PUBLIC PERCEPTIONS ON THE USE OF TREATED WASTEWATER FOR DOMESTIC PURPOSES: THE CASE OF LILONGWE CITY

MASTER OF SCIENCE IN WATER RESOURCES MODELLING AND GOVERNANCE

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PUBLIC PERCEPTIONS ON THE USE OF TREATED WASTEWATER FOR DOMESTIC PURPOSES: THE CASE OF LILONGWE CITY

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DECLARATION

I, the undersigned, hereby declare that this thesis is my own original work which has not been submitted to any other institution for similar purposes. Where other people's work has been used, acknowledgements have been appropriately made.

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DEDICATION

Dedicated to my sons Joel, Ethan and Jason Kazembe.

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ABSTRACT

Water, an important natural resource throughout the world, requires adequate management practices aimed at efficient use and distribution. While water reclamation, recycling and reuse are recognized around the world as key components of water and wastewater management, the successful implementation of any reuse project hinges on public acceptance. The main objective of this study was to investigate public perceptions on the use of treated wastewater for domestic purposes. Data was collected through a structured purposive survey questionnaire and interviews. The questionnaire was designed to investigate current wastewater disposal practices, knowledge in wastewater reuse and acceptance of wastewater reuse for domestic purposes. Results from this study showed that a majority of the respondents currently get rid of wastewater in their homes using septic tanks followed by use of hole absorbency through open pit. Less than one percent of the respondents indicated that they get rid of wastewater through the public sewer pipeline. The results also showed that most of the respondents were not aware of wastewater treatment and reuse. Overall, the respondents supported the establishment of a wastewater treatment plant for water reuse because of intermittent water supply being experienced in Lilongwe City. This study shows that 63.8% of respondents are willing to use treated wastewater for non-contact and non-potable domestic purposes. However, some of the respondents indicated that would not use treated wastewater because they consider it unsafe for domestic purposes. Further, this study shows that 60.3% of the respondents accepted use of treated wastewater in order to reduce potable water usage.

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LIST OF ABBREVIATIONS

CEC	Commission of the European Communities
IWA	International Water Association
JICA	Japan International Cooperation Agency
LCC	Lilongwe City Council
LWB	Lilongwe Water Board
m^3	Cubic Meter
MBS	Malawi Bureau of Standards
NEAP	National Environmental Action Plan
NRW	Non-Revenue Water
NSO	National Statistical Office
NSP	National Sanitation Policy
NWDP	National Water Development Programme
NWP	National Water Policy
SSA	Sub-Saharan Africa
THA	Traditional Housing Area
UF	Ultrafiltration
UNFPA	United Nations Population Fund
UNICEF	United Nations Children’s Fund
USA	United States of America
UTHA	Unplanned Traditional Housing Area
WB	World Bank
WHO	World Health Organisation
WWTF	Wastewater Treatment Facility

CHAPTER ONE

INTRODUCTION

Freshwater availability is one of the major problems facing the world, and approximately, one third of drinking water requirement of the world is obtained from surface sources like rivers, dams, lakes, and canals (Jonnalagada & Mhere, 2001). Surface water has been exploited for several purposes by humans. It serves as a source of potable water after treatment and as a source of domestic water without treatment particularly in rural areas in developing countries. It has been used for irrigation purposes by farmers, and fishermen get their occupation from harvesting fish in so many freshwater sources. Itis used for swimming and also serves as centres for tourist attraction. Surface water, therefore, should be protected from pollution. Sources of freshwater pollution are raw and partially treated wastewater. The release of domestic and industrial wastewater has led to the increase in freshwater pollution and depletion of clean water resources (Avalon Global Research, 2012). Most quantities of wastewater generated in developing countries do not undergo any form of treatment. In few urban centres, various forms of wastewater treatment facilities (WWTFs) exist but most of them are producing ill‐treated effluents, which are disposed of onto freshwater courses (Dolnicar, Hurlimann, &Grun, 2011).

