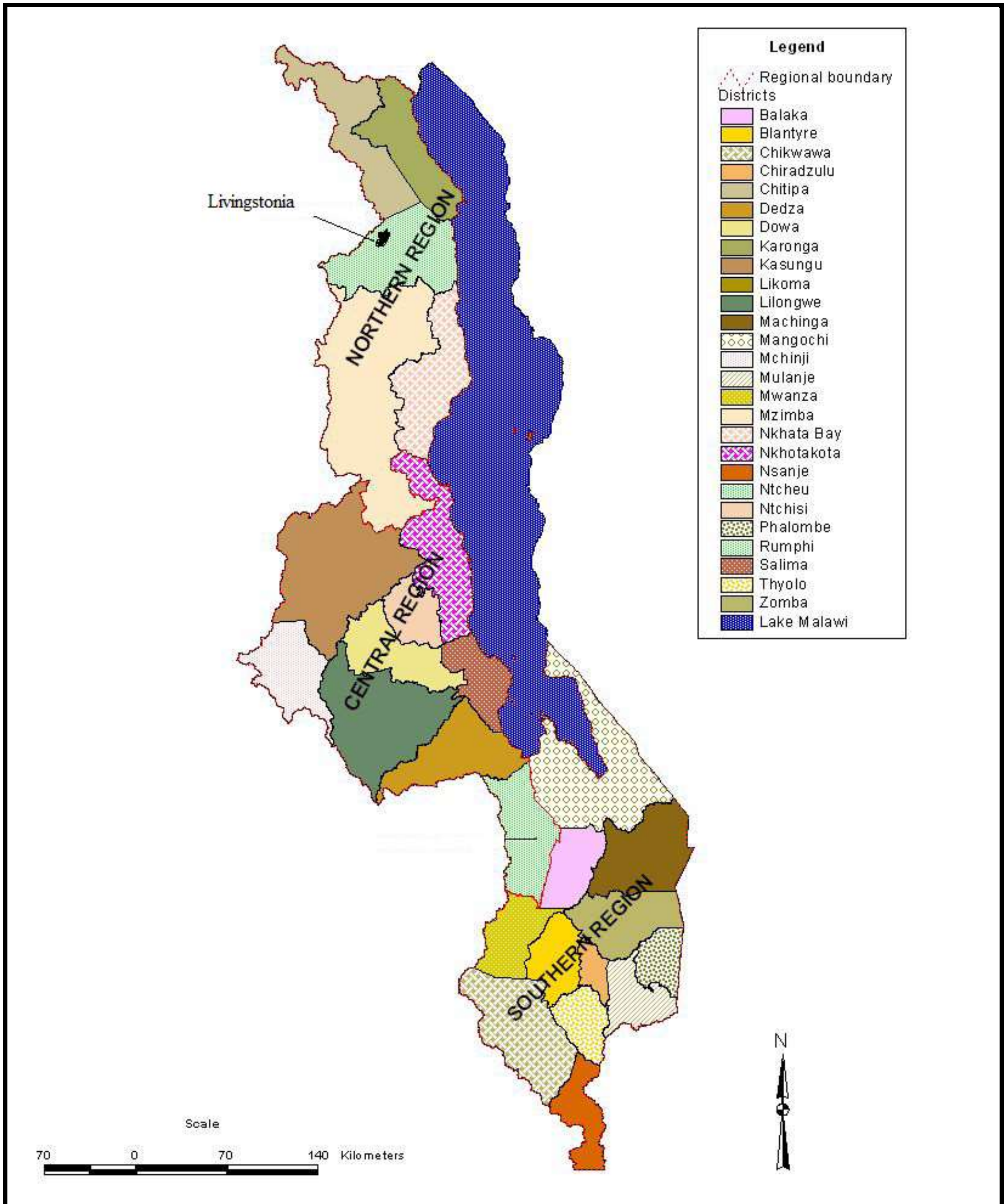

Figure 4: Map of Malawi Showing Location of Rumphi District and Livingstonia

Source: GoM (2008c)

3.3.1 Description of the Livingstonia Area

Livingstonia (Figure 4) lies at the centre of the Uzumara area. It is bounded on the western side by longitude 34^0 12'E and on the south by latitude 10^0 06'S (Kemp, 1975; and GoM, 1977) with the highest altitude of 1400metres above the sea level located at the crest of the eastern escarpment of the Nyika plateau (Kemp, 1975). The place was formerly known as Kondowe and named Livingstonia after a Scottish missionary Dr Livingstone who was the first missionary and Scottish explorer to visit Malawi in the 1850s and urged British missionaries to come to Malawi to encounter slave trade which was destabilising people (McCracken, 1994). The rivers draining the plateau have cut gorges through these escarpments and the smaller subsequent streams flow in deeply incised courses many of which include waterfalls, a good example is the Mantchewe falls where first hydro- electricity was generated in Malawi following the construction of gravity fed water scheme in 1904.

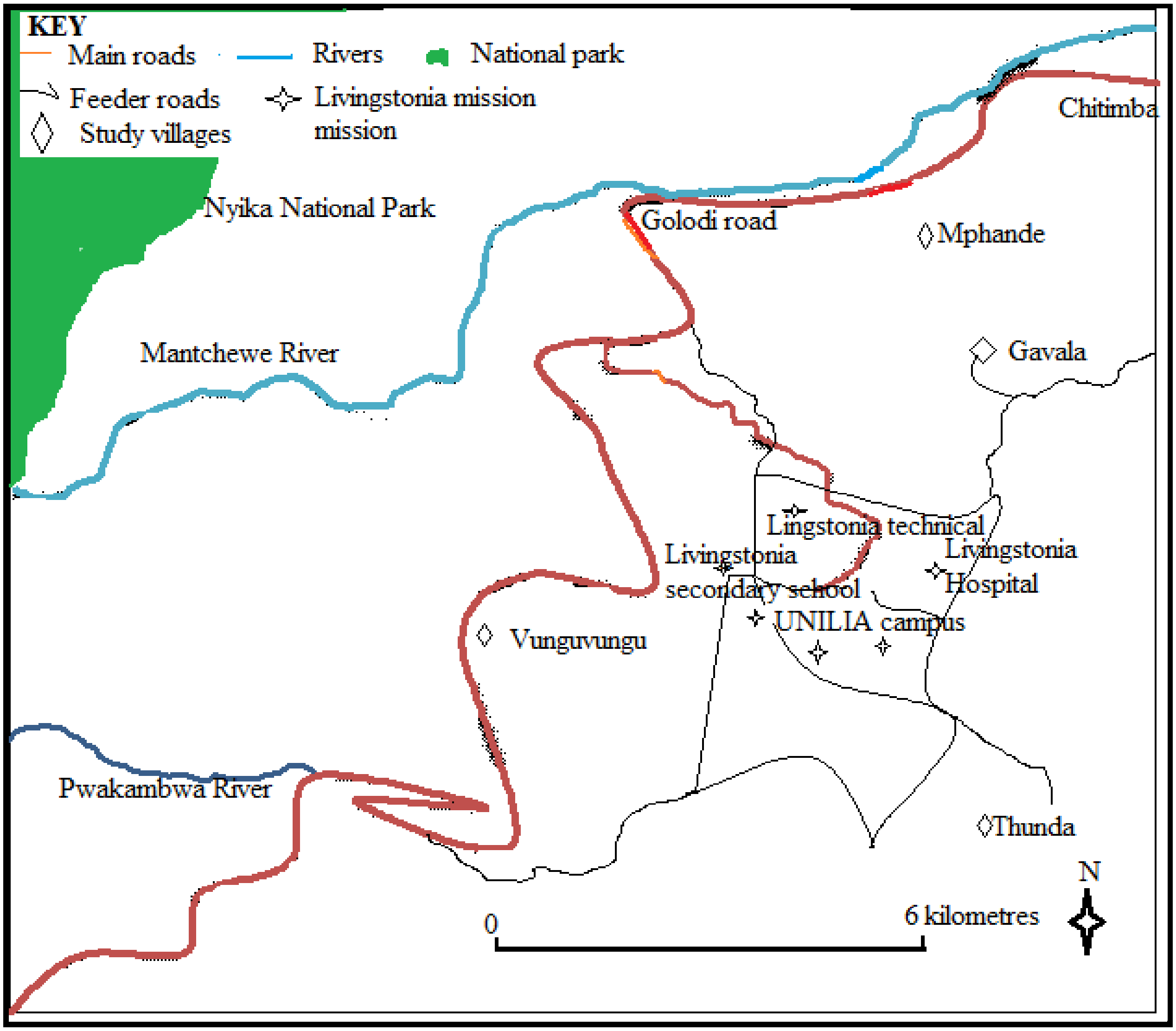

Figure 5: Map of Livingstonia Showing the Study Area

Source: Kalua (2007)

The geology of Livingstonia is made up of igneous and metamorphic rocks (GoM, 2005). The Nyika Plateau on the western part has granite, while the rest of the low plateau area consists of schists, quartzites, gneisses and granulites. The soils at the plateau are generally ferrallitic with *ferrisols* and *lithosols* on the low hill and slopes (Kemp, 1975; and GoM, 1977). Humic ferralitic soils are mostly found in high altitude areas such as Mumbwe where the CCAP mission was located. Vegetation in major parts of the catchment consists of open woodland of *Brachystegia* and *Julbernadia* types. The highlands have rolling grassland and scrub-lands covering most of the area while other parts are covered with woodlands. Temperatures at Livingstonia vary between 18^0 to

21^0 Celsius with annual precipitation of 1200mm to 1600mm whose distribution is controlled by the eastern moisture laden and south easterly winds from October and March (GoM, 2009). Due to the adjacent location of Livingstonia to Lake Malawi and its hills rainfall is primarily orographic, with convectional activities. Agriculture is the most important activity being carried out in the area. The majority of the people living in this area are subsistence farmers. The main crops grown in the area include maize, cassava, millet, sorghum, bananas, and vegetables. Coffee and tobacco are grown as cash crops but on a small scale. The Phoka people herd animals, mainly goats and they are also hunters. However, in recent years, large-scale developments of tea and maize by smallholder farmers have brought large areas in the south western part of the plateau under rain fed agriculture resulting in deforestation of the natural vegetation. Livingstonia is a small community of 15,000 inhabitants (NSO, 2013) but with the following social service institutions; hospital, police unit, post office, university, technical college, secondary school, primary school, churches, markets and many others. Villages within the Livingstonia area tend to be scattered and isolated. In most of the villages, houses are built along ridges although some are built along slopes. Due to the nature of the terrain, with its dissected deep valleys and interlocking spurs, houses tend to be isolated and built in a linear pattern.

3.3.2 Livingstonia Gravity Fed Water Supply Scheme

This scheme is the oldest one in Rumphi which was installed by Dr Robert Laws in 1904 as part of Missionary work at Livingstonia (McCracken, 1994). Numerous streams originate from the Nyika plateau via Nyankhowa hills flowing through Livingstonia area. Most of these are perennial due to the high rainfall that the area receives and the ability of the soil and weathered basement complex to absorb and store much of the precipitation (Msilimba, 2000). However, the perennial rivers show marked seasonal variation with rainfall. Following the commencement of the rains in November/December, discharge from the perennial rivers increases progressively to a maximum in February or March (Holmes, 2005). The most notable rivers flowing out of the area are Kazichi, Kajoni, Lwatizi, Phwakambwa and Wambuto Rivers. These join the Mantchewe River which flows eastwards to join Lake Malawi at Chitimba. The water table is high on the eastern border of Nyika plateau which supports numerous perennial springs flowing through Nyankhowa hills to Lake Malawi. The source of water for this water project is Nyankhowa hills (Kalua, 2007). Nyankhowa hills located in Mwembe village have two perennial streams which supply water to the GFS namely Makandiro and Nyankhowa. The scheme mainly provides domestic water through pipes to all institutions at the plateau and standpipes to surrounding villages such as Mantchewe, Vunguvungu, Mphande, Bale Kajoni, Khuyu, Chituzulo, Lwatizi, Nkhando and Thunda (appendix 2). The water is partly treated, only sedimentation process by gravity and rarely monitored by government water department officers. Besides students and staff members of institutions at Khondowe statistics from 2010 indicates that the scheme benefits 5,000 households while the remainder is served by boreholes and shallow wells.

3.4 Population and Sample

To address the objectives of this research, households, standpipes, water samples, streams, Khondowe Water and sanitation Association (K-WATSAN) Livingstonia Catchment Conservation Committee (CCC) and key extension officers comprised the population of the study. Appropriate sampling procedures were employed in-order to increase the validity of the results. This was given more consideration because it is assumed that a large sample with a poor sampling design probably contains less information than a smaller but carefully designed sample (Creswell, 2009). To generate samples from the population below are procedures which were followed.

3.4.1 Villages, Households and Water Taps' Sampling

In the first place, simple random sampling method was used to pick the five villages to be studied. To arrive at the sampled villages, the list of villages benefiting from the scheme was assigned numbers in ascending order on Windows Microsoft excel sheet (Edriss, 2003). The computer program was instructed to generate five (5) random numbers from the list representing the study sample. In the second place, the issue of sample size was addressed by employing a sampling formula as indicated (Equation1) adopted from Sabola (2002) to generate an appropriate sample.

$$\mathbf{K} = \mathbf{N}/\mathbf{m} \qquad (1)$$

Where K= the sample frame or interval

N= the total number of households benefiting from the scheme

n = the sample size

According to K-WATSAN by the time of the study there were in five thousand households benefiting portable water from the scheme. Therefore a sampling interval of fifty was used to develop an appropriate whose calculations went as follows; n=5000/50 which gave 100 households.

To pick the 100 households from the five sampled villages, simple random sampling was employed. A list of all households from the five selected villages was sought from K-WATSAN. Through Microsoft Excel 100 random numbers were generated to represent the actual households to be included in the study sample.

Using the very same Equation1 and simple random sampling and Microsoft Excel unbiased sample of 40 taps was included in the study. According to statistics from K-WATSAN, there were 400 taps installed by Rotary club and other institutions run under the scheme. In this case, an interval of 10 was used.

3.4.2 Key Informants', WATSAN, CCC, Stream Sampling

From the scheme catchment area, five (5) officers from different institutions with a stake in water issues were selected through purposive sampling technique. The sample was based on the degree of their involvement in water development issues of the scheme. Much preference was given to extension workers who have lived in the area for not less than five (5) years.

Since there is only one WATSAN and CCC and main/perennial stream feeding the water source (Nyankhowa) these were included in the sample purposively.

3.5 Data Collection Procedures

Below are procedures which were employed to collect both primary and secondary data of the study.

3.5.1 Household Questionnaire

Household questionnaires were used (appendix 3) to collect data on a number of objectives of the study. The questionnaire had both open-ended and closed-ended questions (semi-structured questionnaire). In the interview heads of household or their spouses were the respondents. In the event that the head of household was not available, one adult in the responding household was interviewed. Each interview took an average of 30 minutes. A total of hundred (100) household respondents were interviewed over a period of four weeks in November thus before offset of rains. Due to the isolation of settlements and relief barriers the interview extended to December, 2014.

3.5.2 Focus Group Discussions

To assess policy understanding and practices related to water source catchment management amongst community members, Focus group discussions with the Livingstonia Catchment Conservation Committee was also conducted to complement the information obtained through the household survey. Guiding questions (Appendix 4) were used for smooth facilitation of the discussions. This method was employed, firstly, because some answers on the household questionnaire were expected to build on group consensus rather than individual opinions since water facilities are both individual and community assets. Secondly, it allowed clarification and follow up questions; thirdly, it allowed the participants the chance to respond to the comments of the other participants. An audio-tape recorder was used during the discussions to ensure that the participants' responses were fully captured. The discussions were conducted after household interviews and inspection of the water facilities.

3.5.3 Key Informants Interviews

A volume of information was collected such as socio-economic and environmental effects of the scheme. Similarly, Livingstonia water supply scheme history, institutional arrangement, environmental policies and practices weres collected through informal interviews with the key informants, some of the guiding questions are indicated in (Appendix 5). These included; members of Khondowe WATSAN, Agriculture Extension Officer (AEO), Forestry Officer, Health Surveillance Assistant, Village headman, Community member, Community Development Assistant, the Dean of Applied Sciences at University of Livingstonia. Besides exploration of data on some other research questions, interviews were also done to verify as well as to affirm some of the issues that were raised during the FGDs.

3.5.4 Observation

In the study, observation technique was used to assess the status of water facilities and utilisation. This served as a condition survey which according to Cammack (1999) simply means the physical inspection, in this context the water facilities. A digital camera and a checklist (appendix 6) were used to collect the data. Typical items that were checked included the following; functionality of water facility, water yield, condition of drainage system, soak away pit, standing slab, and apron, tightness of bolts and nuts, signs of rusts, cleanliness of the surrounding area, distance between water point and latrines, household waste areas and animal watering points. A total of forty (40) water points were inspected.

3.5.5 Stream Discharge Measurements

In this study, stream flow measurements and tap delivery rates were particularly done to provide water resource managers with baseline data for planning and monitoring purposes in the light of decreasing of water flows due to climatic changes and increased discharge by growing population in the area. The measurements in this study were conducted at the end of the dry season (October). .According to the researcher's personal experience after staying in the area for five years the flow rate was the lowest in October.

Velocity area stream flow method - neutrally buoyant object procedure or float method was used to measure river discharge because Nyankhowa was not gauged. In this method, stream velocity and water depth measurements were taken along a transect perpendicular to the stream. Total stream flow or discharge (Q) was estimated by integrating the stream velocities with the cross sectional area of the stream profile defined by the transect. Jamu and Chimphamba (2005) showed that the discharge obtained from float methods were not significantly different from those obtained by using a current meter. The method was also chosen because it is one of the simplest for determining river discharge (Jamu and Chimphamba, 2005)

The average area of the stream cross-section (A) was calculated using the following formula (Equation2) by FAO, (2001)

$$A = \frac{(\mathbf{b}+\mathbf{a})}{\mathbf{2}} \qquad (2)$$

Where:

A = stream cross-sectional area

b = the streambed width

a = the surface water width

h = the water depth (height)

The average flow velocity (V) was calculated using the following formula (Equation 3) by FAO, (2001);

$V = 0.8Lt$ (3)

Where:

V = stream flow velocity

t = the average travel time of a float object in seconds

L = the distance travelled by the float object between two points

0.8 = a reduction factor because not all the water flows as fast as that in the centre

Therefore, river discharge (Q) for Nyankhowa was calculated using the following formula (Equation 4) provided in FAO (2001):

$Q = V.Am^3/s$ (4)

3.5.6 Tap Water Flow Rate Measurements

Through pipe and bucket method, water delivery rates of forty (40) sampled taps of the scheme were measured. Tap flow rates were measured by recording the time taken to fill a container of known volume (MoWID, 2009). A stop-watch was used for timing. The water was collected three times on the day of investigation and mean values were calculated and recorded. Using the formula (Equation 5), the flow rates were calculated (Savenije; and Laat, 1999).

$Q = C/t$ (5)

Where;

Q = Flow (liters/second)

C= Capacity of container (liters)

t = time to fill (minutes)

3.5.7 Water Supply Infrastructure Quality Assessment

The researcher developed a monitoring framework and a rating system which was employed to assess the status of water facilities in the study area based on a number of parameters for each variable met or unmet on the checklist as outlined below. Equation 6 was used to calculate water Infrastructure index.

$WIQI = 100 - (F_1 + F_2)$ (6)

Where,

WIQI = Water Infrastructure Index

F_1 = The percentage of parameters, whose guidelines are not met.

F_1 calculation:

$$\frac{\text{Number of failed variables}}{\text{Total number of variable}} * \frac{100}{1}$$

F_2 = The percentage of individual tests which do not meet guidelines

F_2 calculation:

$$\frac{\text{Number of failed test}}{\text{Total number of tests}} * \frac{100}{1}$$

Table 4: Water Infrastructure Quality Index Rating System

Percentage	Quality
81-100	Excellent
61-80	Good
41-60	Fair
21-40	Marginal
0-20	Poor

3.5.8 Laboratory Experiments

Selected physico-chemical and microbiological water quality parameters were tested through laboratory analysis of water samples collected from fourty (40) sampling points (taps). The following water quality constituents namely Alkalinity, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Power of Hydrogen ions (pH), Suspended Solids, Turbidity, Total Hardness, Nitrate, Sulphate, Temperature, Ammonia, Faecal Coliform and Total Coliform bacteria. The water quality data generated was evaluated against Malawi Beaural of Standards (MBS) (MS678:2005) Standards and WHO guidelines for drinking water.

EC and TDS values were determined using calibrated Vernier Conductivity Probe connected to the calibrated Lab Quest, a digital device where the registered electrical conductivity value was automatically converted to give TDS value. The power of hydrogen ion (pH), turbidity and temperature values were measured using calibrated vernier pH sensor. Vernier turbidity sensor and Vernier temperature sensor were both connected to calibrated Lab Quest digital device.