In some developed countries of the world, adequate supply of potable water and improved sanitation facilities have been achieved. Strict environmental laws and monitoring for compliance prevent undue pollution to freshwater sources. Good waste management technologies and increased environmental protection awareness have contributed immensely to the success story. This has resulted in fewer cases of waterborne diseases reported compared to developing countries (Angelakis & Bontoux, 2011).

Many people in developing countries of the world still rely on untreated surface water as their basic source of domestic water supply. This is so because either there is an incessant supply of potable water or inadequate water supply systems. This problem is exacerbated in rural areas. Surface water is increasingly under undue stress due to population growth and increased industrialization. The ease of the accessibility of surface water makes them the best choice for wastewater discharge. Wastewater which comprises of several microorganisms, heavy metals, nutrients, radionuclides, pharmaceutical, and personal care products all find their way to surface water resources causing irreversible damage to the aquatic ecosystem and to humans as the aesthetic value of such water is compromised. These pollutants decrease the supply of useable water, increase the cost of purifying it, contaminate aquatic resources, and affect food supplies (Edokpayi et.al., 2014). Pollution combined with the human demand for water affects biodiversity, ecosystem functioning, and the natural services of aquatic systems upon which society depends on (Hurlimann, 2006).

1.1 Background

A number of international declarations regard public participation as essential in the effective management of water resources. For example, Article 14 of the EU Water Framework recognizes the need for equitable allocation and the desire for wider participation regarding water resources (CEC, 2000). The 1992 Dublin Principle number two states that water development and management should be based on a participatory approach involving users, planners, and policy makers at all levels (Bagget, et al., 2006). The Southern Africa Development Community Regional Water Policy (2005) recognizes effective public consultations, involvement of users and integrated people-centered planning as key principles in water resources management in the region.

According to the Ministry of Agriculture, Irrigation and Water Development Strategic Plan (2012 -2017), Malawi has vast natural water resources, with an estimated average of 1,400m^3 of water resources per capita, renewed annually(Malawi Government, 2011).However, the water supply in Malawi is fragile and increasingly impacted by climate change, as characterized by frequent droughts and floods (Chidanti-Malunga, 2011). The spatial and seasonal distribution of the resource, however, leaves a lot of imbalances and makes the country to be categorized currently as "water stressed" according to the Falkernmark's Water Barrier Scale (Brown & Matlock, 2011).Treated or partially treated wastewater from urban areas in Malawi is discharged to receiving rivers and the blend of treated wastewater and runoff is abstracted by communities living downstream. Indirect reuse is therefore taking place in the country where the abstracted water that is partially derived from treated return flows is used for washing, gardening and irrigation in smaller communities and rural areas (Blanca & Takashi, 2008).

In view of this reuse situation and with increasing pressures on water resources, the concept of beneficial use of treated wastewater becomes imperative for water resources management. Around the world, water reclamation, recycling and reuse are now recognized as key components of water and wastewater management (Dolnicar, et al., 2011). Along with technology advances in wastewater treatment, the opportunity for water reuse has never been more viable as an additional source of water for non-potable use (Hurlimann, 2006).

The benefits of using treated wastewater include preservation of water resources, prevention of coastal pollution, recovery of nutrients for agriculture, augmentation of river flow, savings in the cost of water treatment, groundwater recharge, and sustainability of water resource management (Angelakis & Bontoux, 2011). Given these benefits, wastewater reuse should not be treated simply as a means to an end but should be implemented in conjunction with other water conservation measures (Kasperson, 2006).

However, the successful implementation of any reuse project hinges on public acceptance. Irrespective of the conclusions which are drawn from scientific evidence, the impressions and attitudes of the general public can speedily and effectively bring a halt to any reuse project (Katz, 2007). As an aspect of water management, water reuse is indeed widely accepted around the world. The widespread acceptance of water reuse elsewhere does not automatically assume that any reuse projects would be readily accepted in Malawi where the technology and culture of water reuse are not very well developed (Agrifor Consult, 2006). This study seeks to explore ways in which customer perceptions of using treated wastewater for domestic purposes might inform systematic plans for up-scaling water reuse projects and the regulations in Malawi. It will investigate people’s perceptions on the use of treated wastewater for domestic purposes and identify the significant factors for accepting the use of treated wastewater.

Risk is one of the key areas of concern for stakeholders involved in water management (Johnson & Handmer, 2002). While experts tend to define risk in terms of the high value placed by the public on health issues, the public viewpoint on what risk is and the value they attribute to it is more complex (Beierle & Cayford, 2002). People's risk perception and the potential severity of that risk is not based solely on numerical data. If people favour an activity then they tend to judge the risks as low and the benefits as high; conversely, if they feel unfavourable towards it then they will judge it as high risk and of low benefit (Slovic, et al., 2004). Water reuse is perceived to be more acceptable if the risk involved is seen to be more under the direct control of an individual rather than if the risk is controlled by others (Aertgeerts & Angelakis, 2003). This study hence focused on investigating public perceptions on the use of treated wastewater for domestic purposes which are assumed to be influenced by the amount of risk attached to using treated wastewater. This study therefore assessed public perceptions in Lilongwe City on current wastewater disposal practices, determined the overall knowledge on wastewater treatment and the willingness to use treated wastewater for domestic purposes.

1.2 Problem Statement

As urban water demand grows and water purification technologies advance, municipal wastewater is being reclaimed and reused in increasing volumes and for more purposes around the world (Chen, et al., 2013). Besides the public health, environmental, and economic concerns, successful water reuse programs also depend on acceptance and support from the general public (Wu, et al., 2010). The biggest threat to sustainable water supply in Southern Africa is the contamination of available water resources through pollution. Many communities in Southern Africa still rely on untreated or insufficiently treated water from surface resources such as rivers and lakes for their daily supply. They have no or limited access to adequate sanitation facilities and are a high risk to waterborne diseases. Since 2000, there has been a dramatic increase in the episodes of waterborne diseases in Southern Africa (DWAF, 2002).

Public involvement is critical to the successful implementation of any treated wastewater programs (Weiping, et al., 2015). Besides the public health, environmental, and economic concerns, successful water reuse programs also depend on accepatance and support from the general public (Wu, et al., 2010). As the ratepayers will be directly impacted and eventually have to pay for the costs, public opposition may potentially be an obstacle to advanced wastewater reuse projects. After years of modernasation and ecoomic growth, especially rapid development in public media including televisions, cellphones and internet, the general public has become knowledgeable and shows greater environmetantal concerns (Weiping, et al., 2015).

Hartley, (2003) states that several high-profile initiatives have been halted after years of planning and tremendous expenditures due to public opposition to water reuse which could have been avoided through outreach, education and participation. In the 1990s, a number of high profile indirect potable water reuse projects in San Diego and California failed due to stiff public opposition. However, there are also successful water projects on water recycling in semi-arid countries of Southern Africa, namely Botswana, Namibia and South Africa, where treated wastewater presents a resource that is available and that can be used with limited additional treatment (Blanca & Takashi, 2008).

However, in the face of population growth and increasing demand for water, development of agriculture, increasing environmental degradation and climate variations, Malawi needs viable options for long-term security of water supply. The use of treated wastewater presents a key water demand management aspect that stresses on making better use of existing water supplies rather than developing new ones. According to Mulwafu, et al., (2003), substantial savings of water and money could be made through recycling of industrial water thereby reducing demand for water and at the same time reallocating the saved water to serve other customers.

While the rapid rate of growth of formal and informal settlements has been acknowledged by water utilities in cities like Lilongwe, making treated wastewater a key component of water resource management for such cities has not considered the challenges that public opposition may pose on wastewater reuse projects. Neglecting this aspect can speedily and effectively bring a halt to any reuse project. The aim of this study was to investigate people's perceptions on the use of treated wastewater for domestic purposes and identify the significant factors for accepting the use of treated wastewater.

In Malawi like most other developing countries in the world, surface water is usually used for domestic, recreational, and agricultural purposes mostly in the rural areas. Water quality is affected by both natural processes and anthropogenic activities. Generally, natural water quality varies from place to place, depending on seasonal changes, climatic changes, and with the types of soils, rocks, and surfaces through which it moves. A variety of human activities such as agricultural activities, urban and industrial development, mining, and recreation significantly alter the quality of natural waters and change the water use potential (Msilimba & Wanda, 2014).