All water samples from the forty taps were tested for contamination by total coliforms and *E. coli* bacteria. Bacteria analyses were performed with 3M Petrifilm® ChromoCult Coliform Agar together with a membrane-filtration unit and portable incubators. Analysis with the Petrifilm was done in one of two ways. In the case of the samples that were suspected to be highly contaminated, 1ml of sample water was applied directly to the agar film. When a lower level of contamination was suspected, 100 ml of sample water was passed through a 0.47-mm filter paper using a sterile membrane-filtration unit. After filtration, the filter paper was placed within the agar film which had been pre-wet with 1 ml of sterile water. Subsequently, the Petrifilm plates were incubated at 35ºC for 24 hours and the colonies were counted, with blue colonies indicating *E coli* bacteria and red colonies indicating total coliforms. Bacterial concentrations were recorded as colony-forming units per 100 ml of water (CFU/100 ml). The number of counted colonies for the 1-ml samples was multiplied by 100 to maintain consistency of units for concentrations. All bacterial analyses were performed in duplicate; the reported bacterial concentrations represent the average of the 2 analyses.

Alkalinity and Total hardness values were determined by a titrimetric method using 0.0100M H_2SO_4 and 0.010M EDTA respectively, whereas Ammonium and Nitrate were determined using Vanier ammonium ion-selective electrode and Vanier nitrate ion-selective electrode. Heavy metals were determined using Metalyser Deluxe HM2000 at preselected wave-length to measure the absorbance of the metal in the water sample. Suspended Solids values were also determined using UV/VIS spectrophotometer set at a wavelength of 810nm.

3.6 Pre-testing of Methodology

In order to assess the clarity of the questions, the practicability of the study, and correctness of the sample and to double-check the quality of the instruments to be used for data collection, the pilot study was carried out. This was done in Bale-Kajoni village which was included in the actual study. In this exercise, the household questionnaire was administered to twenty (20) respondents and ten (10) water points were visited for inspection. Three FGDs were conducted of which one was with mixed sexes and the other two with single opposite gender only. This exercise assisted the researcher in modifying some of the things, which were deemed possible obstacles to the study.

3.7 Data Analysis and Presentation

Data collected from the questionnaire survey and observation checklist was analyzed using the Statistical Package for Social Science (SPSS) version 16.0 for Windows. The questionnaires were given numbers for identification purposes. Each question was identified by a variable name and within variables there were values and value labels for identification of responses from the respondents. After coding the information from the questionnaires, a template for entering data in the computer program was created. The coded data was then be entered in the SPSS computer program where descriptive statistics for example; frequencies, mean, standard deviations and cross tabulations were computed during the analysis.

Information collected from FGDs and key informant interviews weregrouped together according to the checklist questions and category of respondents and summarized in tables according to the questions and respondents to make it easier for comparisons between different groups on specific issues. Using content analysis qualitative data was analysed. The identified topics and key words were then summarized and interpreted. Since the interviews were carried out in Chitumbuka (A common local language in Rumphi district) the transcripts were translated into English. Different views from different groups were also taken into consideration during interpretations.

Values obtained from water quality data were analysed using Loger Pro and later compared with MBS (MS678:2005) and WHO guidelines on drinking water. Microsoft excel graphics and tables were used to present the results while Microsoft word software program was employed to present qualitative results in form of narrations.

3.8 Recruitment and Training of Research Assistants

The study needed the assistance of two research assistants with Bachelor of Environmental Science degree from Laws Campus, the constituent college of the University of Livingstonia. Their choice was based on their previous exposure to such kind of research work and familiarity with the study area. Before commencement of the study they were briefed on background and aim of the study, their expected conduct in the study and administration and mechanics of the various data collection techniques to be used. Their competence was assessed during the pilot study.

3.9 Ethical Considerations

In the first place permission was sought from the Malawi Polytechnic (Appendix 7). Before administration of the survey questionnaire a consent form was first issued (Appendix 8) to ensure that the study participants were treated ethically. The signing of the consent form by each participant before taking part in the study guaranteed all their freedoms and rights. The pictures used in this study were only taken after permission was sought from the owner. Intellectual property rights were respected through proper acknowledgement and citation of all borrowed work.

CHAPTER FOUR: RESULTS, INTERPRETATIONS AND DISCUSSIONS

4.1 Introduction

This chapter presents analyses and discusses results of the study by firstly describing the sample characteristics of water users, water resource, water facilities and overall issues and challenges affecting the Livingstonia gravity water supply scheme, and the protection and conservation of its water source catchment area.

4.2 Sample Characteristics

Researchers take it as a miscalculation talking about study findings without considering some significant sample characteristics which have a bearing in understanding links and association among various variables (Kaombe and Namangale, 2012). It was, therefore, necessary to discuss sample characterization in this section before proceeding with the presentation of the actual study results based on study objectives. As indicated in Table 5 below the study involved 100 respondents both males and females from five villages in the following proportions; Gavala (16%), Thunda (22%), Vunguvungu (19%), Mantchewe (26%) and Mphande (17%).

Table 5: Respondents' Demographic Characteristics

Villages %	**Education status %**	**Marital status %**	**Gender %**
Gavala 16	None 14	Single 24	Male 40
Thunda 22	Primary 59	Married 62	Female 60
Vunguvungu 19	Secondary 22	Divorced 5	
Mantchewe 26	Tertiary 5	Widow/widow 10	
Mphande 17			

4.2.1 Location, Household size, Gender, Age, Education and Marital Status of the Respondents

The majority of the respondents were from Mantchewe village as indicated from the Table 5. As earlier alluded to, mountains with steep slopes separated by wide valleys characterize the topography of the Livingstonia area (Figure 6).

Figure 6: Sparse Population at Livingstonia

Figure 7: Compacted Mantchewe Village

Mantchewe on the other hand has at least an extensive flat valley with compacted settlement pattern (Figure 7). Apart from flat terrain, most settlements from the past have a tendency of being located along or close to the main road. As indicated from its imagery Mantchewe is located along Gorodi road joining Livingstonia to the Mzuzu –Karonga main road at Chitimba.

Although 69% of the households in Malawi are jure facto male headed (NSO, 2000), in this study as indicated in Table 5 above, the majority of respondents were females. This coincides with the demographic structure of Malawi, where 52% are males and 48% of the population is female (NSO, 2010). Of all the respondents, 9.3% had lived in the areas for less than 10 years, while 90.7% had lived in the study areas for more than 10 years, with the majority having lived for more than twenty years. The higher rate of female respondents could be due to the fact that in Malawi traditionally or culturally, water collection and storage in the home is predominantly the responsibility of women and girls. As such in most of the households the researcher visited, women and girls were given priority to answer the administered questions because men in those households thought that traditionally women are influential in any decision regarding communal water supplies. This was owing to the fact that they are directly engaged in the management of domestic water supplies at homestead level. In addition to this, most of the households in the rural areas of Malawi are de facto female headed because this is where the economic crisis has pushed men to migrate to cities in search of extra incomes to support their families.

The study has also revealed that majority of the respondents were married and a few divorced. The high proportion of married may be explained by the fact that majority of the respondents were women and all of them had reached Malawian minimum marriage age and also owing to the fact that cases of divorces among the Tumbukas in rural areas are relatively lower compared to other tribes such as the Yao according to in 2010 Malawi demographic and Health Survey (MDHS) report (NSO, 2013).

Literacy is defined as the ability to read and write in any language (NSO, 2013). The level of education of any individual is an indispensable factor that determines the life style and status the individual enjoys in a society. It affects many aspects of life including the individual’s ability to receive information and capacity to learn and be able to project issues from one generation to another. Each respondent was asked about the highest level reached. The majority of the respondents as indicated in Table 5 completed primary school education implying that they can be able to read and write at least one particular language. This result is very high in comparison to district rate of 8.5 in MDHS 2010 report (NSO, 2013). This may be explained by the fact that missionaries came with formal education at Livingstonia as early as 1896. The early establishment of a secondary school, Technical College and University by Scottish missionaries at Livingstonia probably has a significant influence on higher literacy rate against national figures.

The education levels in the area are exceptionally high unlike other rural areas of Malawi. This scenario is very supportive to environmentalism because in absence of access to formal education, opportunities available to most people will continue to be limited, with possible negative influence on the environment and water in particular. Education empowers a society to understand and articulate the socio-economic and environmental issues affecting their lives. Studies conducted by UNEP, UNDP and World Bank, 1996 as cited by Phalira (2006) have shown that education coupled with employment, especially of women, yields substantial improvements in environmental management. On the other hand, lack of adequate educational background amongst the farmers poses a very big threat to water. This is because in most cases, water is taken as a public resource, hence; it is always wasted by its users (Van der Zaag, 2002). The situation in Livingstonia water supply Scheme is further worsened by the fact that women, who are the custodians of water resources management and conservation, have a lower literacy rate than men.

The size of the household has a significant bearing on household welfare and water demand. Economic resources are often more limited in larger households. Moreover, where the size of the household is large, crowding also can lead to health problems which exert more pressure on household income depriving other priorities such as water user fee. The 2010 MDHS results indicate that the average household size is 4.6 persons, with rural households (4.7 persons) having slightly more members than urban households (4.4 persons). As indicated in Table 6, this is slightly higher than the district's mean size of the household of 3.8 persons (NSO, 2013).

Table 6: Household Composition

Respondent age		**Number of people in HH**
Mean	45.44	5.23
Mode	29	4
Median	20.7	2.719
Minimum	15	1
Maximum	85	10

In addition, based on results indicated in Table 6, the study included almost all ages in the productive bracket. The mean age of 45.44 was considered old enough to be able to give in depth knowledge of water issues. Demographically, it can be concluded that Livingstonia area is dominated by a young generation. This is consistent with national population composition that has more than 60% of the Malawian population comprising the young generation (GoM, 2004)

4.2.2 Respondents' Socio-Economic Characteristics

Household socio-economic status has several implications on water utilization and management of water facilities and protection of water source catchment areas. A household with high economic status has the capacity to contribute towards the maintenance of water facilities and at the same time has a wide range of energy options rather than firewood which is to blame for rampant removal of forests cover in water source catchment areas. However, due to limitations of employing direct estimation methods of the economic status of households or asking the total annual income of the household, similar studies such as Multiple Indicator Survey (MICS), Malawi Demographic Health Survey uses many and different proxies (NSO, 2013). In this study, among so many as indicated in Table 7, proxies of a household's wealth/income, the occupation, type of roofing materials and the possession of assets were used.

Table 7: Respondents' Socio-economic Characteristics

Wealth possessions	%	Type of roofing materials	%	Occupation	%
Radio	65	Thatched grass	79	Farming	57
Television	14	Iron sheets	19	Business	23
Car	4	Tiles	2	Casual labor	12
Bicycle	3				
Motorcycle	2				
Head of cattle	11				
Ox cat	1				

The assets such as radio, bicycle, motorcycle, motorcar, oxcart, television and herd of cattle and roofing material with which the house is made of were used. The major primary activity of the respondents was domestic workers on family farms, results also show that few respondents were engaged in secondary activities. The major economic activities in the area are farming, small businesses and casual labour in estates. This scenario has a negative implication on natural resources use and management in Livingstonia GFS water source catchment. This is because without other means of livelihood, most of the activities by the local communities are mostly based on natural resources such as charcoal manufacturing and trade of non-timber forest products (NTFPs). The 2008 Malawi Housing and Population Census (MHC) indicated that about 79% of houses in rural areas of Malawi are grass thatched (NSO, 2013). This study indicated that most of the households had their houses with grass as the roofing material. The higher proportion of grass thatched roofs is a clear reflection of low income of the households surveyed because corrugated iron sheets are regarded as expensive roofing materials in the country.

The availability of durable consumer goods is a good indicator of a household's socioeconomic status. Moreover, particular goods have specific benefits. For instance, access to a radio or a television exposes household members to innovative ideas in the management and utilization of water and other related issues. The majority of the respondents had radios in the study area. In Malawi, the radio with its countrywide coverage has the largest audience; hence its effective impact on the dissemination of information about water and environment. Two of the current radio programmes aired by the Malawi Broadcasting Corporation (MBC) that could be utilized in this respect are; "You and the Environment" and the vernacular one, "Madzi ndi Moyo". The former deals with environmental issues in general whereas the latter is specific to water. According to the NSO (2013) report, forty four percent of the households own a bicycle (30 percent in urban areas and 47 percent in rural areas). However, ownership of bicycles in the study area is very contrary to national rural figures due to poor terrain of the area. The same reason also applies to ownership of oxcarts, motorcycle and cars.

The ownership of herds of cattle among the Phoka (dominant tribe of the area) is a very significant indicator of wealth that is why it ranks third. However, this is very low in comparison to national figures whereas farm animals are owned by 60% of households (66 percent in rural areas and 27 percent in urban areas) as indicated in MDHS 2010 report (NSO, 2013). In general, the results in this section clearly indicates low household income due to high figures of grass thatched houses and few respondents with herds of cattle in the area.

4.3 Water Accessibility and Utilization

One of the Millennium Development Goals (MDGs) that Malawi and other countries had adopted is to increase the percentage of the population with sustainable access to an improved water source in both urban and rural areas. Improved water sources (NSO, 2013) refer to a household connection (piped), public standpipe, tube well or borehole, protected dug well, and protected spring or rainwater. This section includes a number of indicators that are useful in monitoring household access to improved drinking water.

4.3.1 Households' Main and Alternative Sources of Water

Both rural and urban areas in Malawi face issues with water distribution and utilization. Many lack the water infrastructures. However, even communities with existing water infrastructure face inequalities in water. Many existing water distribution systems in most schemes are inefficient and unmaintained and lead to the overall decrease in safe water coverage. Various sources of water exist in the study area including boreholes, wells, springs, and swamps, standing taps, rainwater and wells. In this study, the most frequently used and convenient source is referred to as "main" and the "alternative" as a substitute. As it is in most developing countries, households in this study utilize more than one type of water source for drinking and other purposes. However, the descriptive results presented in Figure 8 are based on the main source of drinking water used by the sampled households.

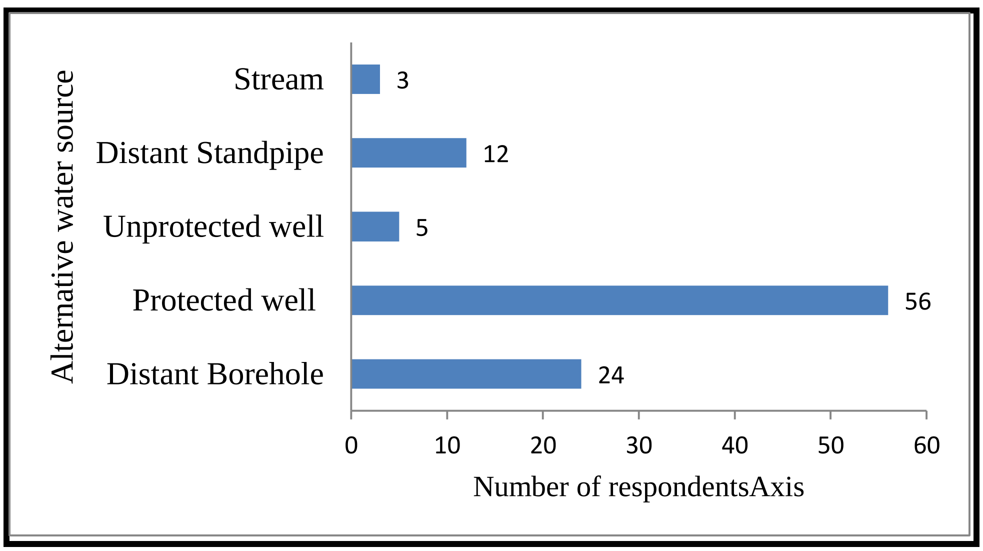

Figure 8: Main Water Source

Despite the multiplicity of sources, majority of the respondents in the study area used standpipes as their main water source. Standpipes are in a category of protected water sources. Only few respondents reported to use unprotected sources.

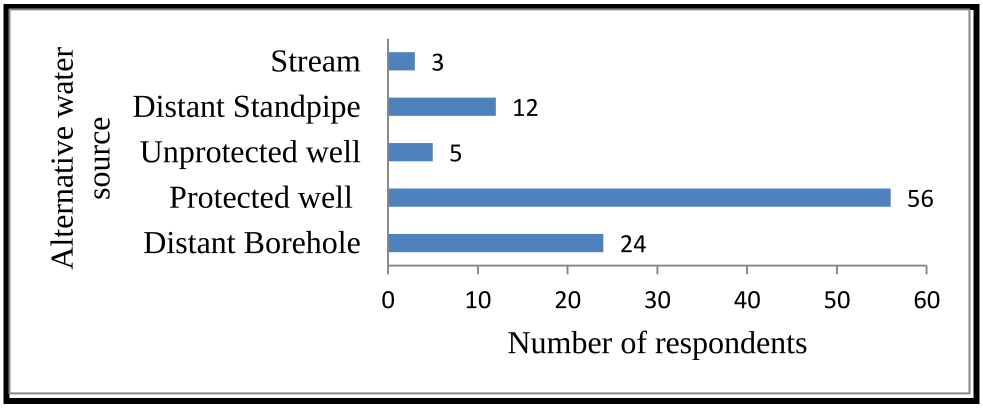

Figure 9: Alternative Water Sources

Alternatively, the households get most of their water from protected water sources such as protected wells and distant boreholes and, standpipes. As indicated in Figure 9 above only a few respondents used unprotected sources as their alternative to primary sources. The coverage of pipe borne water is not 100% in the study area due to topographic limitations of some areas. Some households are located on higher ground which limits natural pressure through gravity to supply water to such areas. Other technologies such as shallow wells and play or solar pumps may be more applicable in such localities other than GFS.

Generally, the area registers a relatively higher rate, which is 56 percent of safe water coverage unlike most rural areas in Malawi and developing countries in Sub-Sahara region. This is partly because of water supply interventions by the Primary Health Care (PHC) unit at David Golden Memorial Hospital (DGMH) and Malawi Social Action Fund (MASAF). From 2002 through MASAF, Livingstonia area has benefited more than 50 boreholes (GoM, 2008c). Besides boreholes drilled by MASAF, the PHC unit has dug 300 protected shallow wells in the same study area (DGMH, 2010). The results imply that in the area there is higher coverage of improved water sources compared statistics provided for Rumphi district and Malawi as a whole (NSO, 2013). In addition, studies by Chipofya et al (2012) report that approximately 65% of the population of Rumphi district has convenient access to safe water. The Joint Monitoring Programme on the other hand, reports that 83% of the Malawi population has access to an improved drinking water source (WHO/UNICEF, 2014).

4.3.2 Usage of Water from Main and Alternative Sources

According to Mulwafu (2003) understanding of the importance of many uses of water in the lives of poor people and their sources, has implications on how water resources are managed. Water resources in Malawi are mainly used for domestic, sanitation, irrigation, industry, energy and transport. The utilization of the resources can be categorized into two groups; consumptive and non-consumptive uses, (Chipofya et al., 2012). In this study, households were asked to report their main consumptive usage of water from the scheme whose results are presented in Figure 10 below.

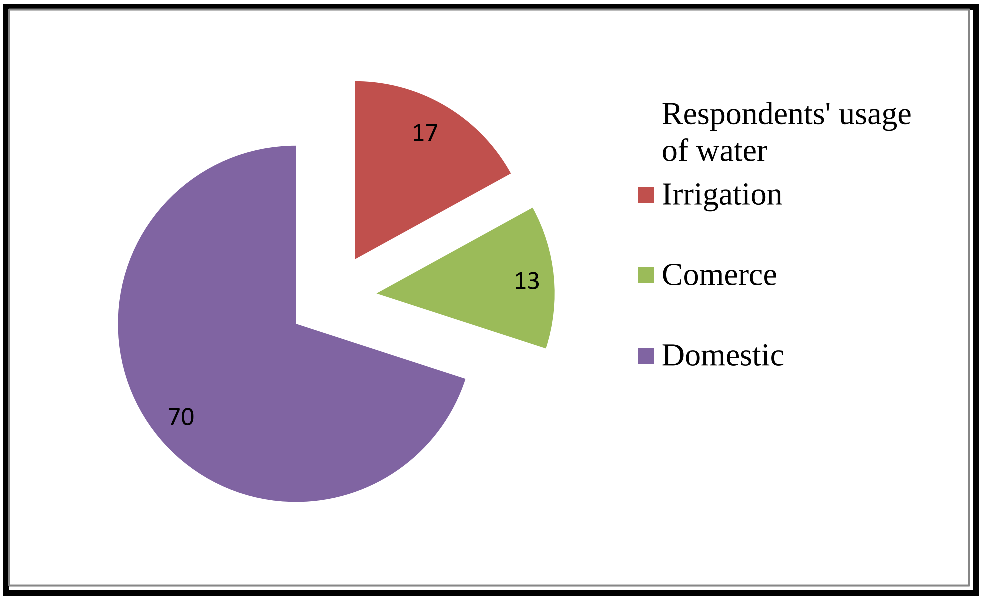

Figure 10: Utilisation of Water from Main Sources

On water usage, the majority of the respondents as indicated in Figure 10 water is used in their households for various domestic purposes. This was seconded by agriculture and lastly, commercial purposes. Commercial activities in the area include brick making; irrigation of garden crops; livestock watering and beer brewing. There is no restriction of use to the scheme water though there different tariffs for different purposes. The results therefore, clearly indicate that water in the area is not considered as an economic asset to advance their well- being. While the major occupation of the respondents in the area is farming the results indicate underutilization of water resources as regards agriculture. The results are in sharp contrast to the sectoral distribution of water in Malawi which according to Mulwafu et al (2002) is estimated to be 34% domestic, 17% industry and 49% agriculture and natural resources. However, the area has perennial streams which have been mentioned as alternative sources which are probably used for other productive activities such as farming.