Human waste disposal and management is generally very poor in Malawi. Waste water management plans are lacking or inappropriate and sewerage urban effluent enters river systems that are also sources of drinking water for downstream communities. This results in outbreaks of communicable diseases, especially diarrhoea and cholera. In 2006, only 6% (Chipofya, et al., 2010) of the total population had access to adequate sanitation, with 23% access in urban areas and only 4% in rural areas. The extremely low figure is attributed to the use of traditional pit latrines as an alternative, while these are considered to be an unsafe form of sanitation.

The four major urban centres (Blantyre, Lilongwe, Mzuzu, and Zomba) have offsite sewage systems but only 15% of the population is connected to waterborne sewerage and 15% to septic tanks (Mtethiwa, et al., 2007). The old sewage systems frequently break down at treatment plants and sewer lines blockages occur due to poor maintenance and a lack of spare parts, improper design of some sections, and also lack of public awareness on proper use of the sewerage systems. Sanitation has recently become a major cause of concern in THAs and squatter areas, especially in major urban areas. Outbreaks of cholera and other waterborne diseases from poor sanitation have caused national alarm.

Industrial effluent is usually collected in septic tanks or discharged into the sewerage systems, and pre-treatment of industrial waste water is uncommon. The City assemblies do clear septic tanks but very little waste water is treated in any way before being discharged to rivers or open quarries. The lack of adequate waste water treatment causes today severe water pollution especially in Lilongwe (Chatuwa stream, Mchesi and Lilongwe Rivers) and Blantyre (Mudi, Naperi, Limbe) (Chipofya, et al., 2010).

Decrease in water quality can lead to increased treatment costs of potable and industrial process water. The use of water with poor quality for agricultural activities can affect crop yield and cause food insecurity. The presence, transport, and fate of heavy metals and organic compounds (which are toxic and persistent) in water bodies are a cause for serious concern globally (Chipofya, et al., 2010). Groundwater can be polluted through the release of chemicals contained in wastewater. Riverbeds and wetlands are threatened with increased sediment impoundments and the presence of toxic and persistent chemicals. Such pollution can persist long after their original sources have ceased (Madyiwa, et al., 2003).

The health of the aquatic ecosystem can be negatively affected by the presence of toxic substances. This is further exacerbated with high population of pathogens in the water. The use of microbiologically contaminated water for domestic and other purposes is detrimental to human health and the society at large (Chipofya, et al., 2010). These conditions may also affect wildlife, which uses surface water for drinking or as a habitat. Generally, for measuring water quality, the physical (turbidity, electrical conductivity, temperature, total dissolved solids, colour, and taste),chemical (pH, COD, BOD, non-metals, metals, and persistent organic pollutants, POPs),and biological (faecal coliform, total coliform, and *enterococci* count) analyses are usually performed(Chipofya, et al., 2010; Mtethiwa, et al., 2007; Kuyeli, 2007).

As a developing African country with a unique culture, the public's perspectives on wastewater reuse in Malawi are difficult to fathom. While public opposition does not have the same role that it does in developed countries, the public acceptance and support have become more and more important in successful implementation of national policies. So far, the attitudes of the Malawian general public on treated wastewater reuse are unclear and it is unknown how their perception would be affected by socio-economical attributes or not. In this research, Lilongwe City was picked as a case study to assess the attitudes of residents towards treated wastewater reuse. Structured questionnaires were administered and interviews conducted to examine the awareness of residents of Lilongwe City on treated wastewater reuse and risk concerns from the residents. Factors affecting residents' attitudes on treated wastewater reuse were discussed. This study will enhance findings on public perceptions on treated wastewater reuse especially in developing countries where few studies have been done.

1.3 Aim and Objectives of the Study

1.3.1 Main Objective

The main objective of this study was to investigate public perceptions on the use of treated wastewater for domestic purposes and how these can potentially impact on future water reuse projects in Malawiwhich are meant to reduce demand on dwindling water resources.

1.3.2 Specific Objectives

In order to achieve aim or main objective, the study will:

- Examine public awareness on treated wastewater reuse;

- Evaluate the personal characteristics that determine the use of treated wastewater for various domestic purposes;
- Explore perceptions associated with use of treated wastewater for domestic purposes.

1.3.3 Research Questions

- Does awareness of water management practices and experience with using water from different sources lead to acceptance of using treated wastewater?
- What are some of the concerns with using treated wastewater for domestic purposes?
- What are the personal factors that influence acceptance of using treated wastewater?

1.4 Significance of the Study

One of the specific goals of the Malawi National Water Policy is to ensure water of acceptable quality for all needs in the country (Malawi Government, 2005). The recent widespread drought experienced in Malawi has led to water restrictions in the cities, Lilongwe in particular, and has convinced people that that water is a limited resource. Most of the water used for agriculture and some used for industrial and domestic purposes does not need to be water of drinking quality. Wastewater should be seen as a recyclable resource rather than a disposal problem. Wider use of treated wastewater for domestic purposes should be undertaken where water of drinking water quality is not required.

This research is expected to increase knowledge and information on public perceptions on reusing treated wastewater for domestic purposes. It will assist in identifying the public views on and risks associated with using treated or partially treated wastewater and how these can impact on future water reuse projects in Malawi. This will help in creating an enabling environment for further water reuse projects implementation. This study contends that using treated wastewater for various domestic purposes for instance watering lawns and gardens, washing cars, and sanitation can reduce water demand; however, consumer perceptions on recycled wastewater need to be addressed.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Wastewater comprises of all used water in homes and industries including storm water and runoffs from lands, which must be treated before it is released into the environment in order to prevent any harm or risk it may have on the environment and human health. The major aim of wastewater treatment is to protect human health and prevent environmental degradation by the safe disposal of domestic and industrial wastewater generated during the use of water. One of the objectives of wastewater treatment is to recycle wastewater for reuse in irrigation, thereby preserving water resources, which is scarce in arid and semiarid regions of the world (Weber et.al., 2006)

In ancient times, there was no specific treatment given to wastewater. Instead, wastewater was channelled from buildings into waterways through gutters and canals, which eventually ended up in rivers, streams, lakes, and oceans, which were used by people. This natural treatment process based on dilution was adequate presumably due to a smaller population and low population density as well as human activities, resulting in lower pollution load as compared to the present times (Grabow, 2009).Increase in population and industrial growth led to the generation of a high quantity of untreated wastewater channelled to water bodies as raw water. However, it has been discovered that the wastewater organic load contains high levels of a variety of hazardous organic pollutants, and thus, additional treatment steps and control measures become very necessary (Bahri, et al., 2008).

The quality of wastewater varies according to the types of effluents the WWTFs receive such as domestic wastewater, dry and wet atmospheric deposition, urban runoff containing traffic-related pollution, or agricultural runoff (Van der Merwe, et al., 2008). The range of contaminants becomes broader when industrial wastewater is included into the raw water stream that enters a waste water treatment facility (Weber et.al., 2006). Wastewater needs to be adequately treated prior to its disposal or reuse in order to protect receiving water bodies from contamination. The discharge of poorly treated wastewater usually affects water users downstream and contaminates groundwater. Waste stabilization ponds (WSPs) are usually used to provide an effective and low - cost means of handling domestic wastewater for smaller towns and communities (Rodriguez, et al., 2009).

Wastewater treatment does not depend only on its economic and environmental feasibility, but mainly on the support of the public, who, ultimately, pay for it, and might be affected by the reuse. Irrespective of scientific and engineering-based considerations, public opposition has the potential to cause wastewater reuse to fail, before, during or after their execution (Jeffrey & Temple, 1999).

The two major issues of concern for users of reclaimed wastewater are the quantity and quality of this water. The concern regarding a reliable quality of treated wastewater deals with how dependable the source is for use, whether they be domestic, commercial, or industrial. The quantity or volume of the reclaimed wastewater must be assured otherwise the user will probably not appreciate any wastewater or reuse project (Rowe & Abdel-Magid, 1995).