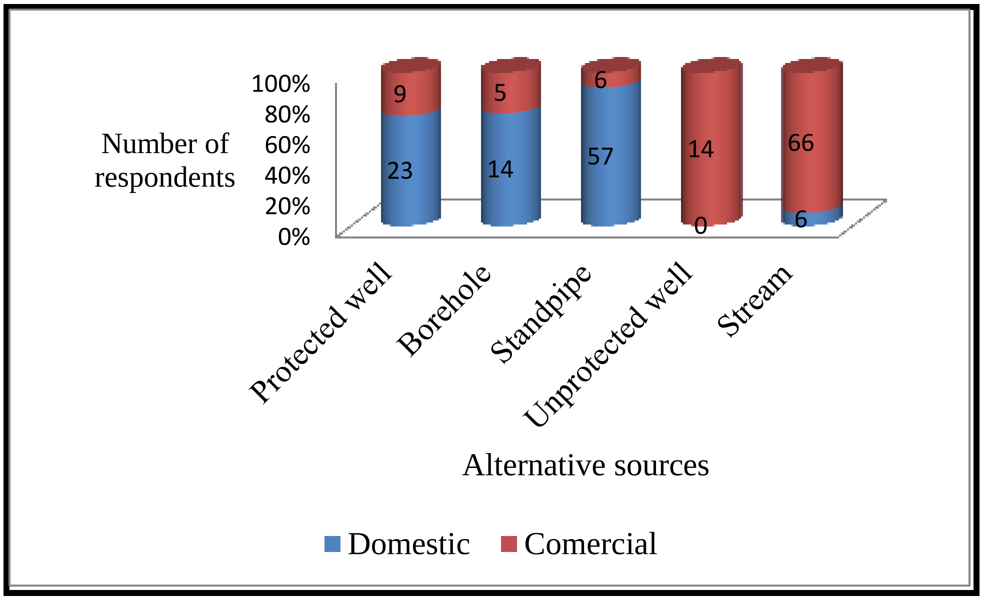

Figure 11: Usage of Alternative Sources

As shown in Figure 11, the majority of the respondents use natural streams and unprotected wells (unimproved sources) for commercial purposes. As a control mechanism those who opt to use improved sources for commercial purposes do so at a higher fee of five thousand Malawi kwacha (US$ 0.03) per 20 litre drum. In the study area unprotected sources are largely used for livestock watering and gardening. Commercial activities such as brick making consume a relatively larger amount of water thereby increasing the queuing time for other water collectors and this is a justification for the additional water fee. The adoption of this bye-law to a large extent is an effort to manage the supply rather than the demand for water in the scheme. This measure is similar to Water Demand Management (WDM) strategy of user fees. Based on Mulwafu et al (2002) argument, where the provision of water has no monetary attachment, especially in the rural communities, water is abused.

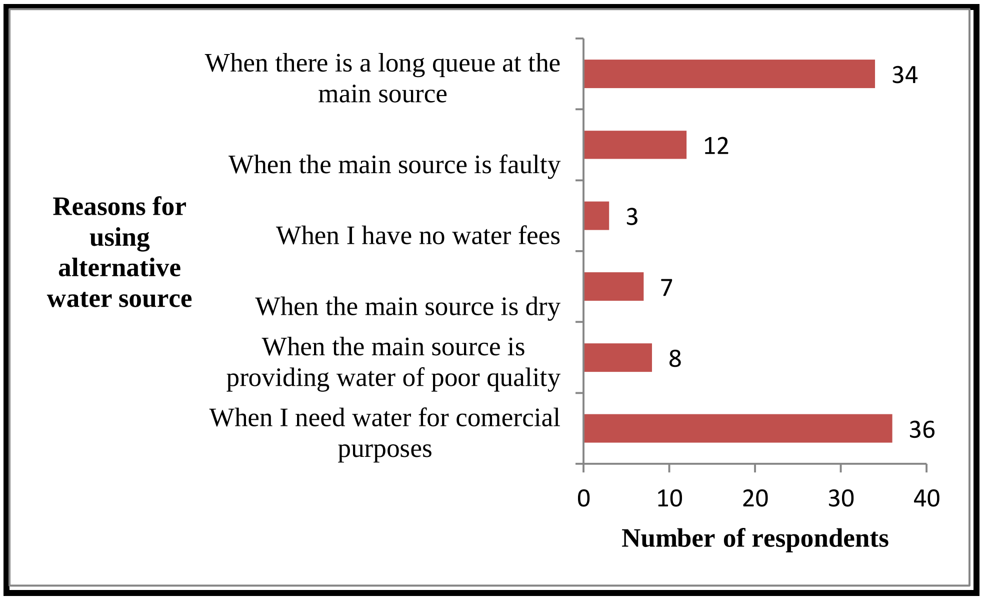

Figure 12: Reasons for Using Alternative Sources

On the use of alternative water sources, as indicated in Figure 12, the leading factor was to meet the water requirements for commercial purposes. In most similar studies, the mal-functioning of the main source is a principal reason for using alternative sources which are also largely unsafe. However, to the contrary, studies by Njalam'mano (2007) and Mtinda (2006) majority of the alternative sources for drinking water were improved and the major reason for using alternative sources was saving supplies of the main sources for domestic utilities.

4.3.3 Location and Accessibility of Water Sources

There are various definitions of access; according to who defines it. What is clear however is that there is no agreement on definitions of accessibility (Mtafu and Manda, 2009). The crucial issue is to examine the availability, quantity, distance, time taken to access the facility and types of facilities available while other scholars suggest that there is a difference between coverage and accessibility to water services in an area. According to WHO/UNICEF (2014) factors such as distance, time spent to collect water, user pressure on a water point and financial limitations may affect household accessibility even where safe water coverage is high. This implies that higher coverage does not always mean higher accessibility.

Households were asked to report the distances they cover to collect water, money spent on water user fees, the length of time spent to collect water from main sources from their households. The findings were complemented by physical observations on some water points. A camera was also used to capture some photos at some of the water points. As indicated (Table 8) the average distance spent on fetching water from primary was 214 metres. With positive distribution skewness the results imply that most of them covered less than the mean distance to fetch water. However, other households could cover a maximum of 590 metres due to the rugged terrain of the area. Long distances to an improved source of water have several implications such as compromising water quality and a disproportionate burden on female members of the households (NSO, 2010).

Table 8: Factors Affecting Accessibility to Portable Water in the Area

Statistics	**Distance(meters)**	**Time(minutes)**	**Number of people served/hr.**	**Number/queue**
Mean	213.9	70.3	21.1	14.3
Median	171	60	20	15
Mode	226	60	32	22
Standard deviation	157.3	35.5	10.2	7.2
Kurtosis	-0.0	2.1	-0.8	-1.0
Skewness	0.9	1.3	-0.1	-0.2
Range	574	170	39	24
Minimum	16	20	1	1
Maximum	590	190	40	25
Sum	21184	6964	825	561
Count	100	100	40	40
Confidence level (99.0 %)	41.5	9.4	4.5	3.2

Water fetched from an improved source that is not close to a household may be vulnerable to contamination during transport (Kanyerere, et al., 2009). On the other hand, the collection of water from a long distance may limit the quantity of suitable drinking water available to a household.

Access to water is defined by the World Health Organization as the availability of 20 litres per capita per day at a distance no longer than 1,000 metres (WHO/UNICEF, 2000 cited in Hillbrunner, 2007). In Tanzania, a water point serving no more than 250 people with water of acceptable quality, at a distance of not more than 400 meters from their homestead, and at the rate of 25 litres per person per day is established as a national standard (User Requirement Table (URT), 2002). However, recent Malawi government documents use a distance of 500metres as signifying adequate access to water. However, to the contrary, Catholic Relief Service (CRS) (2007) study found that, whereas rural communities face a distance barrier to accessing potable water, urban communities are affected by high prices for water. Therefore, defining access as the availability of a facility is misleading, because other factors operate. For example, because of the high cost of water from kiosks, shallow wells are constructed next to the kiosks. The safer water is physically available, but economically out of reach for the urban poor.

It can be concluded from this study finding that the area is on the right track with the recommended maximum Malawi national water policy distance of 500 metres though the labour of covering the same may vary depending on terrain or topography of the area. Nevertheless, in some cases achieving these targets requires a huge investment of resources (e.g. sparsely populated rural areas like most parts of Livingstonia) may demand a high density of other new sources.

The average time spent on fetching water from the main source was 70 minutes. This time took into consideration distance between the water source and the point of use, waiting time, and to a certain degree an effort needed to obtain water. As indicated by a positive skewness most people in the area get their water in less than 70 minutes but this is significantly affected by distance, length of the queue, size of water collection buckets on a queue, whether its peak hour or not and water delivery rates of the water point.

As observed from Figure 13d most of the water points had long queues with an average of 21 people waiting. This was common during peak hours (around 6 in the morning and 5 in the afternoon). It was further observed that quantity of water collection buckets ranged from 20 to 25 litres (Figures 13 a, c and d). The majority of the water collectors were females. Men and women take different times in fetching water (Njalam'mano, 2007). According to Njalam'mano study it was indicated that men take much less collection time because once they arrive at the water point women give them chance to fetch water first. This is done due to the fact that culturally people in the rural areas of Malawi think that water collection is not the responsibility of men so women do that to avoid being labelled as social deviants.

With no exception of Livingstonia, women and girls in rural areas of developing countries are most affected by the lack of access to water. GoM (2014) statistics show that it is women who are largely responsible for collecting water (82% of females assume responsibility for domestic activities which include fetching and handling water against only 18% of males (Njalam'mano, 2007). Women spend over eight times more time than men fetching water and girls spend over three times more time than boys GoM (2014). Such a scenario relatively put women at a socio-economic disadvantage than men due to their limited time to engage in more productive activities against the intention of the Malawi national gender policy (GoM, 2007).

Figure 13: Household Water Collection Practices

4.4 Water Resource Quantification

In order to determine if the source is contributing to the failure or poor performance of water supply system, a simple flow rate measurement is required (Simpson, 2007). There was a need therefore to ascertain the impact of this scheme on Nyankhowa River discharge with regards to increased population and number of taps in the scheme infrastructures. This may assist in the planning and construction of appropriate size of schemes with increased water demand pressure in order to minimize the effects of river degradation. There was also a need to find out the efficiency of the scheme and its impact on river flow downstream.

4.4.1 Nyankhowa Stream Cross Sectional Area, Velocity and Discharge

Starting from the catchment box a stretch of 400 metres towards uphill was divided into four sections; A, B, C and D with 100 metres each. Equations; 2, 3 and 4 were used to come up with the cross-stream area, velocity and discharge of the four points respectively; the results are as shown (Table 9). The river had 4.42m^2, 0.03metres per second and 0.11m^3 per second average cross sectional area, velocity and discharge respectively. However, other sections close to the catchment box (C and D) had relatively smaller cross sectional area due to heavy sediment deposition taking place as compared to the up-stream. In general as indicated in Table 9, the mean stream velocity fluctuated between 0.02 m/s and 0.03 m/s from sampling station A to D with high velocities observed towards the upper end and this was attributed to the gradient of the river as it passes through the steep valleys.

Table 9: Nyankhowa Stream Cross-Sectional Area, Velocity and Discharge

Sections	Time (seconds)	Distance (metres)	Reduction factor	Velocity (metres/second)	Cross section area (square metres)	Distance (cubic metres per second)
A	160	5	0.8	0.03	5.40	0.13
B	150	5	0.8	0.03	4.96	0.13
C	170	5	0.8	0.03	3.86	0.09
D	150	5	0.8	0.03	3.45	0.09
Mean	158	5	0.8	0.03	4.42	0.11

With reference to physical observation, besides the presence of large stones and rocks on the bottom of the stream, changes in form and shape of Nyankhowa as it cuts hills and cliffs have a marked effect on its cross sectional area and discharge. Deposition taking place in the stream was a result of stream bank cultivation that encouraged loose soil to fall into the river channel and reduce discharge (Morisawa, 1985). In most cases, land use changes from natural vegetation cover to agriculture affects sediment yield. Van Dijk and Vogelgang 1948 in Morisawa, (1985) their study observed an increased sediment yield downstream resulting from the conversion of areas protected by natural vegetation to grazing and farming in the tropics. River sedimentation most often causes the shape of the river to dwindle in terms of its cross sectional area. Afforestation and deforestation are known major human activities responsible for altering river flow behaviour in many catchments (Calder, 1992 in Ngongondo 2002). There are a number of causes of deforestation including encroachment for cultivation and settlement due to high population in the area. Some of the notable ones from researcher's physical observation in the area included; uncontrolled bush fires and wanton cutting down of trees which is contributed by activities such as burning of bricks, pit sawing, firewood collection charcoal production, and unlawful cultivation.

In Malawi, water and land use planning has been the responsibility of the government through the Water Resources Board to ensure that catchment areas are not utilized for agricultural production and human settlements (GoM, 1998b). This issue is addressed by the Water Resources Act 1999, which prohibits agricultural production in catchment areas, and bars people from developing the area at a distance less than 50 metres from the water body. However, it seems this Act is not being adhered to in Livingstonia water supply Scheme catchment area.

4.4.2 Water Taps Flow Rates

Despite the fact that communities have access to water from their water schemes, the quantity of water delivered by taps in a specified time matters most for planning purposes. A bucket-stop watch method was used for tap delivery rate measurements. A calibrated 20 litres water bucket and a stop watch were used to measure delivery rate for each of 20 taps from the five sampled villages. Measurements were taken at 6.00 hours, 12.00 hours and 18.00 hours as most communal taps were opened on those time schedules. Three readings were averaged to come up with mean tap delivery rate. The results are shown (Table 10). Spatial and temporal variations of average water tap delivery rates were observed in the scheme. Taps in the morning were delivering an average of 8.61 litres per minute which was the lowest compared to noon and evening peak hours.

Most households in the area would prefer fetching water in the morning rather than noon and evening. Because of high water demand in the morning water pressure drops down as many taps are open. Taps in the scheme deliver on average 11.18 litres per minute and 10.10 litres per minute during at lunch and dawn hour respectively.

Table 10: Livingstonia GFS Average Tap Delivery Rates

Average tap delivery rates in litres per minute					
Village	Trap	Morning	afternoon	evening	Mean
Thunda	1	7.06	9.13	8.02	8.07
	2	10.00	12.45	9.00	10.48
	3	9.00	10.08	9.00	9.36
	4	8.30	9.00	8.30	8.32
					9.11
Vunguvungu	3	10.11	11.14	11.11	10.83
	6	9.00	13.01	12.00	11.14
	7	9.00	12.06	6.00	9.02
	8	7.45	9.09	7.45	8.00
					9.80
Mantchewe	9	9.00	13.23	11.30	11.18
	10	10.00	10.11	10.00	10.04
	11	7.00	11.49	13.00	10.50
	12	6.15	12.00	9.15	9.10
					10.20
Mphonde	12	6.23	12.30	8.23	8.92
	14	10.06	12.00	13.06	11.71
	13	7.11	12.21	12.11	10.48
	16	10.23	11.42	11.23	11.03
					10.53
Gavala	17	9.44	10.10	10.50	10.01
	18	6.08	10.00	9.08	8.39
	19	9.33	10.44	10.12	9.95
	20	10.00	10.00	11.08	10.36
					9.68
Mean delivery rates		8.61	11.18	10.10	

The result implies that time spent on fetching water in the morning is longer compared to other times of the day. For example, one will take about 3 minutes to draw water using a 25 litres bucket in the morning but only 2 minutes during lunch hour. This also implies that the length of queues is relatively longer in the morning than the other peak hours. Mphande and Mantchewe villages have relatively higher averages; 10.53 litres per second and 10.20 litres per second respectively partly due to their lower altitude location in relation to the water source. There is an extension of a flat valley joining the two villages lower than 900 metres while the water source is seated at 1200 metres above the sea level. According to a handbook of gravity water flow system (Thomas and Jordan, 1980 cited by UNICEF, 2000) standard tap stand flow is 0.225 LPS (13.5 liters/minute) and such a tap can adequately serve a population of 200-230 persons. Though the delivery rates are lower than standard but this is a negligible problem in the area.

4.4.3 Household Water Consumption

The overall 2005 Malawi national water policy goal is, "sustainable management and utilization of water resources, in order to provide water of acceptable quality and of sufficient quantities that satisfy the basic requirements of every Malawian," (GoM, 2008b). The respondents were asked to report the quantities of water they draw on a daily basis from the main sources.

Table 11: Quantitative of Water Drawn by Household per Day (Litres)

Statistics	Results
Mean	200.21
Median	200
Mode	280
Standard deviation	77.33
Sample variation	5986.31
Kurtosis	-1.11
Skewness	-0.02
Range	240
Minimum	40
Maximum	280
Sum	16500
Count	100

The responses were given in form of numbers of 20 litres buckets which were then converted into litres by the researcher. The results were as shown (Table 11). On average households were drawing 200 litres on daily basis. The average amount of money spend direct on water purchasing was also calculated based on the same figures. The K-WATSAN charges US$0.03 per 20 litres bucket, implying that on average households were spending about US$3 and US$90 on daily and monthly basis respectively. The water pricing though it varies from urban to rural areas and different service providers, the rates are similar to other studies done in Malawi. For example, Manda and Mtafu (2009) found in Blantyre, kiosks selling water at or above US$ 0.03 and some at US$ 0.02, US$ 0.01 per 20 litre pail and kiosks run by Water Users' Associations in Lilongwe charged US$ 0.02 per 20-litre pail. A study by CRS (2007) found out that the Mchengautuwa Federation Village kiosk in Mzuzu charges US$ 0.02 per 20-litre pail.

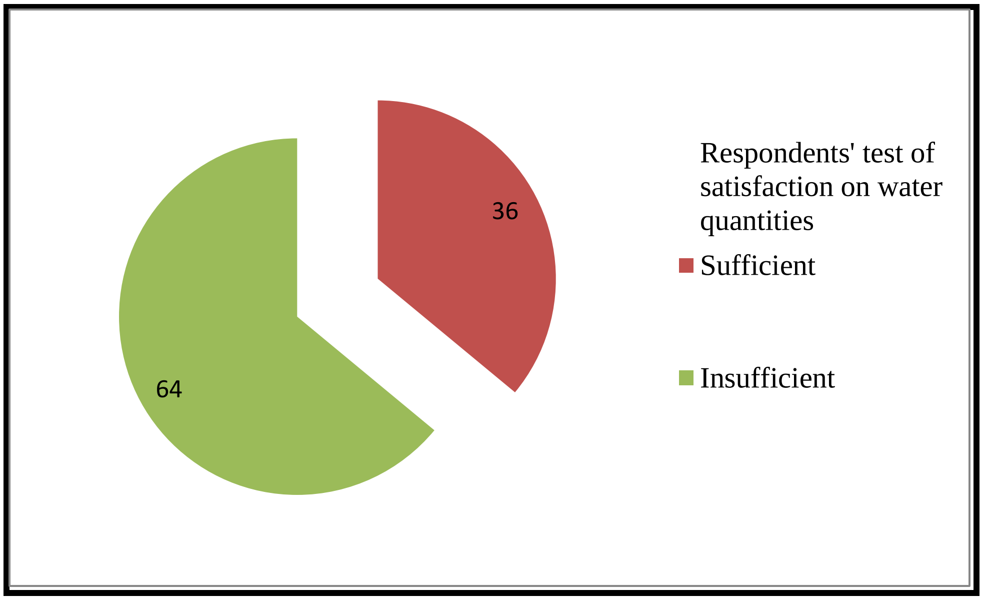

Figure 14: Households' Satisfaction with Water Quantities

The respondents were further asked if they were satisfied with the amount of water drawn from their respect water points. The results are shown in (Figure 14). Majority of the respondents were satisfied with the amount the system provides them while the remainder was not satisfied. According to interview response from one village headman, "The major reason for not being satisfied is the inconsistency of water supply especially in rainy season." According to him this was due to blocking of open water conduits by rocks and mud during landslides. Topography and altitude of the villages in relation to the height of the reservoir tank had also a stronger impact on quantities of water received in other villages.