The reuse of treated effluent may bring important advantages such as the production of water suitable for domestic use and irrigation, reduction of residual pollution loads discharged in water streams and the reduction of water abstraction volumes for domestic use which constitutes important environmental and economic benefits (Monte & Albuquerque, 2010).

Reusing wastewater for applications that do not require potable water supply, such as producing food and watering plants has been seen to result in savings of freshwater resources that could be used for other beneficial purposes (Jamrah, et al., 2007). Promotion of groundwater recharge and increased food production have also been identified as potential benefits of reusing wastewater (Madungwe & Sakuringwa, 2007). Economic benefits of water reuse can be especially pronounced in regions dealing with water scarcity and high potable water costs (Ghaitidak & Yadav, 2013).

2.2 Wastewater Reuse in Africa

Africa is experiencing rapid population growth with the rate of urbanization being the highest in the world (5.8% in Sub-Saharan Africa (SSA) and this trend is expected to remain the same for several decades (UNFPA, 2007). Africa has, at the same time, except a few countries, the lowest economic growth. Its urbanization is therefore termed demographic urbanization as it has not been accompanied by infrastructural transformations in the agricultural and industrial sectors (Bahri, et al., 2008). According to Songsore (2004), this is one of the major reasons the economic, social and health benefits of urbanization have so far failed to materialize.

With only 64% of the population having access to “improved water supply”, the African continent has the lowest total water supply coverage (coverage refers to the number of people receiving adequate levels of water supply and sanitation services of any region in the world (WHO, et al., 2000). The situation is much worse in rural areas, where drinking water supply coverage is 50% compared to 86% in urban areas (Table 2-1).

Table 2-1 Drinking water and sanitation coverage in Africa and sub-Saharan Africa

Year: 2004		*Africa*		*SSA*	
		People unserved (Million)	Coverage with improved facilities (%)	People unserved (Million)	Coverage with improved facilities (%)
Drinking water	Total	355	64	322	56
	Urban		86		80
	Rural		50		42
Sanitation	Total	498	60	463	37
	Urban		80		53
	Rural		48		28

Source: WHO & UNICEF (2006)

The majority of urban dwellers in Africa are served by on-site sanitation systems (over 85% of the population in Ethiopia, Ghana, Mali and Tanzania, for example) and this should grow rapidly. Septic tank sludges regularly pollute the environment in many cities while storm water gutters also receive and channel greywater and other wastewater to larger drains and inner-city streams (Keraita, et al., 2003). These appear in many cities as large wastewater drains absorbing in addition all kinds of plastics and solid wastes (Bahri, et al., 2008).

The situation of water reuse in Africa is highly variable. In some locations, water reuse is been practiced without much legal control. This is the case of Accra (Ghana) where water from drains is reused for growing a wide range of vegetables, even when it undergoes no proper treatment (Murray & Drechsel 2011). In Burkina Faso, the government has agreed with the reuse of wastewater and has therefore developed areas for market gardening using this resource under some restrictions (only for selected vegetables). But in Senegal, water reuse is not always practiced even if a potential exists for that (current uses include gardening or livestock watering) for reasons including unsuitable location of the WWTP which causes the treated water not to be accessible to potential users (Evans et al., 2012).

The most important challenges with reuse acceptability in agriculture are observed in the case study countries of North Africa. While, on the one hand, Morocco significantly limits this practice for agriculture, Egypt on the other hand encourages it for selected farming activities. In practice, 45 % of the treated water in Morocco (25% of the wastewater undergoes any form of treatment) is reused, mainly for lawn irrigation, groundwater recharge and by industries. In Tunisia, it is used for golf courses and other green spaces' irrigation. In Algeria, the main uses include town road cleaning and for cooling fire engines. In all these 3 countries, the use in agriculture is limited. In Egypt, the permitted use of treated water depends on its quality (Murray & Drechsel, 2011).

Small proportions of the cities in SSA are sewered and only 1% wastewater is treated (WHO, 2000). This is due to low financial, technical and/or managerial capacity. The rapid and unplanned growth of cities makes the management of wastewater more complex. Existing wastewater treatment plants are often not functioning or overloaded and thus discharge effluents into the environment (rivers, lakes, and seas) making the water unsuitable for safe reuse. These effluents may contaminate food and downstream water supplies, creating public health risks, environmental damage, and unpleasant living conditions (Bahri, et al., 2008).