Respondents who were not satisfied with the water quantities were asked to estimate how much additional water they required to meet their respective needs. Results are indicated (Table 12).

Table 12: Household Water Deficits

Statistics	Results
Mean	40.00
Median	20.00
Mode	40
Standard deviation	14.17
Kurtosis	-1.23
Skewness	0.05
Range	40
Minimum	20
Maximum	80
Sum	880
Count	34

On average each households needed additional 40 litres in order to meet daily water requirements. Most of the households had deficits due to financial reasons not necessarily system failure. Since the average household size in this study was 5 and average water drawn was 200 litres.The figures imply 40 litres per capita per day. The figure includes allowances for personal washing, drinking, cooking, and a portion of domestic animal needs. The result is higher than what other literature have established as minimum required amount of water per capita. For example, (Carter and Howsam, 1999; Madulu and Zaba, 1997 and United Nations Development Programme (UNDP), 2001) access to 20 litres of water per person per day is a minimum requirement for respecting human right to water and minimum hygiene standard. Gravity fed water supply schemes in Malawi were designed to provide at least 27 litres per capita per day within a walking distance of less than 500 metres. Definition of access to water is apparently 20–27 litres per person per day

(Mtafu and Manda, 2009 as implied by CRS, 2007; MoIWD, 2008). Despite differences in standards by different authors and authorities results indicate that the scheme is meeting household's water daily needs though figures are slightly lower to international standard of forty-five litres per person per day (Jordan, 1983 as cited by Niskanen, 2003).

In other countries such as South Africa, the challenge of failure of households to get adequate water quantities due to financial limitations is solved through a policy called free basic water access. According to the South African constitution every citizen is entitled to a certain amount of water regardless of his ability to pay for it; this policy defines the amount of entitlement be 6000 litres per household per month (Gothren and Paula, 2013). In Peri-urban areas of Malawi the challenge is dealt with through water tariff subsidies (Manda and Mtafu, 2009). Similar to free basic water access policy the K-WATSAN has a list of disadvantaged households who benefit water services for free in-order to increasing equity and reduction of water related diseases.

4.5 Water Quality

Despite the fact that communities have access to water from their water schemes, the quality of water is one of the critical parameters to be taken into consideration in planning and monitoring water supply schemes. The purpose of building a water system is to eliminate health problems related to contaminate drinking water. Theoretically, GFS provides portable drinking water (Kleemeier, 2000; Chipofya, et al., 2009). However, in under other varied circumstances the case is different hence the importance of water quality assessment was crucial since at Livingstonia just like many other GFS in Malawi there are no treatment plants. Physical inspection, questionnaires and laboratory analysis were employed to come up with water quality reality of the scheme.

4.5.1 Perceived Water Quality

Through a questionnaire all 100 households reported their perceptions about the quality of the water from the scheme; results are shown in (Figure 15).

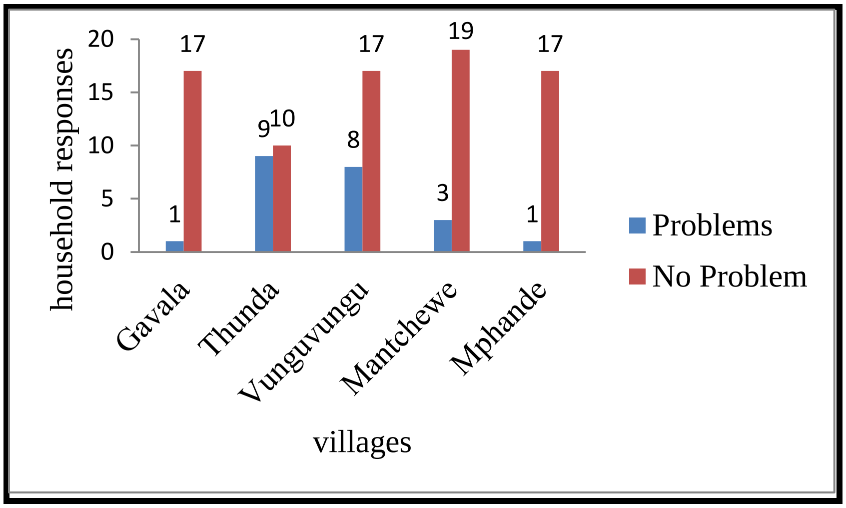

Figure 15: Households' Perceived Water Quality

The majority reported that the water has no any problems related to water quality; however, minority reported some problems with their water especially during rainy seasons.

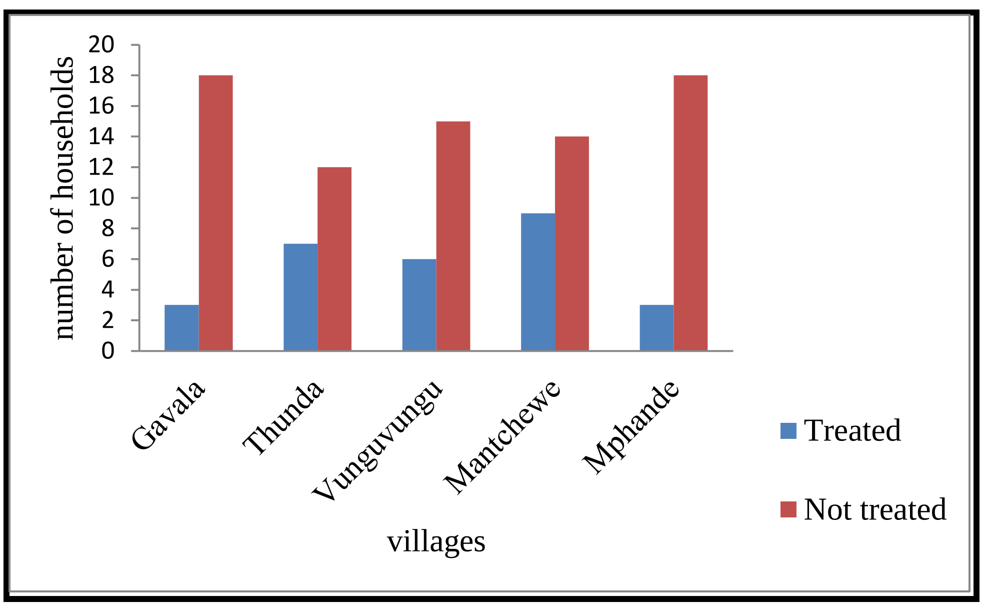

Figure 16: Household Water Treatment

As indicated in Figure 16, only a few households treated their water. A few number of households though they reported problems but they did not treat the water due to financial limitations while others said they will do so unless there are outbreak of water related diseases in the area. The overall policy goal of the Malawi Water Resources Management Policy and Strategy is, “sustainable management and utilization of water resources in order to provide water of acceptable quality…”(GoM, 2007).Though the concept of acceptability varies with space and time, the results indicate high acceptability of the water in the scheme. High acceptability in studies done by Harvey and Reed (2004) is one of key social aspect that enhances sustainability of water projects.

Besides the questionnaire, 40 taps from the selected five villages were physically analysed and was rated, poor, average and good by the researcher. Poor means that water was not used for human consumption, average implies that water was rusty or had some organisms or saline. Observation results were as shown (Figure 17).

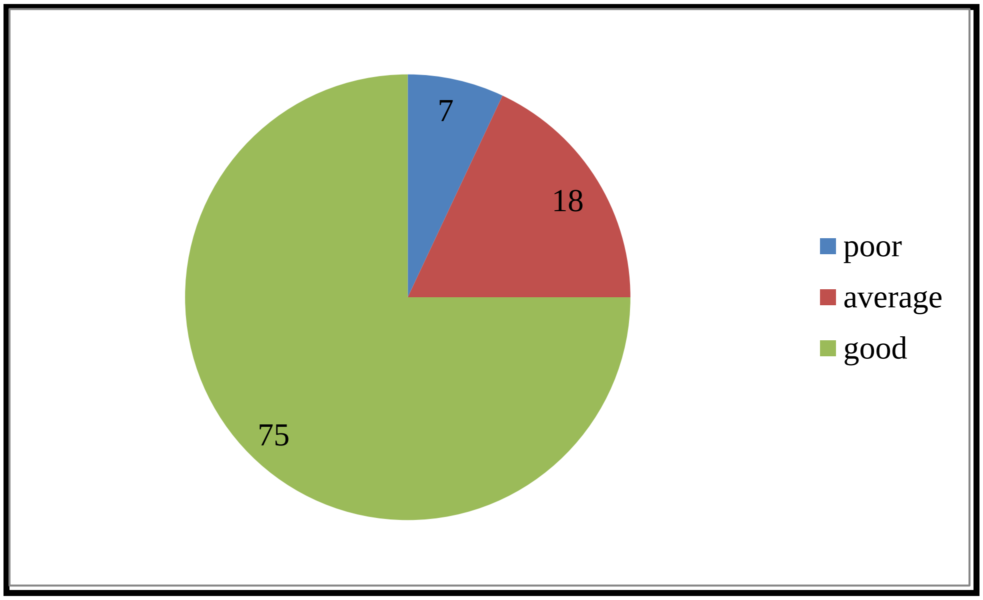

Figure 17: Households' Physical Assessment of Water Quality

Out of the 40 water taps majority rated the water as good andly a few rated the water poor since by the beginning of the rains the water is very dirty and unfit for human consumption. It could be the problem of broken pipes whereby dirty water from run off find their way into the system. These taps are often neglected and abandoned in rainy season however, put back to use during dry season.

4.5.2 Treatment Methods to Perceived Water Quality Problems

The 28% of the respondents who were not satisfied with the quality of their water were asked through a questionnaire survey to mention the water quality problems in the scheme and the results are shown (Figure 18A).

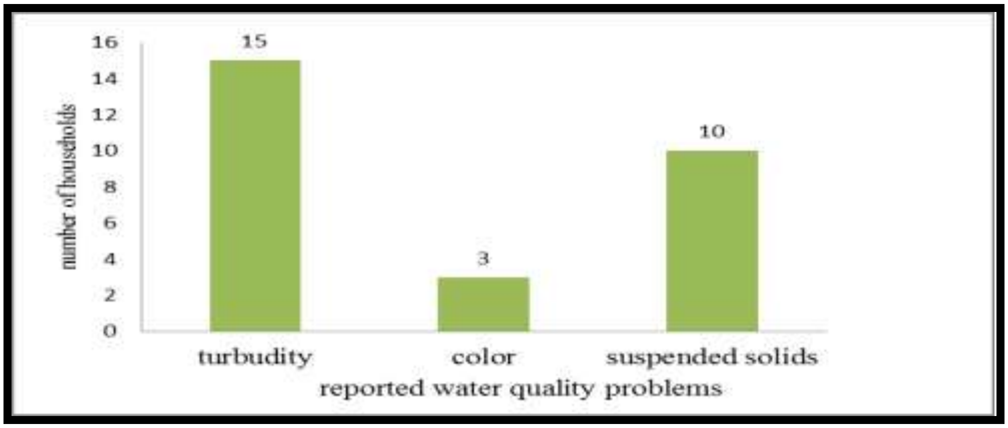

Figure 18 A: Physical Water Challenges

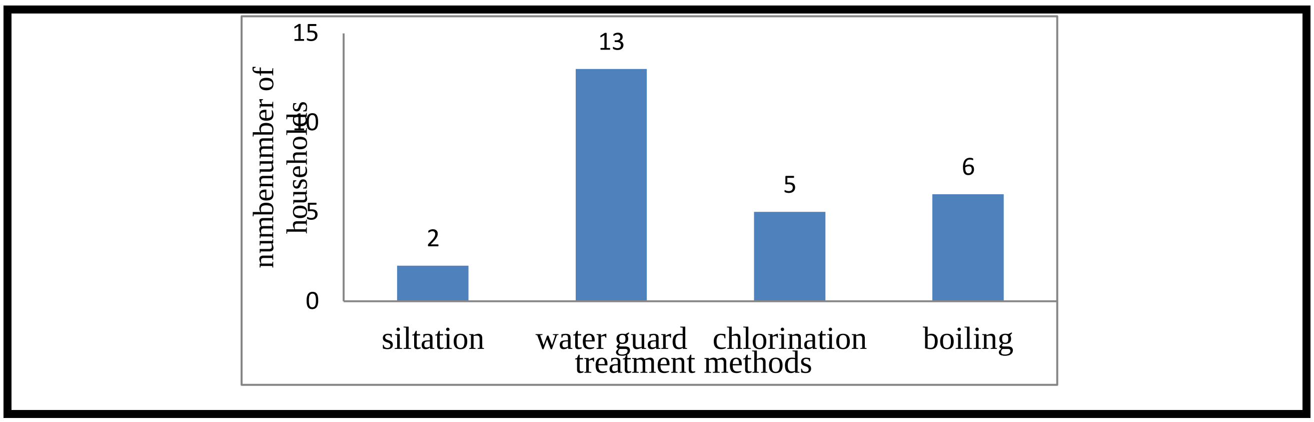

Figure 19 B: Remediation Methods

The most typical problem was turbidity seconded by suspended solids which recorded 15 (54%) and 10 (36%) households respectively. The typical treatment of water within the study area as indicated (Figure 18 B) was the use of water guard, 13 households representing 52 percent those who perceived water quality problems reported using chlorine as a means of drinking water treatment. Reasons for not using chlorine to treat water included lack of money, difficulty in obtaining chlorine, lack of knowledge on the dosage and bad taste. Some other households were not treating their water due to lack of knowledge, finances, technical know- how and others because they had safe alternative sources. This concurs with Austin (1987) study findings which pointed out that many times if an adequate quantity of water is available, the users may not be willing to financially support the treatment necessary to improve water quality.

4.5.3 Laboratory Water Quality Analysis

The importance of providing scientific evidence for contamination of water in order to inform the revision of guidelines on rural water service provision cannot be overemphasized. For this reason, to compliment and validate results from questionnaires and observations, microbiological, physical and chemical analysis of water was conducted. Water samples from 50 sampling points (taps)in five selected villages were collected and analysed using an in-situ water quality testing kit 'Lab Quest' to determine microbiological, chemical and physical status of the water. The water quality testing exercise was conducted in line with the Standard methods for the examination of water and waste water 21st Edition. Table 13 below shows laboratory analysis results of water samples.

Table 13: Physico-chemical and Microbiological Water Quality Analysis Results

Microbiological, Physical and Chemical Water Quality Results												
Village	**pH**	**Turbidity NTU**	**Suspended Solids**	**Conductivity µS/cm**	**TDS mg/l**	**Faecal Coliform/100ml**	**Total Coliform/100ml**	**SO_4^{2-} mg/l**	**NO_3 mg/l**	**Temp**	**Ammonia NH_4 mg/l**	**Total Hardness ($CaCO_3$)**
Mphande	5.69 - 6.28	10.3	8.40	42.2	27.4	70	299	8.24	0.94	23.7	0.34	10.4
Gavala	6.10 - 8.03	9.13	7.90	44.1	28.7	144	233	5.61	0.13	22.9	0.33	11.3
Vunguvungu	5.81 - 6.33	10.9	8.80	46.5	30.2	235	605	5.43	0.03	23.5	0.34	11.4
Bale Kajoni	6.71 - 7.98	10.6	8.70	44.7	29.1	128	218	3.12	0.10	24.6	0.34	10.4
Thunda	7.01 - 8.04	16.2	12.4	50	32.1	116	405	5.29	0.45	24.3	1.00	11.4
Mean Values		**11.4**	**9.24**	**45.5**	**29.5**	**140**	**352**	**5.41**	**0.33**	**23.8**	**0.47**	**11.1**
Guidelines												
WHO	**6.5-8.5**	**5**	**-**	**1000**	**-**	**0**	**0**	**-**	**-**	**-**	**-**	**-**
MS678:2005	**6.0-9.5**	**5**	**-**	**3500**	**-**	**0**	**0**	**-**	**-**	**-**	**-**	**800**

The results obtained from the analysis of water sample indicated that most of the physico-chemical constituents analysed were found to be within the acceptable limits except that of Turbidity. Mean turbidity value obtained was 11.4 NTU which was above the recommended limit of 5NTU according to both WHO and MBS guidelines for drinking water. Total hardness and power of hydrogen ions (pH) data indicated that the water was very soft and ranged from being slightly acidic to slightly alkaline. The result concurs with households' perception on water quality as indicated from questionnaire survey results. In both cases besides minor limitations water is good for consumption.

Studies have identified turbidity, temperature and pH as crucial physical or chemical parameters that affect the effectiveness of chlorine in drinking water (WHO, 2008; 2009). Theoretically, chlorine treatment in drinking water does not effectively penetrate suspended silt and organic particles where bacteria may reside (WHO, 2009). The higher the turbidity levels, the higher the risk of gastrointestinal diseases (WHO, 2008). Turbid materials can shield pathogens thereby interfering with effectiveness of both chlorine and ultraviolet sterilisation of water (WHO, 2008; 2009). For effective chlorination treatment, water should be at turbidity less than 30 NTU (Kanyerere et al., 2009). This indirectly entails that cost of treating high turbid water is higher. In addition, it can also be explained that high turbidity levels also contributes to reported problems of water colour. Kanyerere, et al (2009) also mentions of turbidity affecting water aesthetics.

Microbiological water quality results indicates that water from the water points under review was contaminated with faecal matter, this assumption was based on the two bacteria types enumerated in the water sample namely faecal coliform and total coliform bacteria which registered very high counts. In terms of total coliform, the results show that 100% of the sampling points (taps) did not meet the temporary drinking water guidelines set by Malawi Bureau of Standards of 0 Counts/100 ml for untreated water. Total coliform bacteria were detected in water with values ranging from 70 to 344 CFU/100 mℓ. Through observations on the catchment area, humans, livestock, birds and wild game wastes were contributing factors to such high levels of microbiological contamination. Microbiological contamination is responsible for high cases of water related diseases such as dysentery. Results obtained implied that if water users do not treat water with chlorine or other disinfectants as was the case during the time of sampling process, then they stand a high risk of contracting water related infections. However, according to Mtafu and Manda, (2009) based on

WHO (2000) guidelines from which Malawi borrows a copy, it is expected that potable water must have a zero count of faecal coliforms. On the contrary, rural water supplies in Malawi from boreholes and piped gravity fed schemes are still considered potable even without conventional treatment (Mtafu and Manda, 2009).

Findings regarding the concentrations of inorganic solutes in this study agree with those of Mtafu and Manda, (2009) who concluded that the quality of drinking water from groundwater sources, both boreholes and shallow wells, in terms of physico-chemical status, is within acceptable limits as set by both (WHO, 2008 and MBS, 2005).

4.6 Status of Water Supply Infrastructure

Quality of the available water supply infrastructure components is one of the most critical factors that underpins the success and sustainability of rural water supply (Baumann and Danert, 2008). To this regard, a situation analysis was done through observation checklist and questionnaire survey to ascertain the status and performance of the scheme. Variables such as functionality, age of the facility, location of water point, cleanliness of the surrounding areas, crowding around water point and physical status were analysed based on a self-developed assessment rating system whose results were reported in percentages (Figure 18).

4.6.1 Water Facility Operation Status

The parameters which were considered to assess functionality (operation status) included; ability to provide water, absence of leakage at and around tap point and the presence of broken parts of the tap. The study findings as shown in Figure 19 revealed over 90% rating (excellent category) of functionality in all villages except for Vunguvungu. The scheme has more reliable taps since the infrastructure is relatively new. The result is in sharp contrast to several other studies, for example, research carried out by University of Malawi–Centre for Social Research in 1989, revealed that many GFS in the country were not operational due to a number of problems (Kleemeir, 2000).

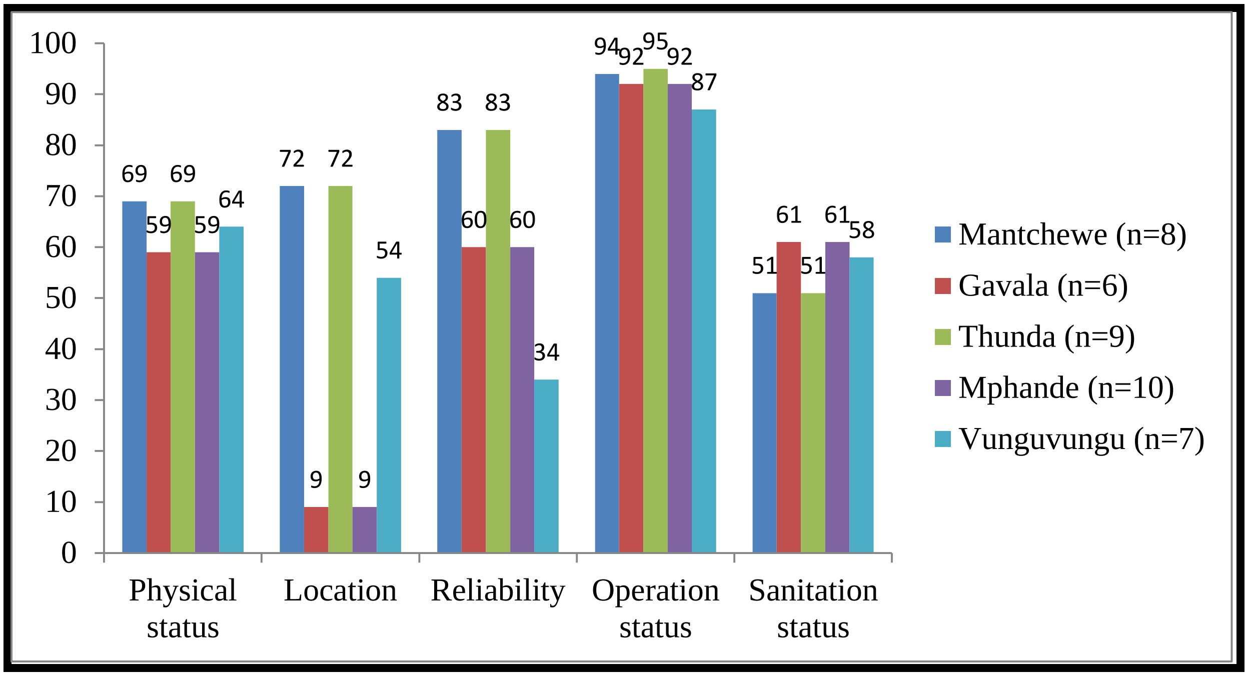

Figure 20: Water Supply Infrastructure Quality Analysis

Studies conducted on Chambe, Lifani and Lingamasa water schemes in Malawi in 2002 indicated that even though the three schemes were still working, each was only partially working (Salim, 2002). A study carried out by Baumann and Danert (2008) on operation and maintenance of rural water supplies in Malawi which suggest that practically all of Malawi's rural Gravity Flow Systems are in a sorry state. To contribute to achieving the UN MDGs, Malawi's specific water policy objectives were developed to ensure that at least 80% of the population have access to potable water, and to reduce non-functional water-points from 31% to 25%, by 2011 (GoM, 2008).The non-functionality rate in this study is less than government targeted bench mark hence the scheme helps government to be on right track with MDGs. The functionality rate is relatively higher side in comparison to figures of other countries such as Kenya. For example, it was estimated that 30% of the approximately 12,000 hand-pumps throughout Kenya in 2012 were not functioning, and a similar proportion of piped water systems were beleaguered by partial or total system failure (Rural Water Supply Network, 2009). The situation of functionality is better partly because of the bye-Laws (Appendix 9) and high levels of education in the area.

4.6.2 Water Point Location

Proper siting of a water point is clearly essential component of a successful water supply project. Poor siting of a water point may contribute to contamination of water. Study done by Kanyerere (2009) shows that the water source with the highest measured E. coli concentration, was the one that was nearest to a latrine. To ascertain appropriateness of a water tap the following parameters were considered; distance a water point residential, farming, household waste areas, distance to main road, location in the village and whether it was on the uphill or down in relation to point sources of pollution. This study as shown in figure 18 has revealed that water points were rated in good category in both Mantchewe and Thunda village since standpipes were among other things located more than 100metres away from the pit latrines, farming and residential areas. In Gavala and Mphande villages there were a lot of challenges in siting water points. From personal observation the major obstacle was due to poor topography. Contrary to existing legislation most water taps in Gavala and Mphande villages were found very close (less than 100 metres) to latrines and households waste area. The water pollution control regulations in the Water Resources Act stipulate that water points be 100 metres upstream of sanitation facilities (Lakudzala and Mukhuwa, 2005).

4.6.3 Water Facilities Physical Status

Indicators for physical status included availability of fence, tightness of bots and nuts, presence of rust, cracks and condition of the platform. According to Mason, et al (2005) a platform consists of an apron, a standing slab, a drainage channel and a soak-away pit. In this study these parts were treated as separate variables. It was also observed from Figure 20 that majority of the water facilities physical status was between 60 and 70 (good category). The facilities failed to reach the excellent category because of absence of fences and signs of rust. Cracks on platforms also contributed to low ranking especially in Vunguvungu village. According to similar study done by Njalam'mano (2007) in Kapeni Blantyre cracking was attributed to type of soils on which the platforms were constructed. It was observed that most of the soil types in the area were clay which swell when it is wet and shrink when it is dry lowering the civil work thereby causing cracks.

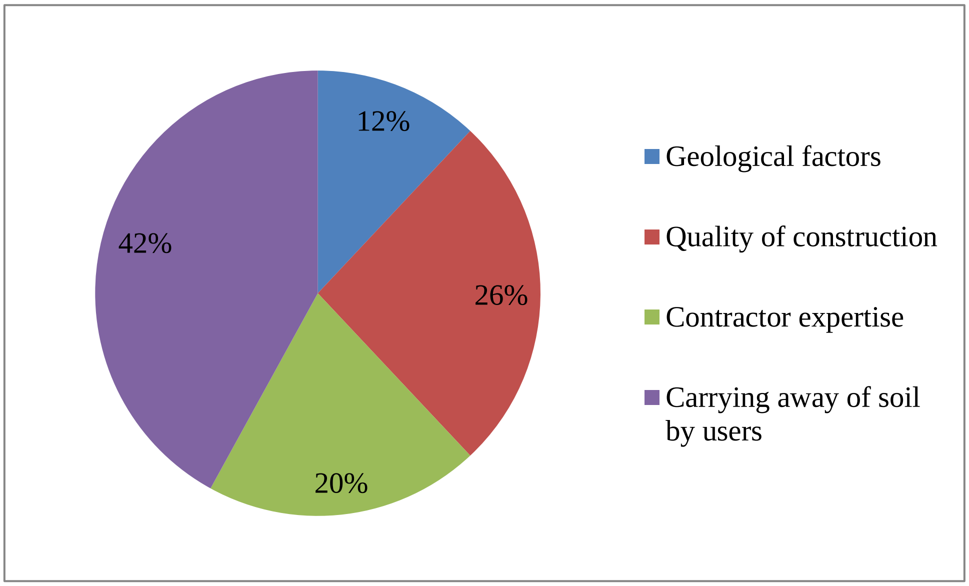

Figure 21: Reasons for Platform Cracks

Majority of the respondents reported that the ground level around standpipes fell because soil was taken away from them to be used for washing water carrying containers. On the other hand, 26 percent of the respondents attributed the cracking of platforms as a result of poor quality of construction material i.e. use of non-recommended sand cement mixture ratio. Other respondents (20%) attributed the situation to lack of expertise in the construction team. Usually untrained local masons are used for many community projects. The capillary network of cracks were reported by (12%) of the respondents being a result of geological weakness of the Livingstonia landscape.

The platforms in good condition are needed so that people drawing water do not have to walk through mud or stagnant water where they may pick up diseases. Water development projects are intended to improve the quality of the human environment. However, unless well planned, designed and implemented, a water project may bring about a decrease in one type of disease but cause an increase in a more severe type. One of the principal justifications for rural water supply projects according to GoM (2008) is to improve people's health outcomes however; for instance, the presence of platform cracks may endanger the whole essence of positive health outputs. The crack networks if left unchecked according to Chertkov and Ravina (2001) become breeding place for disease causing water vectors like mosquitoes which causes malaria and snail that causes schistosomiasis.

4.6.4 Water Facility Sanitation Status

Sanitation status in this study was measured by the following parameters; fence availability and sweeping. Fence availability is one important factor that enhances sanitation around a water point. It is important in breaking wind which may carry dust into water resulting into contamination. Fences also help to reduce wind strength that may increase water wastage through spillage from water containers during the drawing process. In areas where there is more free range livestock farming fences keep away livestock from the water point. These fences were in this study rated into categories namely: poor, average, good, and excellent.

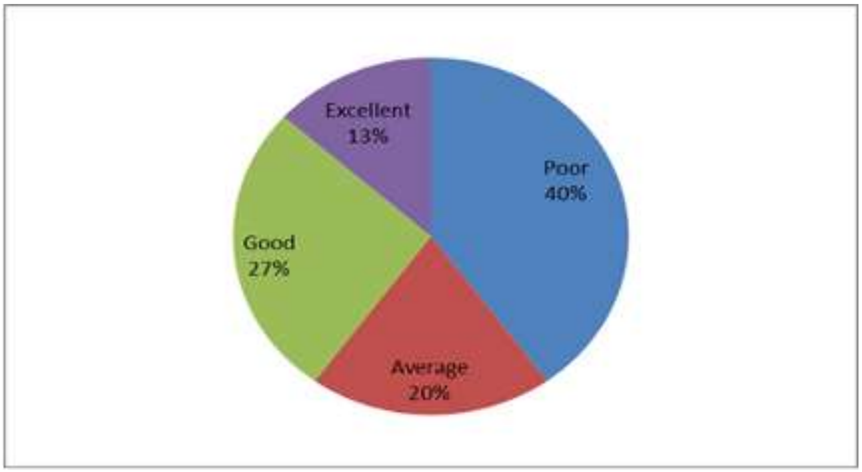

Figure 22: Condition of Water Point Fences

The categories were further grouped into classes, for example; fair category (good and excellent) and poor category (average and poor). Poor meant the fence was in dilapidated condition that could not even break wind or livestock. Good referred to one with ability to keep away livestock and wind. Average referred to fences with ability to control either wind or livestock. Excellent referred to fences built with materials like planks or bricks rather than grass and full ability to control wind and livestock. These livestock could act as a source of water contamination. The study as indicated in Figure 21 showed that in all five villages sanitation ranking ranged between 50% and 60% (Fair Category) only fifteen out of forty sampled water points had fences with varied conditions.

Majority (40%) of fences were in poor condition. From observation fences were constructed with locally available materials, i.e., poles and elephant grass (*Pennistum purpureum*). It is the responsibility of the water users at a water point to construct fences however; some household members in the area are unwilling to do so because they do not want to spend time to collect water for watering livestock in their homes instead they (the livestock) serve themselves.

Besides fencing sanitation at water point can also be a function of regular sweeping and clearing around a water point. While clearing is done after observing growing of bushes, sweeping is a daily responsibility of the water users of a particular water point. Out of 40 water points 32 were swept. The figure was high partly because of the effect of Water Sanitation and Hygiene (WASH) programs which are being implemented by DGMH Primary Health Care Unit.

4.6.5 Water Facility Reliability

System re1iabi1ity is primari1y the capabi1ity of a water system to provide uninterrupted service throughout the year (Warmer, 1986). In any water system, service interruptions can occur for a variety of reasons: inadequate source, demand greater than the capacity of the reticulation system, pipe breakages, clogged pipes and fittings, and poor design of tanks and pipelines. Reliability tests were also performed since not all functional water points are provide water at the at constant delivery rate for several reasons such as low water pressure at the source or poor topographic siting. The forty selected taps were left running from 6 am to 6 pm. The following parameters were considered; ability to maintain constant delivery rate throughout the day, ability to maintain constant physical water quality and whether a tap completely stops due either low pressure or high demand while open during the observation time. Reliability results show as indicated in figure 18 showed excellent rating for Mantchewe and Thunda water taps, fair for Gavala and Mphande and marginal for Vunguvungu. As earlier alluded to Mantchewe and Thunda villages are located on a low lying valley hence taps have relatively higher water pressure in comparison to taps in the other villages. In addition, the result can be attributed to the availability and use of alternative water sources. Being in a low lying place water table is higher to furnish shallow wells which are sometimes used by the households hence relieving pressure at water points.

4.7 Management of the Water Supply Scheme

The scheme is run through various committees using a community based approach (CBA) employing a Local Level Integrated Water Resource Management (LLIRWM) framework. From the water source there are three distributional lines as indicated in sketch map (appendix 10). The first and oldest line was constructed by the Scottish missionaries in 1904 and serves all institutions at the Livingstonia plateau (Mumbwe) including other few households neighboring the mission. The extension to neighboring households which were not part of the Mumbwe mission was done by the ministry of water and development in the 1980s. In 1976 the Christian service commission through IDB funding constructed another pipeline serving the then Livingstonia secondary school now the University of Livingstonia Laws campus. In 2006 the Rotary Club International constructed a third line targeting the communal taps which in this study is described as Livingstonia water supply scheme. The GDMH has its own line but breaks off from the Scottish distribution line.

4.7.1 Institutional Structure and Management of Water Supply Services at Livingstonia

The Livingstonia scheme is managed by two different organizations, the Livingstonia CCAP mission water and sanitation department and the Khondowe water and sanitation users' association. Both organisations share one water source owned by the mission, as well as sharing transmission lines. Due to having shared areas of the water system, and to ease the operation and maintenance of the rest of the system, the two organizations agreed to sign a Memorandum of Understanding (MOU) as indicated (Appendix 11) stating the terms of their partnership in managing and maintaining the system.

Village development committee (VDC) has two members of opposite gender who are responsible for all water issues at village level. The members form the water area committee which reports to the water users' association trustees. At the helm there is the joint executive committee which has a membership from all institutions at the plateau plus those from K-WATSAN. The Church and K-WATSAN have technical offices with employed staff that runs the day to day activities related to water (Figure 22).

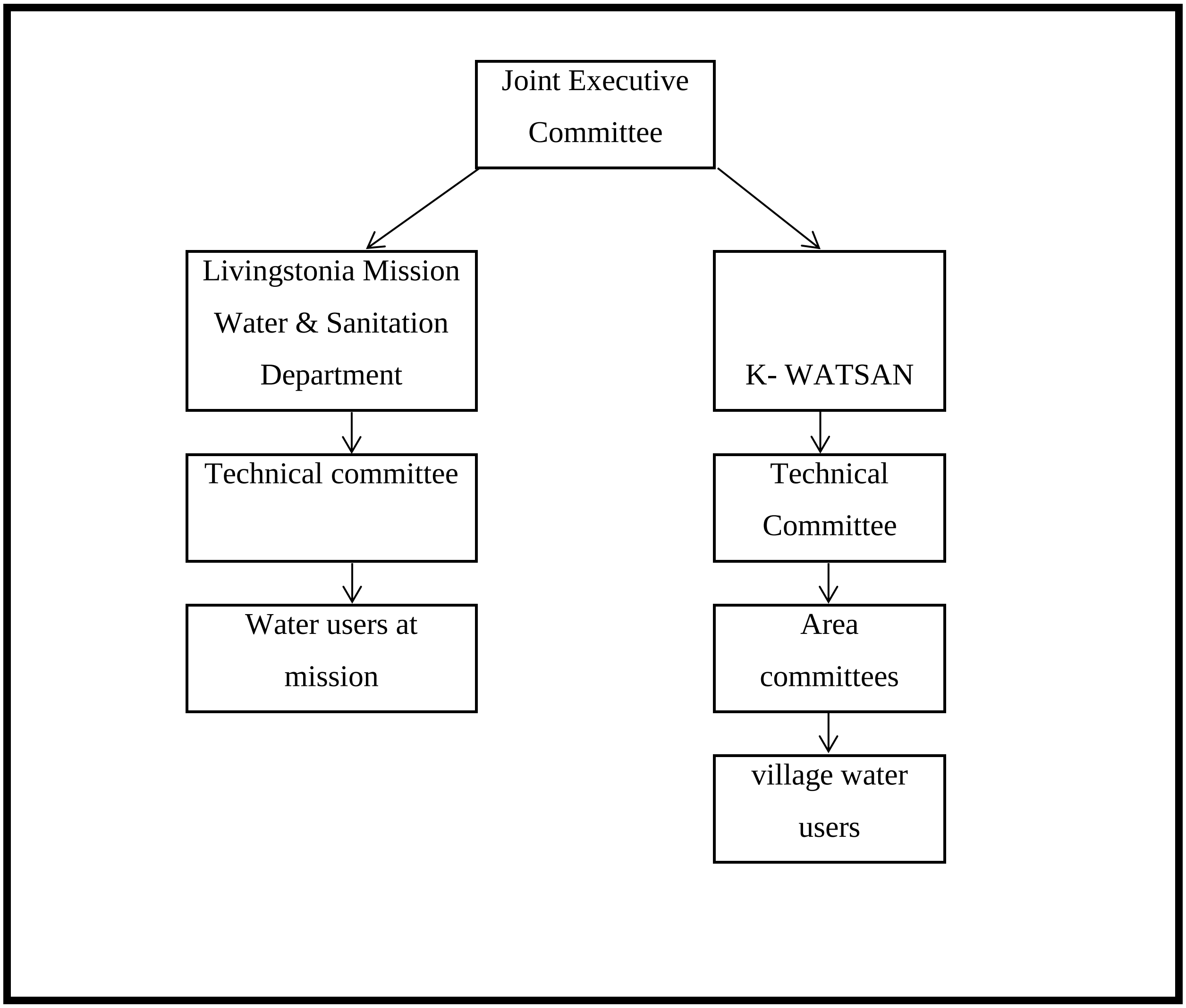

Figure 23: Livingstonia Water Supply Managemente Organogram

The K-WATSAN manages all communal taps drawing their water from the Rotary Club international distribution line while the remainder is manned by the mission. K-WATSAN and the CCAP mission are the legal owners of the water supply scheme. Except for private taps all water infrastructure are owned by the two entities.

Figure 24: Khondowe WATSAN Offices

The management of water scheme at Livingstonia reflects the adherence to the decentralization policy and the enacted Local Government Act (GoM, 1998c). The decentralization process aims at enhancing community participation in governance and development by devolving political and administrative authority to the district level. The Environmental Affairs Department (EAD) has been instrumental in developing a Decentralized Environmental Management (DEM) strategy devolving Environmental Natural Resource Management (ENRM) to local authorities in line with the local government act (GoM, 1998c). This is supported by the Community Based Natural Resources Management (CBNRM) strategy that empowers communities in sustainable natural resource management consistent with the national land resources management policy and strategy (GoM, 2000).

The current national decentralisation policy and local government act which among other things blames poor performance of development programs implemented in the past due to centralisation which resulted into a shift towards a more user-centred approach to development, based on popular participation. The decentralisation policy reflects a shift of Neo-liberal polices in the 1990s from mere community participation to local governance (Khanal, 2003). The underlying theory is that meaningful and rapid development is possible only if it is planned and implemented from below by the people expected to be the beneficiaries of such development, and development from below is best achieved through decentralization (Maro, 1990). It is based on the devolution of responsibility for water schemes from governments to villagers, and on a participatory approach involving users, planners and policymakers at all levels. Though the management of the scheme lacks backup support from other stakeholders especially government, Livingstonia Water users' Association has adopted the community based approach as key to ensuring local participation, representation of felt needs, the equitable distribution of resources, and sustainability of the scheme.

4.7.2 Operation and Maintenance of Water Facilities

There are different causes of failure in water supply systems and the need to put in place mechanisms of checking the problems is critical for successful performance of a scheme. Through questionnaires, members of the examined households reported causes, frequency and management of water supply infrastructure faults. Some water facilities in the area are more than fifty years old and those which are relatively new this may be one of the major (32%) contributing factors of frequent failure of the system especially in the rainy season due to rock fall, mudflow and landslides. The result is similar to what Kleemeier (2000) found that age contributed to failure of most GFS in Malawi. Though not periodic, maintenance work is carried out by a trained plumber employed by K-WATSAN. In addition, the institution has By-Laws (appendix 9) which assist in compliance promotion to best practices by community members. It was also observed that the maintenance in the area is “breakdown-based”. During the study time there were two shops at Livingstonia with tap spare parts. Just like Njalam’mano (2007) study it was noted that maintenance of civil works such as platforms and soak away pits is neglected in all the water points that were visited. This could be due to the fact that people in the area think such a condition does affect their water supply.

The scheme uses user fees for operation and maintenance though it is a big burden for the most vulnerable groups within the community. The mission uses a flat rate charge of MK2, 500 per household per month while the Water user Association (WUA) has a flat rate of MK1500.00 for private taps and MK3.00 per 20 litre pail on communal taps. Some other households are forced to collect water from unprotected sources -when available- or to make do with minimum amounts at other times due to failure to raise the required user fees especially in the lean months of January and February.