However, there are also successful water projects on water recycling in semi-arid countries of Southern Africa, namely Botswana, Namibia and South Africa (Blanca, et al., 2008). In Namibia, treated wastewater has been blended with drinking water for more than 40 years. It is based on the multiple treatment barriers concept (i.e. pre-ozonation, enhanced coagulation/dissolved air flotation/rapid sand filtration, and subsequent ozone, biological activated carbon/granular activated carbon, ultrafiltration (UF), chlorination) to reduce associated risks and improve the water quality(Rodriguez, et al., 2009).Since 1968 the capital of Namibia, Windhoek, has used reclaimed wastewater as one of their drinking water sources,(Grabow, 2009)which nowadays accounts for about 14% of the city’s drinking water production (Van der Merwe, et al., 2008). In 2001, the New Goreangab Reclamation Plant was built by the City of Windhoek and it started to deliver drinking water in 2002 with a plant production of about 21,000 m^3 of water per day (Van der Merwe, et al., 2008).

In as much as there are successful wastewater reuse schemes in Africa, the majority of the African cities have embraced water reuse as one of the key components of water resource management. Policies on water mainly focus on maintaining water infrastructure and establishing new sources of water supply with little or no mention of water demand management strategies, among them, wastewater reuse.

2.3 Wastewater Reuse in Malawi

2.3.1 Wastewater Generation and Treatment

In Malawi, wastewater is generated throughout the country, that is, both in rural and urban centres. Wastewater generation has increased due to increase in population, urbanisation and industrialisation (Msilimba & Wanda, 2014). In the four cities of Malawi, wastewater treatment works are done in the following sites: at Soche and Limbe in Blantyre; at Kauma in Lilongwe; at Chikanda in Zomba; and finally, at Moyale in Mzuzu. There is no information on the quantities of wastewater generated in Malawi at the moment (Msilimba& Wanda, 2014). However, observations show that sometreated or partially treated wastewater from urban areas in Malawi is discharged to receiving rivers and the blend of treated wastewater and runoff is abstracted by communities living downstream. Indirect reuse is therefore taking place in the country where the abstracted water that is partially derived from treated return flows is used for washing, gardening and irrigation in smaller communities and rural areas (Blanca et.al., 2008).

These have offsite sewage systems but only 15% of the population is connected to waterborne sewerage and 15% to septic tanks according to National Environmental Action Plan, NEAP (Malawi Governement, 1994). The dominant treatment types are the primary and secondary type which mainly removes just about 30% of the organic wastes and 50% of suspended solids and bacteria. Sewage system break down are caused by sewer lines blockages occur due to poor maintenance, improper design of some sections, and also lack of public awareness on use of the sewerage systems (Agrifor Consult, 2006). The generation of wastewater has been on the increase throughout the country although wastewater treatment facilities have not been increased. In addition, the existing facilities do not allow for further treatment of the wastewater for reuse by the public.

2.3.2 Current Wastewater Disposal Practices

Industrial and household effluent is collected in septic tanks or discharged into the sewerage systems. The City Councils do clear the septic tanks but very little wastewater is treated in any way before being discharged to rivers or open quarries (Msilimba & Wanda, 2014). In Traditional Housing Areas (THAs) and squatter areas, waste water is usually discharged into storm drains, road sides, streams and rivers. Msilimba & Wanda (2014) also reported that agricultural wastewater reuse is an important supply source in Malawi's urban food supply systems as well as a critical food supply valve for poor urban households. The short-term benefits of wastewater reuse in urban agriculture could be offset by health and environmental considerations. According to Madyiwa, et al. (2003) wastewater contains chemical pollutants such as heavy metals, pathogens and helminths, such as roundworms, hookworms, and guinea worm that threaten the health of humans as well as the environment. The worst-case scenario occurs when untreated wastewater is used to irrigate vegetables or salad crops that are eaten raw (Msilimba & Wanda, 2014).