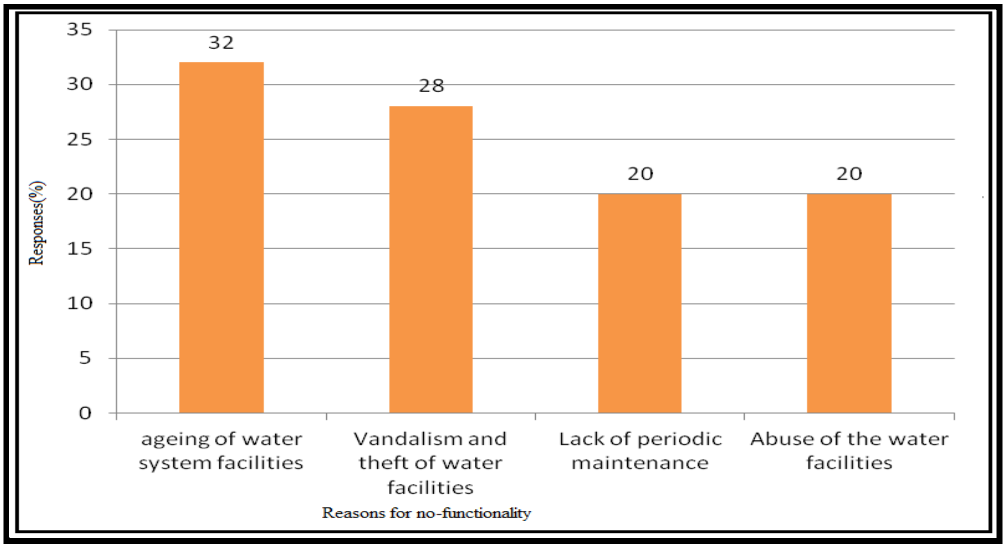

Figure 25: Reasons for Non-functional Taps

There is a need to come up with a pro-poor policy framework which should be characterized in terms of a trade-off between equity, cost and sustainability, how can water be made accessible, at an affordable cost, on a sustainable basis equity at the local level (Cleaver et al., 2005; Jaglin, 2002) is an essential sustainability criteria, therefore innovative strategies are needed to adequately serve the poorest, either through some form of subsidies (by the government or by the communities) or through some form of free tariff. A realistic, targeted, and transparent financial mechanism for assisting the poor is required, while ensuring that sufficient finances are generated to sustain services.

4.7.3 Community Participation

Many writers have commended the concept of community participation and management of water supply and sanitation services as the most effective way of achieving sustainability (Shiva, 2002). In this study household members were asked to report through the questionnaire forms of participation in the running of the water scheme during, before and after scheme establishment.

Majority as indicated in Table 14 reported to have participated in the project by providing self-help labour which included a wide variety of activities. The digging and backfilling of pipelines were the major self-help activity, but others included the digging of foundations for tanks and tap aprons, the loading and unloading of sand, stone, and materials, the carrying of materials and equipment to project sites, the breaking of stones for aggregate, and the assisting of field operators in pipeline construction.

Table 14: Forms of Community Participation at Livingstonia GFS

Forms of community participation	Percentage (%)
Provision of self-help labour	25
Provision of local commodities	20
Provision of land for water point installation	3
Provision of guarding services at water point	4
Cleaning and clearing at water point	19
Monetary contributions towards maintenance	17
Attending water committee meetings	12

Some households (20%) reported to have participated in the project through provision of local commodities which included sand, some stone, and niggling tools. In addition to labor and local commodity provision, local communities' participation is evidenced by their spending of significant amount of time in organizing and attending water committee meetings. Cleaning and clearing around water points was mentioned by (19%) of the respondents which were largely females as a form of participation in the project. The results imply that communities themselves are strongly committed to the success as well as continued operation and maintenance of the water network and also show the acceptance and sense of community ownership of the scheme at Livingstonia. This finding is also supported by Manikutty (1998) and IRC (2003) who found that community participation and management, has been seen as a device to enhance effectiveness of projects aided by donors. Other arguments given in favour of community management of projects are; the vehicle for decentralization, capacity building and improved sustainability through increased beneficiary's commitment.

The involvement of local community at Livingstonia scheme reflects principles of the Malawi National Water Policy of 2005 (GoM, 2010) which among many other things observes that water supply and basic sanitation services provided without active community participation in planning and management are often not properly operated and maintained, hence not sustainable. It is also acknowledged by international reports that most sustainable community level interventions are characterized by significant community investment of labour, other in kind services, and user fees in design, construction, maintenance and operation of facilities (UN, 2005). The Dublin principles adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro 1992, Agenda 21 and the World Summit on Sustainable Development (WSSD) in South Africa in 2002 both put more emphasis on community participation in management of water resources (Doe and Khan, 2004; Solanes and Gonzalez-Villarreal, 1999). Vandana Shiva argues that, “more than any other resource, water needs to remain a common good and requires community management” (Shiva, 2002).

In rural Malawi it has become more evident that community management of water supply and sanitation services under a well-established institutional set-up can contribute to sustainability of services for enhancing community development. However the community should be the key stakeholder in water supply and sanitation services in their respective villages. Back-up from the local government and other development partners such as NGOs and private sectors are essential for proper functions of the community managed water projects.

4.8 Socio-Economic and Environmental Impacts of the Water Scheme

An impact assessment was carried out using interviews and observation to assess significant socio-economic and environmental changes within the project area from the water source to the receiving end. A number of stakeholders participated in the assessment whose findings are presented and discussed in this section.

4.8.1 Socio- Economic Impacts

Increased access to clean water is an integral part of Malawi’s economic development and poverty reduction policy. Economic development calls for an increasing use of water, not only for simple domestic purposes but also for enhancement of the local economy. Below are some of significant social and economic activities which have been realized following the implementation of this scheme in the area.

4.8.1.1 Increased Participation of Women in Development Activities

A number of households interviewed expressed that the scheme has helped in the increasing the time of women to participate in productive activities such as businesses and farming. This was also echoed by the Community Development Assistant of the area; 'Some of the factors which detour women from equally participating in productive activities include attending to the sick and spending more time on fetching water from distant and unreliable water points.' The reviews of Hughes (1981) and Mc Junkin (1982) conclude that despite wide variation in the results of individual studies there is a steady trend of improvements in health status as water supply and sanitation improvements are made. Improved water brought by the scheme has reduced the number of cases of water related illness which usually in rural areas increases burden on women who take up guardianship role at health facilities instead of pursuing productive activities such as farming and businesses. On the other hand, collection of household water is predominantly a female chore in rural Malawi; this implies that the scheme has reduced the distance and time for women to provide their homes with water. This saved time therefore is being used for other profit ventures. The result augurs well with the observation of the 2007 Malawi Gender Policy which among other things recommends improving accessibility of portable water as a strategy of women empowerment and steering of overall national economic growth (GoM, 2010).

4.8.1.2 Diversification of Economic Activities

Livingstonia water scheme is faced with the dilemma of attempting to encourage economic developments while striving to preserve the present equity of the system. However, according to one member of WATSAN, 'there are certain uses which are promoted in the project area and have led to desirable economic outcomes, such as brick making, irrigation farming, and livestock raising. In addition, the water from the source is used to run maize milling machine, a hydropower station and opened up opportunities of employment and businesses in the project area as may be observed from Figure 25 below. The milling machine was constructed by the missionaries in the late 1890s in-order to assist the community with grinding of maize into flour. The machine is run by water from the reservoir tank of the scheme. Apart from helping the community with milling, its existence has helped to reduce the burden of women travelling long distance to make flour. There are 3 people who are fully employed by the mission to run the plant. In addition, the milling machine also plays an important role to academics at the plateau as the University of Livingstonia physics department uses it as a learning resource.

Figure 26: Maize Mill Powered by Water from the Scheme Water Source Reservoir Tank

Water is an important catalyst necessary for speeding up sustainable socioeconomic system of every nation and poverty reduction (Madula, 2000). Poverty is defined by UN (2010) as inability to access and afford basic services such as food, shelter and education. A milling machine in rural community is considered very crucial for survival as it facilitates the turning of crops into flour. Currently the Malawi energy sector is facing a lot of challenges, in particular persistent power blackouts; the scheme helps rural communities around Livingstonia to enjoy milling services without being interrupted by Electricity Supply Commission of Malawi (ESCOM) power supply challenges as the case is countrywide. The Government of Malawi's Growth and Development Strategy (MGDS II, 2011-2016) has the objective to 'continue reducing poverty through sustainable economic growth and infrastructure development.' It identifies nine priority areas, including water development and sanitation, to meet its goals under the Vision 2020. This project at national scale helps Malawi government to be on right track with Millennium Development Goals (MDGs) through poverty reduction.

Figure 27: Hydro-electricity Plant Powered by Scheme Water from the Reservoir Tank

The first hydro-electric station in Malawi is known to have started at Livingstonia water scheme by Scottish missionaries in 1904 (Central Intelligence Agency (CIA), 2012). The station used to produces 1.3 megawatts and used to meet all the energy requirements of institutions at Livingstonia plateau. However, this site is no longer in operation due to the lack of maintenance by the CCAP mission as well as limited financial and technical capacity to replace worn out parts. This is because the plant was constructed by overseas company and engineers that also manufactured the plant components and are now non-existent. In this era in which Malawi is experiencing power problems; the plant could assist the lives of rural Malawians in various ways towards poverty alleviation strategies such as opening battery charging places, barbershops and saloons.

4.8.1.3 Enhancement of Social Cohesion

One of the five village headmen reported that , ‘one of the main advantages to the water connections in his village is that there will be more peace as many disputes erupt at the spring taps and people argue over entitlements or queuing’. This village head sees the reliability and water pressure in the scheme taps as benefiting community relations as households’ conflicts and disputes are less common as the case was at shallow wells which were sometimes drying up. The village head also sees water access as having the ability to improve the economic situation of households as people will have time to do other things which will also help to create more peace within the community. Another community member reported that ‘women staying out waiting for water on long queues until late hours raised a lot of suspicions linked to promiscuity which was source of family disruptions’. In both cases, the scheme has played an important role in building peace and unity at household and community level.

4.8.2 Environmental Impacts

“Environment" means the physical factors of the surroundings of the human being including land, water, atmosphere, climate, sound, odour, taste, and the biological factors of fauna and flora, and includes the cultural, social and economic aspects of human activity, the natural and the built environment (GoM, 1996). As the case with other similar projects, the project may have some minor and temporary environmental impacts resulting mainly from the construction of water supply and sanitation facilities. Surface water abstraction usually impacts downstream users during low river/stream flows. The researcher through interviews and field observation came out with a list of environmental impacts as listed below;

4.8.2.1 Effects on Environmental Hygiene

The development of cracks on water tap platforms may attract accumulation of stagnant water around water points as indicated (Figure 27). The observation was also supported by a Health Surveillance Assistance (HSA) in the area, ‘obsolete digging places such as borrow pit and stone quarry offer a good place for the reproduction of mosquito and other pests, which are harmful to people and livestock.’ This implies that besides improving people’s welfare, water schemes if not well managed can also contribute to poor health outcomes. Besides health impact such places often produces foul smell and contribute to loss of environmental aesthetic beauty.

Figure 28: Poor Wastewater Disposal

This finding relates to what UN (2010) found that Done Mo Village Head expressed concern that an outbreak of malaria in his town may have been caused by people not covering water or lack of an appropriate drainage network. Furthermore, a rural Blantyre study by Njalam'mano observed that water points with damaged platforms were health risk areas since they were found to be conducive breeding grounds for mosquito and flies (Njalam'mano, 2007).

4.8.2.2 Disturbance of Ecological Balance and Biodiversity

The implementation of small civil works during construction and large maintenance exercises have potential of offsetting local ecology which possibly resulted in the temporary emigration of animals and other riverine species. Due to noise during construction works, it is very likely that some animals were displaced however; the researcher did not have an inventory of animals which have since disappeared during the time of construction. Long-term studies (Glowacki and Penczak 2000; Penczak, 1992, 1999; Penczak, et al., 1998; Kruk, et al., 2001) indicate that certain facultative riverine species may suffer impacts from the impounding of streams for different purposes. According to the Forestry Officer of the area, 'Some fish usually in rainy season rise up and breed in uplands however, due to impounding of Nyankhowa river at intake point as shown in Figure 28, the upper stream does not have fish species such as opsaridium micocephalus.' The upper stream is reported to have few numbers of clarias gariepinas only which was not a case before the water project. This implies that water schemes if planned as isolated independent system from local ecosystem may pose serious ecological disruptions in an area. This is also true based on Falkenmark, et al (2000) argument that many of the problems of environmental degradation result from human use of water resources with lack of understanding of how changes in the quantity and quality of water at one point in space and time can affect aquatic and their associated ecosystems at another point in space and time. In most GFS water intakes, they build a weir to catch the water but let most of it still continue downstream so that the ecosystem is not disrupted and that the water could still be used for laundry and irrigation downstream (Niskanen, 2003).

Figure 29: Livingstonia GFS Water In-take at Nyankhowa Stream

There is therefore, a need to consider the upstream and downstream impacts of water use and understand better the linkages between water and the landscape that it flows through in-order to harmonise water projects with environmental conservation. Many authors (Rijsberman and Molden 2001; Wallace and Gregory, 2002) have also pointed out that it is necessary to not only understand the linkages within the physical water system and the ecosystems it supports, but also the linkages with the social systems that depend on and manage the water resources. This mixture of physical and social issues is very complex and it is therefore vital to have some frame of reference within which this complexity can be addressed. Within the hydrological community, this frame of reference is the catchment, a generally well defined geographical unit where it is possible to describe water inputs and outputs as well as flows within the system. Using a catchment as the unit of study allows the impacts of change in one part of the catchment to be predicted in another part of the catchment. For example, deforestation or afforestation of the uplands in a catchment can alter flows and water quality downstream, an issue that has long been studied by hydrologists (Calder and Newson, 1979).

The construction of dams or impounding of a river has different effects on aquatic habitats and fish populations. Several studies (Martinez, et al., 1994; Penczak, 1999, Petts, 1984) show that obligatory riverine fish species suffer severely from dam construction without effective fish ladders, including the local extirpation of many of them. The main reason for this is disruption of river continuum (Ward and Stanford, 1983). Stream impounding often leads to changes in flow regime, amount and composition of suspended solids, alternation of physical and chemical water parameters, reduction in number of microhabitats, blocking of migration routes, and changes in abundance of food (Welcomme, 1985).

4.8.2.3 Facilitation of Landslides and Soil Erosion

It was observed during the study that the Scottish distribution line feeding the sedimentation tank used uncovered canals as over a distance of 300 metres which in rainy season used to overflow resulting into landslides and soil erosion within the catchment area as indicated in Figure 29 below. Earthwork developments, involving large land surfaces in mountainous areas, can have a big impact on the stability of slopes. A remarkable interference is the removal of lateral supports by excavation for road construction, dam building, housing and farming (Knapen et al., 2006).
Digging ditches, dispatching water and constructing canals contributes to soil erosion in the study area. It also facilitates landslides in the area which damages plants and crops in the neighbouring farms and in other instances destroy the natural sight of some parts. According to the Agriculture Extension Officer of the area, 'the sediments have been noticed increasing downstream resulting in floods over the past few years especially in rainy season.' Apart from variations in precipitation, irrigation, faulty leaking pipes, and reservoirs are also known to have triggered landslides (Crozier, 1989; Msilimba, 2002; and Msilimba and Holmes, 2005).

Figure 30: Overflow from Open Conduit Causing Landslides

Human-induced slides are numerous (Knapen, et al., 2006, McCall, 1992). Locally, it has been suggested that the 1999 Chiweta road landslide and the 2000 Nyankhowa landslides were caused by the slope cutting that exposed covered dipping and jointed beds (Manda, 1999; Msilimba, 2002; and Msilimba and Holmes, 2005). It has been observed that as the slump mass on sloppy hill sides of the plateau became saturated with water, pore pressure increases, initiating a failure. Such mechanisms in other areas have contributed to the flooding of the banks of rivers for example Mzinga River as reported by (Harp, et al., 1989; 2002).

4.9 Water Source Catchment Protection

Despite having in place functional taps and effective water supply management the contribution of the catchments, source areas and reserves play a vital role in ensuring the sustainability of the water sources of GFS. The study examined a number of policies and practices in relation protection, conservation and management of the water source catchment area by various stakeholders in the area using interviews, observations and focus group discussions.

4.9.1 Community Knowledge and Practices in Catchment Conservation

Although the understanding of drinking water sources and their catchments is incomplete, the first step in protecting water sources and catchments is to properly understand them. Water resource managers need to document current level of knowledge, and identify the areas where understanding is lacking. It was for this purpose the knowledge and practices were assessed through observations and focus group discussions with the scheme Catchment Conservation Committee. Tables 15 below are results. Although various approaches to implementing water source protection are recognized, a framework for managing water source catchment in Malawi has not yet been developed. Such a framework could have helped to determine the level of knowledge and effectiveness of the existing practices at the scheme.

Table 15: Catchment Conservation Committee's Knowledge and Conservation Practices

Knowledge and practices in protecting catchment areas		
Catchment protection	Understanding	Practices
	Water Quality control	Avoidance of soil erosion by farmers Control grazing in the catchment areas Avoid encroachment of the catchment by wild animals
	Water Quantity control	Encourage g efficient irrigation practices Reduce planting in the riparian zones
	Forestry	Guard against deforestation Planting trees Removing invasive vegetation species Guarding against bush fires
	Land Use Control	Limiting intensity of settlements and human activities In the catchment area through Local leaders

However, based on comparison with contemporary best practice in other schemes, the results are more appealing, for example, gravity fed schemes studied by Kleemeie in 2000 cited by MoWID (2007) in Balaka, Thyolo and Phalombe had catchment management committees whose understanding and practices are similar to current results though with minor variations. Similar results in South Africa are also presented in Blignaut and King (2006) studies. The minor variations are justified since our knowledge of our natural and ecological assets and processes affecting water source management evolves.

4.9.2 Forestry

The introduction of the tree-planting period introduced by the government is a clear realisation of the dangers that the water resources of the country face as catchments continue to undergo deforestation (Laisi, 2009). The Livingstonia catchment conservation committee with support from foreign volunteers has gone a long way in sensitising local communities in planting trees in order to rehabilitate the water source catchment area. The Malawi National Environmental Policy emphasizes the promotion and support of the conservation and protection of forest ecosystems on catchment areas and the growing of trees by the individual companies, estates, local communities and authorities, including integration of forests and trees into the farming systems, soil conservation activities and land use systems (GoM, 2000).

In response to the increased rate of forest mismanagement powered by rapid population growth and caused by cultivation, fuel wood, forest fires, overgrazing and infrastructure; the department of environmental management at the University of Livingstonia in support of the current forest policy of Malawi government has a number of programs that are put in place to deal with the problem of forest mismanagement such as yearly tree planting exercises. In addition, the geography department has also taken catchment protection as one of its mainstream research focal area.

According to the Dean of Applied Sciences at Laws Campus, University of Livingstonia in 2014 rainy season the department planted various plant species of which 5,000 and 3,000 were exotic and indigenous species respectively. The notable ones included; *Pinus patula, Eucalyptus graudis and branstegia, Colophospermum mopane and Yasica.*

To the contrary, other studies blame low catchment yields on increased forestation in water source areas. Studies on small watersheds in tropical, temperate and boreal region have shown that in general, a decrease in vegetation density can be expected to increase annual mean water yield and discharge (Bosch and Hewlett, 1982). While an increase in vegetation density tends to reduce water yield and discharge, consistent with alterations to total evapotranspiration and soil infiltration rates (Bosch and Hewlett, 1982). This may be true with high water consumptive species such as Eucalyptus which are not recommended in catchment areas. However, forests are known to play a role in watershed conservation including storing excess rainfall through interception of run-off and increasing the infiltration of rainwater, thereby recharging underground aquifers and serving as a source of stream flow. This supports Calder (1992) observation that the largest changes in terms of land area and arguably also in terms of hydrological impacts often arise from afforestation and deforestation activities. In addition, one of the roles of forests that are gaining ground is the potential for forests as carbon sinks. This potential offers opportunity for developing countries to get economic return from forests through carbon trading (Leach, 2004).

Several studies indicate that there is noticeable deforestation in most water source catchment areas, for example, (Bloomfield, 1965; GoM, 2001; Sabola, 2002) in Machinga forest reserve which is a water source for Lingoni gravity fed irrigation scheme. In addition, Shams (2010) observed the same scenario in Liwonde forest which supplies water to Chagwa gravity fed scheme. Although catchment areas are under threat for various reasons which encompass encroachment for cultivation and settlement, uncontrolled bush fires, wanton cutting down of trees the situation is different in the study area. With continued proper management, Nyankhowa River can continue providing water that is relatively free from contamination, soft, clear and odourless; which can be used for bathing, cooking, washing and gardening. It is very important that all those using water from the catchment understand all the potential dangers of disturbing the catchment. Unfortunately, just like the case with most schemes in Malawi, in this catchment area, there are no government agencies overseeing the safety of the forest resources apart from two guards employed by the Water Users' Association.

4.9.3 Prohibition of Human Activities

Restraining people from encroaching the catchment area through various activities was mentioned in the focus group discussions as one strategy in catchment conservation, however, field observation indicate some form of breeching of the said by-laws around the source through cultivation (Figure 30). Historically, agriculture has been a major driver of ecosystem loss and degradation where people have managed agro ecosystems simply to optimize crop production, without considering the larger landscape such as river depletion and consequent degradation of downstream ecosystems. Best management practices to mitigate the effects of agriculture include various measures such as cover crops, vegetative buffer strips, irrigation scheduling, erosion control structures, grassed waterways, residue management practices, conservation strip cropping and terracing (Agriculture and Agri-food Research Center (AARC), 1997).

Figure 30: Anthropogenic Activities within Water Source Catchment Areas

Other than non-compliance people might have encroached the catchment area due to challenges of demarcating the hydrogeological boundaries of the supposed protected area. Similar challenges were observed in 2005 in Sri-Lanka and formed a basis of policy review (United Republic of Sri-Lanka (URS), 2014). Land use and management regulations made in 1999 to control land use in environmentally fragile areas such as water source catchment areas (GoM, 1999b).Contrary, the department of agriculture policy for long time allowed cultivation on steep slopes and along river banks (Laisi, 2009). The Water Resources Board in Malawi through the Water Resources Act 1999, prohibits agricultural production in catchment areas, and bars people from developing the area at a distance less than 50 metres from the water body (GoM, 2000). However, it seems this Act is not being adhered to at the water source catchment area of the Scheme due to competing demands in the area poverty and population pressure.

Despite the fact thousands of trees are planted every year during the tree planting season, forests are still disappearing at a faster rate in agreement to National Environmental Report (GoM, 2003). Due to absence of government agencies at Lingoni catchment in Machinga district, Nakapa, (2010) observed that people in the area were abusing the water source catchment areas to meet their own personal needs. As it can be observed (Figure 30) there are signs of deforestation in other sections. The committee members amongst many others blame the University of Livingstonia Laws Campus and the Livingstonia technical college for offering market of wood to their cafeteria. Against the promotion of clean energy technologies as advocated by the Malawi National Energy Policy (GoM, 2003b) the two institutions use wood as a source of energy which indirectly has been the major contributing factor behind massive deforestation especially in Mumbwe forest which is the integral part of the scheme water source catchment.

4.9.4 Environmental Policy and Management Framework Impact Analysis

The success of any project depends on availability of appropriate policies, laws and regulation to guide management and practices. The laws and policies pertaining to the water sources conservation in Malawi has been included under various sectors namely land development, water and forest conservation and soil conservation and many more. However, their implementation is in a lower stage which has also been affected by the lack of resources as well as a large number of various technical and institutional matters. On the other hand, these enactments had been passed few decades ago some of which have failed to grant legal provision as to give firm solutions to the problems arising at present. In this section, the researcher through interviews with key informants analysed some of significant policy shortcomings affecting the implementation and impact of some key legislation in relation to water source conservation in the area. Notable issues that came out from the interviews were as indicated; 'the current legal and policy framework is conducive to the community-based management of the water, land and forest resources but the rural communities are not fully conversant of the frameworks.' Forestry Extension Officer (FEO).

As rightly noted by FEO, according to the district water development officer, "a major challenge facing the proper management of water source catchment conservation is not the enabling policy or legal environment but information gaps." Creating an informed society has been recognized as a prerequisite to conservation efforts in environmental managerialism. A number of studies have identified and determined the human resource capacity development needs for water resource management (Forster, 1997; Gumbo et al., 2004; Mudege and Taylor, 2001; Wright et al., 2001; Krugmann and Sim, 2002; Van der Zaag, 2003 as cited by Nakapa, 2010). Capacity building is required especially at lowest community level. Similarly, Laisi (2009) points out those IWRM concepts are poorly understood in spite of the recent trends by the United Nations in recognition of the need to adopt IWRM principles for sustainable water resources management. In another study, Chipofya, et al. (2009) indicates that due to lack of awareness of key policy frameworks in Malawi, important hydrological and ecological functions in catchment areas are considered to be of marginal value. It is therefore not surprising that environmental issues continue to receive less attention from most stakeholders and its protection is seen by decision makers as a "green" issue promoted largely by external interest groups. Information and database are very important as management decision tool, information on impact of forest cover change on stream flow is essential for proper management of both forestry and water resources. Furthermore, it was found out that in Thyolo and Mulanje studies by Kafakoma and Silungwe (2003) many communities and organizations do not know the existence and functions of the Water Resources Board that was constituted under the Water Resources Act (Cap: 72:03) let alone the NWRA as envisaged under the National Water Policy. This therefore calls for urgent need among various players in water sector to invest in capacity building and sensitization on policy and changes within the sector through available channels. 'For the communities to fully control the water facilities and their catchment areas, they need to form village level institutions that are legally constituted under the laws of Malawi.' Community Development Assistant

The National Water and Forestry Policies (GoM, 1996) place an emphasis on providing an enabling framework for promoting the participation of local communities and Community Based Organizations to ensure sustainable utilization of forest and water resources. As rightly put, community based natural resource management can be a failure without providing the local institutions with legal existence. Currently, enforcement of rules and regulation by a non- legal entity is very difficult because of many freedoms that the new political dispensation in Malawi has brought. Under the laws of Malawi a community may enjoy use of public water under a water right for all other purposes if such a community is constituted under a modicum of some legal personality as a partnership under the Partnership Act (cap.46:04) or a company under the Companies Act (cap.46:03) or a trust under the Trustees Incorporation Act (cap.5:03) or a cooperative society under the Cooperative Societies Act (No. 36 of 1998) (Kafakoma and Silungwe, 2003).

This means that the communities will have to transform their various committees to legal entities so that they can be legally recognized and have the power to sue and be sued. However, at present, just like the case with Livingstonia scheme, most GFS in Malawi are not legally registered entities except for few which make it difficult for local leaders to influence compliance by the local communities. A study in Thyolo, Phalombe and Mulanje on water ownership rights found out that previously, it was possible for the chief and village headmen to set and enforce by-laws on the management of the riverbanks, springs and streams though the enforcement is dependent on the charisma and strength of the local leaders (Kafakoma and Silungwe, 2003). This clearly shows that among many other things successful implementation of catchment conservation plans at local level requires institutional legislation. "Current Environmental legislation fails to provide incentives for land owners, users or managers for environmentally prudent land management practices" (Dean of Applied Science at University of Livingstonia (UNILIA) Laws Campus).

The National Environmental Policy emphasizes the promotion and support of the conservation and protection of forest ecosystems and the growing of trees by the individual companies, estates, local communities and authorities, including integration of forests and trees into the farming systems, soil conservation activities and land use systems (GOM, 2004a). This would ensure watershed conservation and sustainable socioeconomic development. The Environment Management Act (EMA) (GoM, 1996b) deals with implementing sectoral regulations under it. Land use and management regulations were made in 1999 (GoM, 1999b) to control land use in environmentally fragile areas such as mountains and hilly areas, riverbanks, lakes and wetlands. The Malawi Water Resources Management Policy and Strategies (GoM, 1999b) recognizes that resources like water and forest systems are being continuously threatened from the vagaries of weather, overexploitation, mismanagement, environmental degradation and pollution (GoM, 1999). This has been partly attributed to lack of incentives that may induce positive compliance towards their appropriate management.

Incentives for catchment protection services have been widely recognised internationally, theoretically, they have the potential to change natural use practices to become more environmentally advantageous. According to Environmental Management Act 23 cap vii section 31(a) the Minister, on the recommendation of the Council and in consultation with the Minister of Finance, shall determine a fiscal incentives as are necessary for promoting the protection and management of the environment and the conservation and sustainable utilization of natural resources (GoM, 2005). Incentives in (Landell-Mills and Poras, 2002; Pagiola and Platais, 2002) studies aim at encourage land users, land owners and resource users, managers to undertake environmental friendly practices that support the development, protection or conservation of environmental services such as landscape beauty, carbon sequestration, biodiversity conservation and watershed protection. Contrary to legal provision as noted by the Dean of applied Science, prudent natural resource users in Malawi do not receive any form of incentives. However, in other countries, for example in South Africa incentives are implemented to internalise both the benefit and the costs of environmentally prudent land management practices (Pagiola and Platais, 2002).

In nut shell, the environmental management framework gives an overview of the gaps in the current environmental policy and legislation with reference to water source catchment management. The analysis therefore calls for best management practices in-order to enhance sustainability of the scheme.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter draws conclusions on a number of identified strengths, shortfalls, problems and immediate needs that require appropriate attention by both researchers and water resource managers. It goes further to make recommendations on areas that need improvement in-order to enhance the performance and sustainability of water services and supply management at Livingstonia gravity fed scheme.

5.2 Conclusions

The first objective of the study was to characterize accessibility and utilization of water, state of water and water facilities, and scheme management. The study has shown that water supply is generally sufficient to meet the demands of the community throughout the whole year except for few villages which are disadvantaged due to them being located on higher ground than the water source. The study also found out that there are vibrant management structures coupled with active community participation unlike in other similar schemes which has resulted into high water tap functionality rates. There is therefore high accessibility and utilization of improved water despite ageing of the system facilities. The study further shows that although the scheme committees are vibrant they are operating as social grouping with no clearly defined legal personality. These institutions have documents such as constitutions or by-laws to indicate their legal status but not yet registered. The current status therefore put the institutions in an awkward position when dealing with cases of default of by-laws such as illegal connections, deforestation and encroachment of the catchment areas.

The study has shown that although water is used for both drinking and cooking in the scheme, it is of poor microbiological quality. The scheme does not chemically treat the water. The contamination may be attributed to encroachment of the water source by wild games, birds and people. Farming around the source attracts a lot of baboons and monkeys which in turn defecate in the open canals transmitting water to the sedimentation tanks. The presence of *E.coli* in tap water is of public health significance as it is indicative of faecal contamination. Such a situation could promote occurrence of diarrheal disease outbreaks in the area. In addition, quality of water especially in the rainy season is aesthetically undesirable due to high levels of turbidity. This could be as a result of frequent landslides which pushes earth materials into the open conduits and the stream.

The second objective was to assess the socio-economic and environmental impact of the water supply scheme in the area. The study has demonstrates that Livingstonia gravity fed water scheme is playing a pivotal role in enhancing the socio-economic status of community members in the study area. A good example is its contribution towards women participation in development activities; due to reduction of distances to water collection points, women who are primary water collectors have more time for productive activities. The study has further shown that the scheme is contributing to creation of employment. The scheme is run by a technical team which comprise of employed staff in addition to area mechanics.

The study has also shown the impact of the scheme on the diversification of activities in the area some of which have led to desirable economic outcomes, such as brick making, irrigation farming, and livestock rearing. In addition, the water from the source is used to run maize milling machine and a hydropower station. The presence of the milling machine running using water is not only a prestige but also a great relief to communities in the area in light of frequent ESCOM power interruptions common in most parts of Malawi.

On environmental impacts the study has shown that besides improving people's welfare, the water scheme is also contributing to poor health outcomes. This is true in some few water points with damaged aprons and soaks away pits. Around such mismanaged water points tend to harbour stagnant water which often produces foul smell and contribute to loss of environmental aesthetic beauty. Such environments also support mosquito breeding leading to higher cases of malarial attacks in the buffer zones. The study also noted that the impounding of Nyankhowa streams for the scheme purpose has resulted in reduction of some riverine species such as *opsaridiummicocephalus.* The upper stream is reported to have few numbers of clarias gariepinas which was not a case before the water project. This implies that water schemes if not planned as isolated independent system from local ecosystem may pose serious ecological disruptions in an area.

Besides disturbance of ecological balance the study also observed that during most of rainy seasons there is water overflow from open conduits resulting into landslides and soil erosion within the catchment area. On the lower stream this has resulted into heavy siltation and flooding in the surrounding areas. This is also known to have facilitated landslides in the area which damages plants and crops in the neighboring farms and in other instances destroy the natural sight of some parts. Apart from faulty and leaking pipes water reservoirs are also known to have triggered landslides in the area.

The last objective of the study was to analyze the impact of existing conservation and legislation practices on water source catchment area of the scheme. To that regard, the study has shown that due to proper conservation of the catchment area, Nyankhowa River is reliable water source even in the driest month of the year (October). In curbing deforestation, the department of environmental management at the University of Livingstonia has a number of programs that are put in place to deal with the problem of forest mismanagement such as yearly tree planting exercises and research. In addition, the scheme receives volunteers who help the CCC in sensitizing the communities around the water source in practicing environmental friendly economic activities such as conservation farming, avoidance of livestock grazing and prohibiting of habitation around the water source.

While there is a lot of legislation in place to enhance environmental compliance, the study has observed the lack of adequate knowledge of the important pieces of legislation to govern the conduct of various committees and environmental product users. To this regard, the study has exposed knowledge gaps as a cause of concern. The gaps are due to in-availability of policy and legal documents at local level, inadequate awareness and capacity building of local structures on policy changes, standard policy frameworks and emerging issues such as integrated water resource management approaches. Such gaps are contributing to poor performance of local institutions in managing water resources and services despite their autonomy under the current decentralized system. In addition, failure of government to operationalize fiscal incentives as indicated in Environmental Management Act 23 cap vii section 31(a) for promoting the protection and management of the environment and the conservation and sustainable utilization of natural is yet another challenge facing the conservation effort of the scheme water source.

5.3 Recommendations

To those areas without adequate water supply, alternative technologies including rainwater harvesting, shallow wells and boreholes should be investigated for use especially in areas where sparse population densities and topography make piped gravity flow water systems too costly. These technologies require little maintenance and need no community cohesion to work effectively.

To enhance water quality, it is recommended that the scheme authorities work in collaboration with the Public Health, Geography and Chemistry Department at University of Livingstonia and the Primary Health Care Unit of DGMH and come up with a water quantity, quality monitoring, and chlorination programmes to ensure health and safety of lives of the community. For example, Nyankhowa and other streams in the catchment area need to be gauged and water samples should be periodically collected and tested. Once this database is complete it is imperative that researchers, water resource managers and donor community use this information to formulate a monitoring strategy. Investing in an institutional support mechanism for the monitoring of existing water supply systems is very critical for sustainability and performance of the scheme. The University of Livingstonia has both the expertise and appropriate laboratory equipment for hydrometrics and water testing and can be of much help to the scheme in ensuring supply of good water quality and quantities throughout the year.

To reduce the magnitude of ecological disturbance on river-line ecosystems, the scheme water intakes should be built with weirs to catch the water but let most of it continue downstream so that the ecosystem is not disrupted and that the water could still be used for laundry and irrigation downstream. In addition, to reduce overflows, the system should use closed conduits from the point of impounding to the sedimentary tank. The closed pipe design could reduce chances of landslides and soil erosion in the area while at the same time reducing water losses through evaporation and contamination by wind and other agents.

To reduce pressure on forests covering up the water source, it is recommended that government or donors through clean development mechanism (CDM) facility should financially and technically assist the University of Livingstonia and Livingstonia technical college to come up and use clean energy sources or establish their own woodlots. Owing to large population of students at both institutions, relying on wood fuel for cooking and heating are considered major factors accelerating deforestation in the area.

Lastly, the government should facilitate implementation of incentives for friendly use of environmental resources and support local institutions and committees to attain legal status through legal registration. Most of them have written constitutions and by-laws but more often they are challenged by deviant community members due to lack of legal authority.

5.4 Areas of Further Research

The water quality assessment in this study was performed on the system constructed in 2006 by the Rotary Club International and in the dry season. This means that there is a need for comparative analysis with the old system constructed by Scottish missionaries in 1904 which feeds water users at Mumbwe plateau. The study will have the potential of providing information related to effects of design, material and age on water quality.

Adjacent to the Scheme, is Ntchenachena Scheme. The scheme is under the operation of the Malawi Government. Therefore, a comparative study between the two may be necessary to establish the differences and similarities of issues and challenges affecting their operations and water resource management practices.

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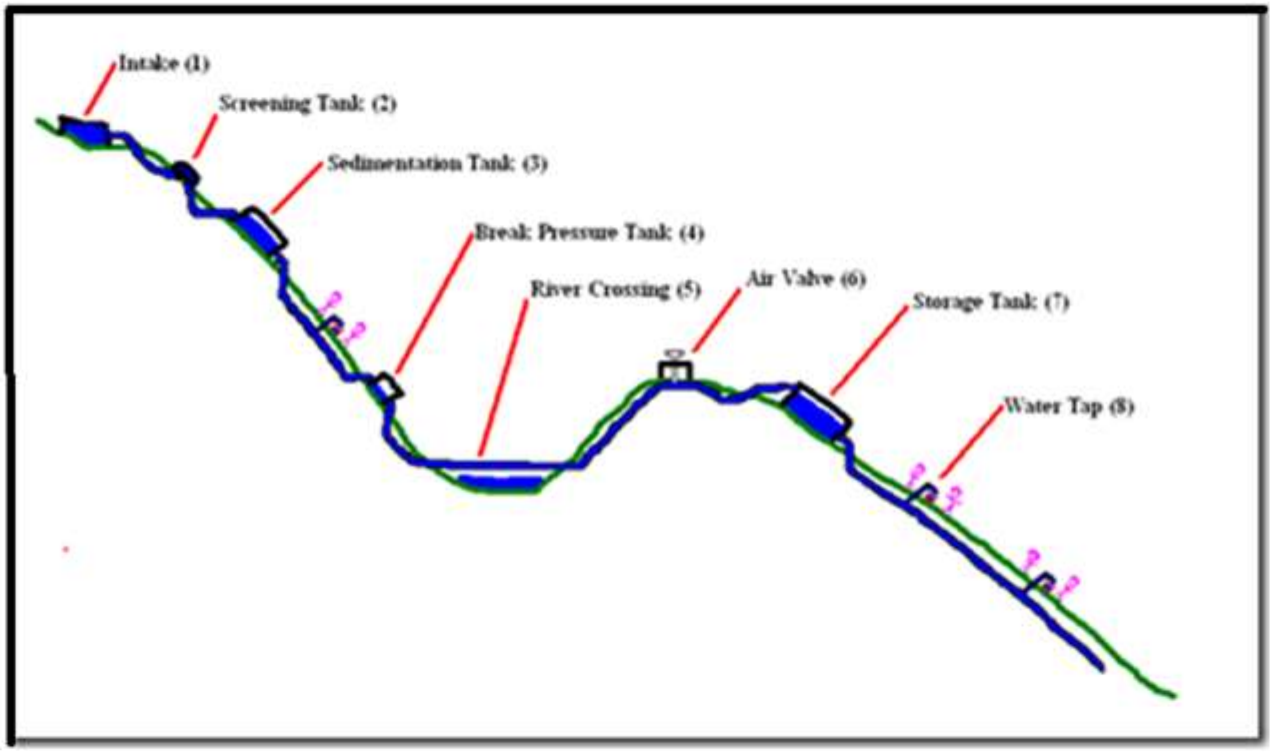
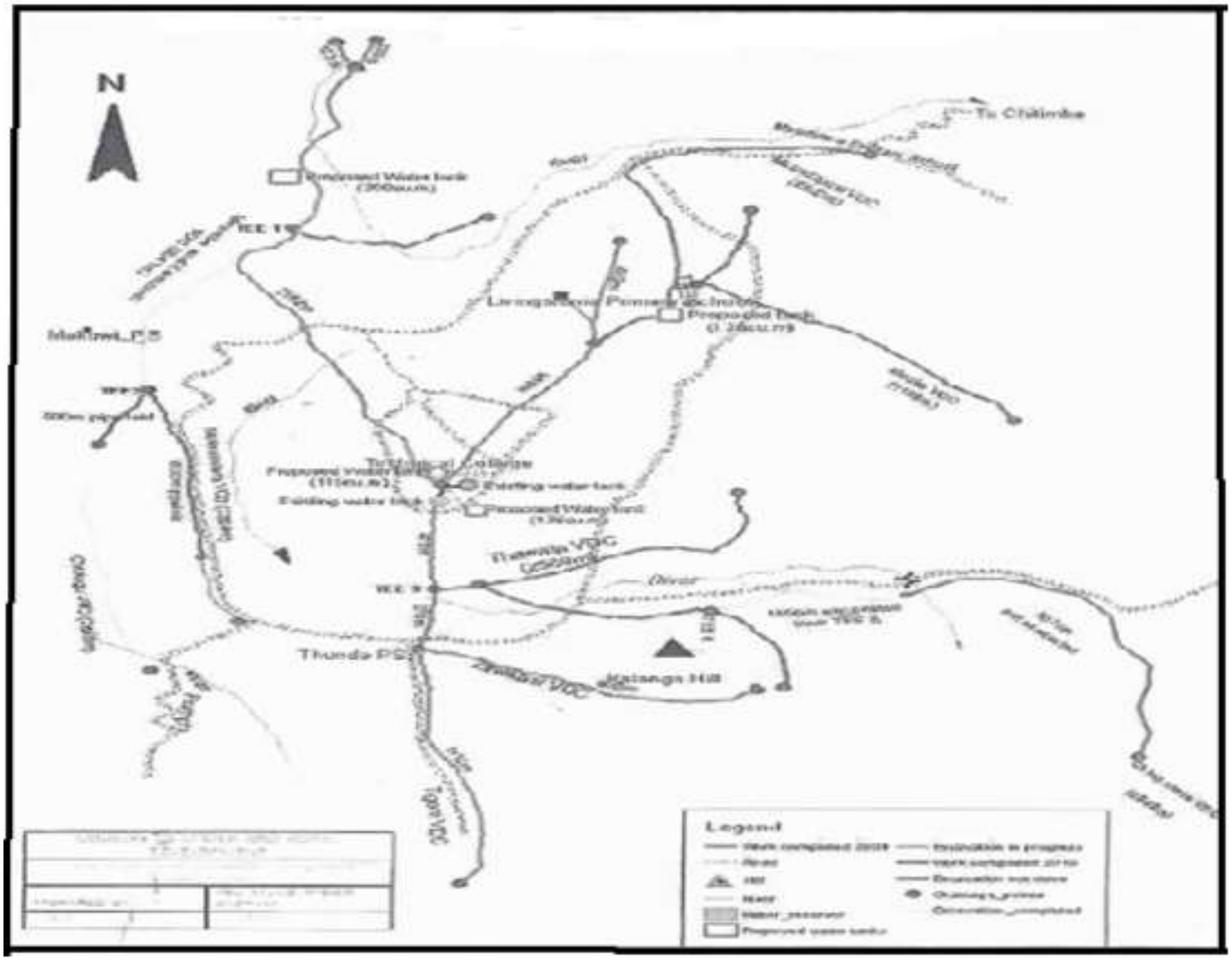
APPENDICES

Appendix 1: Schematic Diagram of a Gravity Fed Water Supply System



Source: (Gileme, 1983; and Warmer 1986)

Appendix 2: Sketch Map of Livingstonia Scheme



Source: Livingstonia Stone House Museum

Appendix 3: Household Questionnaire

	Questions		Responses
1	Name of Village		
2	What is the sex of the respondent?	1	Male 2 Female
3	How old are you?		
4	What is your marital status?	1	Single
		2	Married
		3	Divorce
		4	Widow/widower
5	How many are you in your household?		
6	What is the highest level of school you attended?	1	None
		2	primary
		3	Secondary
		4	Tertially
7	Do you or any member of your household own any of the following	1	Radio
		2	Television
		3	Bicycle
		4	Oxcat
		5	Motorcycle
		6	Car
		7	Head of cattle
8	What is your house roof made of?	1	Thatched grass
		2	Tiles
		3	Iron sheets
9	What is your occupation	1	farming
		2	Formal employment
		3	businesses
		4	casual labour
		5	Self employment
10	What is the main source of your drinking water?	1	Standpipe
		2	Borehole
		3	Well
		4	Stream
11	How far is your water source from your household?		
12	Where is it located?	1	Middle of the village
		2	Village outskirt
		3	Along main road
13	Year of installation	1	Before 1990
		2	1991-2000
		3	2001-2010
		4	2010 and after
14	What is the alternative source of your drinking water?	1	Standpipe
		2	Borehole
		3	Well
		4	Stream
15	When do you use the above mentioned water sources	1	When the water facility is faulty
		2	When there is a long quee at main source
		3	When i have no water fees
		4	When the main source is dry
		5	When the main source is providing water of substandard quality
16	What are the uses of water from the main sources	1	Domestic purposes
		2	Brick making
		3	irrigation farming
		4	Selling
17	Who is responsible for water collection in your household?	1	boys
		2	girls
		3	Men
		4	Women
18	Is the water you draw from the water point sufficient to meet your household needs?	1	Yes 2 No

19	Why it is that water is not sufficient to meet your needs	1	Financial constraints
		2	Eratic flows
		3	Pressure from other users
		4	Inadquate storage materials
20	Water quantity drawn per day		
22	Deficit Water Volume per day		
23	Household monthly expenditure on water		
24	Do you have problems with water quality from the water facility	1	Yes 2 No
25	What are the problems?	1	Turbudity
		2	Hardness
		3	Odour
		4	Taste
		5	color
		6	suspended solids
26	Is drinking water treated?	1	Yes 2 No
27	Reasons for continued use of water source	1	No congestion
		2	Nearness to household
		3	affordable
		4	Only source
28	What are water treatment methods used?	1	Filtration
		2	Chlorination
		3	Boiling
		4	Water guard application
29	What are the benefits of constant reliable safe water supply nearby?	1	Reduced distance in fetching water
		2	Reduction of time spend on waiting
		3	Reduction of incidences of theft when people go far for water
		4	Reduction of conflicts over water
30	How long does it take you to collect and carry water from the water facility to your house?		
31	Do you have constant flow rate throughout the year?	1	Yes 2 No
32	When do you have low flow rates?	1	Dry season
		2	Wet season
33	When the water facility has broken down do you have the alternative water source?	1	Yes 2 No
34	If non-functional. how long does it take to repair		
35	Who provided the water facility you are using?	1	CCAP Synod
		2	Rotary Club
		3	Government
		4	K-WATSAN
		5	Personal
36	Did you participate in the initial stages of water facility construction?	1	Yes 2 No
37	What was your role?	1	Site selection
		2	Construction
		3	Trainings
		4	supply of locally available construction materials
		5	Planning
38	Do you have a trained caretaker or technician in this community?	1	Yes 2 No
39	Breakdown frequency per year		
40	What do you think are the major causes of breakdown of water facilities in this area	1	Lack of periodic maintenance
		2	Ageing of water system facilities
		3	Vandalism and theft of water facilities
		4	Abuse of water facilities
41	Who does the maintenance or repair works	1	CCAP Synod
		2	Rotary Club
		3	Government
		4	K-WATSAN
		5	Hired experts
		6	Myself
42	Where do you buy hand spare parts?	1	From local vendors at livingstonia
		2	From lovendors at Rumphi boma
		3	From shops and hardwares of our cities
		4	Imported from other countries
		5	Elsewhere
43	Who buys the spare parts?	1	K-WATSAN
		2	Sponsor
		3	Government
		4	Water Point Committee

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43	Who buys the spare parts?	1	K-WATSAN
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		3	Government
		4	Water Point Committee

44	Do you have the Water Point Committee for your water facility?	1	Yes 2 No
45	What are some of the WPC roles?	1	Maintain sanitation and hygine at the water point
		2	Maintain the water point when faulty
		3	Organize by law+ money contributions for maintainance
		4	Conduct health education
		5	Pay water bills to WUA
46	Who established the WPC?	1	CCAP synod
		2	Rotaract Club
		3	Government
		4	Villagers
47	When was the WPCestablished?	1	Before water facility installation
		2	During water facility installation
		3	After water facility installation
48	Why is it that you do not have the committee?	1	Lack of trust in other village based committees
		2	Lack of incentives
		3	Lack of guidelines and supervision of the committees
		4	Lack of training opportunities for the committees
		5	Lack of legal authority of the committees
49	Do you have rules on control and use of water?	1	Yes 2 No
50	Do you follow them?	1	Yes 2 No
51	Why do you not follow them?	1	No incentives for compliance
		2	No punishment for offenders
		3	Lack of awareness
		4	Absence of written rules and regulations
52	What do you do to people who do not follow the rules?	1	Nothing
		2	Fined
		3	Suspended from accessing the water point
53	Do you pay for operation and maintenance of the water facility?	1	Yes 2 No
54	How do you pay?	1	Everytime we collect water
		2	Weekly
		3	Monthly
		4	Yearly
55	What are the specific uses of money?	1	Don't know
		2	For maintenance
		3	Payments for tap care takers
		4	For running of the WUA
56	Why do you not pay?	1	The tap is personal
		2	lack of transparency and accountability
		3	Financial constraints
57	Are you willing to pay?	1	Yes 2 No
58	How much are you willing to pay on monthly basis?		
59	Apart from client fees, what are other sources of funds for water facility operation and maintenance?	1	Funds from CDF
		2	Donations from sponsors and volunteers
		3	others

Thanks a lot for your time and participation

Appendix 4: Water Facilities' Condition Observation Checklist

1	Name of Village	1	Gavala
		2	Thunda
		3	Mantchewe
		4	Vunguvungu
		5	Mphande
2	Distance to the main road		
3	Water facility functioning	1	Yes 2 No
4	Sign of cracks	2	Yes 2 No
5	Condition of standing slab	1	Poor
		2	Average
		3	Good
		4	Excellent
6	Condition of drainage channel	1	Poor
		2	Average
		3	Good
		4	Excellent
7	Tightness of boats and nuts	1	Poor
		2	Average
		3	Good
		4	Excellent
8	Condition of soak away pit	1	Poor
		2	Average
		3	Good
		4	Excellent
9	Condition of bucket	1	Poor
		2	Average
		3	Good
		4	Excellent
10	Signs of rust	1	Yes 2 No
11	Fence availability	1	Yes 2 No
12	Condition of fence	1	Poor
		2	Average
		3	Good
		4	Excellent
13	Distance between water point and nearest animal watering area		
14	Location of household waste area to water point	1	Uphill
		2	Downhill
15	Distance between water point and nearest latrine		
16	Location of latrine to the water point	1	Uphill
		2	Downhill
17	Location of fertiliser using farming units	1	Uphill
		2	Downhill
18	Cleanliness of the surrounding area	1	Dirty
		2	Clean
		3	Very Clean
19	Water delivery rate	1	Poor
		2	Average
		3	Good
		4	Excellent
20	Number of people served by the water point in an hour		
21	Number of people on a queue during peak hour		

Appendix 5: Focus Group Discussion Themes

a. Understanding of water source catchment protection and management

b. Policy, practices and challenges towards water source catchment protection and management

Appendix 6: Key Informant Interview Guiding Questions

1. What are the opportunities and shortfalls in the current water and related legislation affecting effective application of best practices towards protection and conservation of GFS water source catchment areas at Livingstonia Scheme and its Catchment areas?
2. What do you think needs to be done to address the shortfalls?
3. Explain some significant socio- economic and environmental impacts of the Livingstonia Gravity Fed Water Supply Scheme.

Appendix 7: Permission Letter

The Polytechnic
Faculty of Applied Sciences
P/Bag 303
Chichiri
Blantyre 3
4th November 2014.

TO WHOM IT MAY CONCERN

INTRODUCTION OF OVERSTONE KONDOWE

The bearer of this letter is Overstone Kondowe. He is currently doing research on gravity fed water schemes as a partial requirement for the award of Master of Science Degree in Environmental Protection and Management at the Malawi Polytechnic.

Kondowe's research is on 'Issues and challenges of Livingstonia Gravity Fed Water Supply Scheme'. Please assist him as he collects data/information on the water scheme.

Kind regards.

D. D. Lakudzala

Coordinator for Master of Science in Environmental Protection and Management.

Appendix 8: Participant Consent Form

My name is Overstone Kondowe. I am a Master of Science Student at University of Malawi, Polytechnic. I have the pleasure to inform you that you have been randomly selected to be a participant of this study as an interviewee; **Issues and challenges of Livingstonia gravity fed water supply scheme.** This is purely an academic research conducted as a partial requirement towards the fulfillment of the degree of Master of Science in Environmental Protection and Management (MSc EPM).

Despite giving you new insights, it is expected that the information generated from this study, will be vital to water resource managers in the development and assessment of rural gravity fed water supply schemes as such facilities still remain the reliable and convenient source of water for both agriculture and domestic purposes in many rural areas of the country. This study will expose points of intervention for improved sustainable rural gravity water supply development which, if addressed, will improve the supply of clean water to eradicate waterborne diseases and saving time spent on water collection consequently open the door to long-term increased labour production in agricultural and other income generating activities in the rural areas of Malawi.

Among many other activities you will be required to participate in interviews and the amount time for the activity would not take more than 30 minutes. However, the study has already dealt with problems of risk and uncertainties. Your benefit from this study is that your contributions will add knowledge to the topic of study. Be reminded that you are not forced to participate in this study, this means that you can withdraw your consent at any time and no punishment will be given to you. Your identity will not be revealed anywhere in the study as well as to other people, which may put you in danger. Read the instructions clearly.If you have some questions and concerns on this research, you may contact the researcher, on 0881329028.

DECLARATION……………………...…I have read this consent form and I have been given the chance to ask questions. I hereby consent to participation in this study as explained above. Signature………………………………………… Date…………………………………

Appendix 9: Khondowe WATSAN By-Laws

KHONDOWE WATSAN BY LAWS GOVERNING THE ASSOCIATION

1. VANDALISM OF PROJECT PROPERTY

The association has agreed that any deliberate vandalism of the project is prohibited. In addition anybody involved in is reliable to pay a fine of K 5000. And failure to comply with this, the case will be referred to court for judicial processes. This is within the period of 2 weeks. However, in-case of accidental breakdown shall asses the cause of the incidence and come up with possible decision to the matter.

2. ILLEGAL CONNECTION

Anybody finds himself or herself connecting water illegally shall be asked to pay K 1000 within period of two weeks, in addition, disconnection of such situation must be done immediately. If she or he does not want to comply with this case, the case shall be referred to the court for judicial processes.

3. DISCONNECTION OF WATER POINTS

Kiosk holder not paying water revenues for the period of three months shall have his or her kiosk disconnected. The reconnection shall only be made after paying the bills and reconnection fee of K500.

4. ABOUT WATER USER

All water users shall have their own boy lows to govern their water points. Any water user not complying with the kiosk by lows, the case will be referred to the board through its structure for judgment.

5. METER TAMPERING

Anybody identified to have tampered with meter shall be mandated to pay K 20000 and failure to comply with the case, this is referred to the court for judicial judgment.

6. THEFTY OF THE PROJECT PROPERTY (ASSOCIATION)

Any illegal in possession of the project property is deemed to have stolen. The case shall therefore be reported to the police.

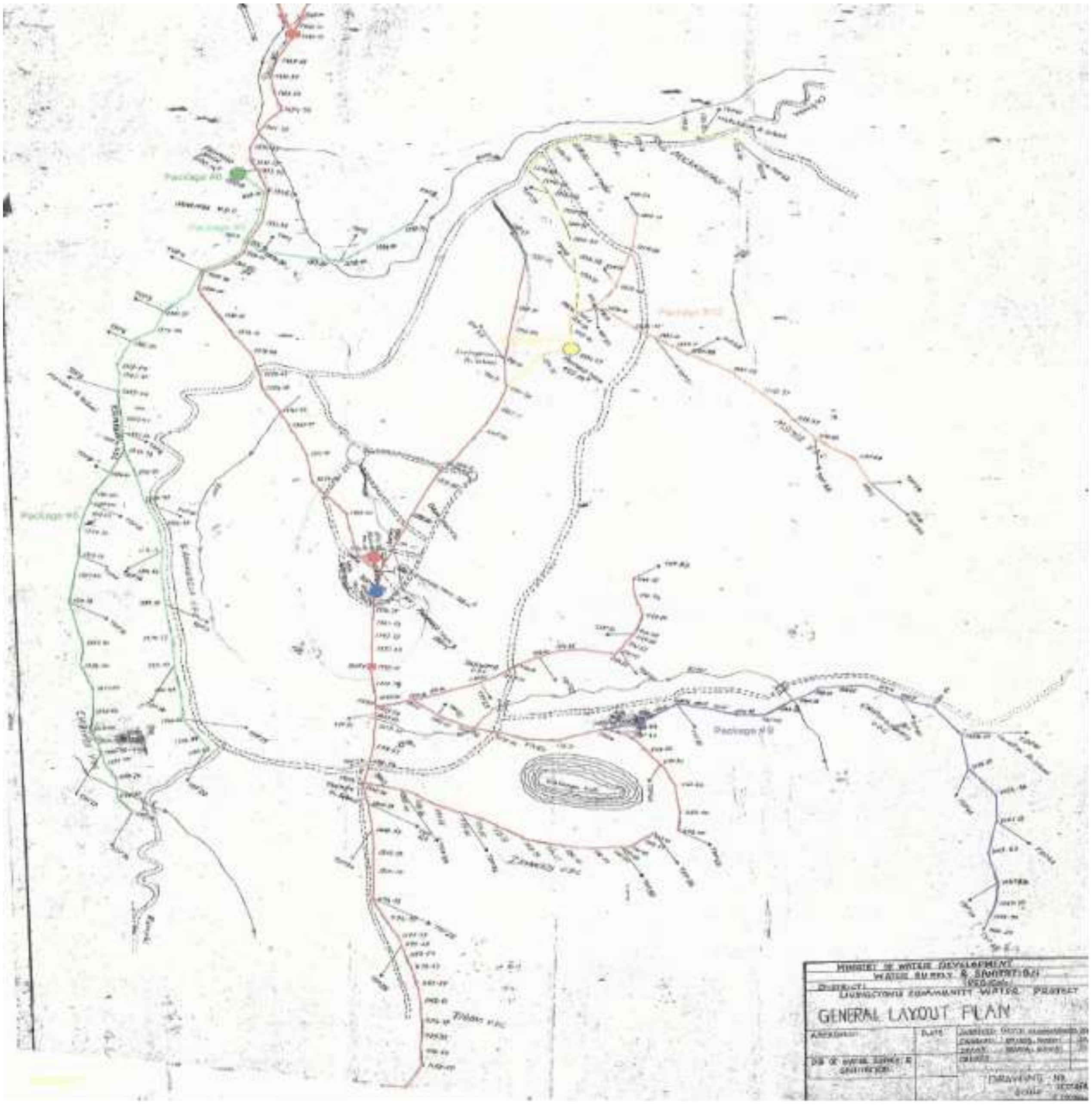
7. ABOUT TOKEN

The association has introduced tokens as means of paying revenue to avoid financial discrepancies. Therefore, anybody finds himself or herself circulation of fake tokens shall be referred to the court for judicial judgment.

8. APPLICATION OF INDIVIDUAL WATER POINTS

Individual water connection is one of the initiatives within the association. However, any one applying for individual water points is asked to pay k 6000 as a connection fee. In addition, shall be asked to provide his or her own materials.

Appendix 10: Livingstonia Scheme Water Line Distribution and Layout



Appendix 11: MOU between Livingstonia and K-WATSAN

Preamble

The Livingstonia Gravity Fed Piped Water System is managed by two different organizations, the Livingstonia Mission Water & sanitation Department and the Khondowe Water and Sanitation Users' Association (K-WATSAN). Both organizations share one water source owned by the Mission, as well as sharing Transmission Lines. Because of having shared areas of the water system, and to ease the operation and maintenance of the rest of the system, the two organizations have agreed to sign a Memorandum of Understanding (MOU) stating the terms of their partnership in managing and maintaining the system.

Terms: the terms of partnership in managing and maintaining the Livingstonia Gravity Fed Piped Water System are as follows:

1. The two organizations will have one Technical Management Office for the operation and maintenance of the Transmission Lines that includes the water catchment area. This office will have a joint bank account to cover management office salaries and minor activities related to the Transmission Lines and the water source catchment area.
2. A joint coordination committee will be established to oversee the Technical Management Office for the operation and maintenance of the Transmission Lines and the catchment area.
3. The joint Coordination Committee will consist of 3 voting members from the Livingstonia Mission Water & Sanitation Department, 3 voting members from K-WATSAN and the manager of the Technical Management Office. Non –voting member shall be a representative from the Community Development Office will have the power to break a tie in the Coordination Committee.
4. Voting members on the joint Coordination Committee will be selected by and from each of the organisation's boards. Each organisation's board may decide the term length and limits of their Coordination Committee representative.
5. The voting members of the Coordination Committee will elect a Chairperson and Treasurer from the current Committee's voting member. At no time will the Chairperson and Treasurer both be from the same organization. The /chairperson is to be from one organization one year, and the other organization the next, rotating annually.
6. The joint Coordination Committee will have the following responsibilities:

a. Monitor the Technical Management Office. The Technical Management Office bank account and a Transmission Line/Catchment Area bank account.
b. Will be required to approve the hiring and firing of all Technical Management Office staff, including hiring and firing of the manager.
c. Will be required to approve the budget of the Technical Management Office and the budget for the Transmission Line/Catchment Area bank account.
d. Meet on a regularly scheduled monthly basis and attend other meetings as needed.

7. Both the Livingstonia Mission Water & Sanitation Department and the K-WATSAN have their own separate bank accounts for their own rate revenues. Each organization has its own administration structure. But each organization will buy parts from a shared store managed by the Technical Management Office. Parts to be used for the Livingstonia Mission Water & Sanitation Department distribution system will be bought using the Livingstonia Mission Water & Sanitation Department account, and parts to be used for the K-WATSAN's distribution system will be bought using the K-WATSAN account. Parts to be used for the Transmission Line will be bought using the joint Transmission Line/Catchment Area bank account.
8. The coordination Committee and manager will create the budget for the Technical Management Office, as well as established the amount of money to be deposited in the Transmission Line/Catchment Area bank account each year for maintenance. The Coordination Committee will decide what percentage the Livingstonia Mission Water & Sanitation Department and what percentage the K-WATSAN will deposit each year to meet the Technical Management Office budget and what percentage each will deposit to the Transmission Line account. These percentages may eventually be based on the percentage of total water consumption each organization uses.
9. This MOU may be amended at any time by a unanimous vote of the Coordination Committee, including the manager and the representative from the Community Development Office, and only after all proposed changes are open to public comment.

This MOU is hereby signed by the following representatives of each organization on this Livingstonia Mission Water & Sanitation Department.