The studies by Msilimba and Wanda (2014) have not gone further to address the possibility of enhancing current wastewater disposal practices to wastewater reuse practices in Malawi. While it is reported that wastewater is available to irrigate vegetable crops, the perception of the public to the use of the untreated or partially treated wastewater has not been addressed.

2.3.3 Policy, Legal and Institutional Framework for Wastewater Management

In Malawi, the National Water Policy (NWP, 2005) promotes water recycling and reuse for urban and peri-urban areas (Malawi Government, 2005). One of the specific goals of the NWP is to ensure water of acceptable quality for all needs in Malawi. The requirement to treat wastewater is underscored by the existing regulatory framework, institutional arrangements, and policy guidelines (Utembe, 2015). In addition, formalised effluent standards exist (Malawi Bureau of Standards, 2015) and the National Sanitation Policy (NSP) stipulates the need to improve delivery of improved sanitation services (Malawi Government, 2007). Some of the strategies for accomplishing this objective include: (1) To provide adequate wastewater disposal facilities at all wastewater generation points and (2) To ensure adequate provision of wastewater treatment and disposal facilities for all new piped water supply connections. The National Sanitation Policy however, does not specifically stipulate guidelines for treated wastewater reuse and water from the treatment facilities is discharged to rivers and used by the public downstream of the rivers.

The institutions responsible for water supply and sanitation in Lilongwe City are Lilongwe Water Board and Lilongwe City Council. Lilongwe Water Board is a government owned utility established in January 1947 and reconstituted by an Act of Parliament, Water Works Act No. 17 of 1995 (LWB, 2015). Under the Act, the Lilongwe Water Board is mandated to provide potable water within the urban and peri-urban areas of the City of Lilongwe. The utility operates on a commercial basis with no subvention from the government.

Lilongwe City Council is responsible for providing sewerage and sanitation services in Lilongwe City (LCC, 2013). The main legal authority comes from the Public Health Act (34:01) of 1969. Part X of the Act (Article 78 to 95) stipulates that it shall be the duty of local authority to provide sewerage and drainage for its administrative area. However, the National Sanitation Policy (NSP) of 2008 recommends that the sewerage service should be transferred to the Water Boards. The Water Works Act also designates Lilongwe Water Board as the responsible organisation for both water supply and sewerage system. There is no specific plan when this merger will take place; so, until that happens, LCC remains responsible for providing sewerage services to its administrative area.

Poor state of wastewater treatment infrastructure and low coverage of the sewerage system within Lilongwe City does not promote prudent wastewater management and cannot facilitate large scale wastewater reuse. Coupled with the uncertainty as to who is responsible for the management of the sewerage system between Lilongwe Water Board and Lilongwe City Council, there is need to have proper management framework which would lead to infrastructure renewal and enhancement of wastewater treatment and reuse.

2.3.4 Research Studies on Different Aspects of Wastewater

Research studies done in Malawi have established levels higher than the recommended Malawi Standards and WHO guidelines for chemical, physical and biological parameters in effluent from the three-major wastewater treatment works in the city of Blantyre and Kauma treatment plant in Lilongwe City (Chipofya, et al., 2010; Mtethiwa, et al., 2007; Kuyeli, 2007). Earlier studies have indicated that surface water from streams near these treatment plants is used by local residents for washing clothes, bathing and irrigating crops which may be eaten raw, and in some cases the streams are used as a source of drinking water(Malawi Government, 1995; Lakudzala, et al., 1999; Sajidu, et al., 2007; Mkandawire, et al., 2008). There is no information on the quantities of wastewater generated in Malawi at the moment. Guidelines and information on wastewater use are not available and the management of wastewater for reuse purposes is also not clear, i.e. (cost of pumping, treatment and supply regime and downstream impacts etc). The use of raw wastewater was noted in some high-density suburbs, although this is against policy framework in Malawi (Msilimba & Wanda, 2014).

Most of the studies above have focussed on the physical and chemical properties of wastewater generated in Malawi. Some of the studies have also touched on the usage of wastewater by communities downstream of rivers from wastewater treatment facilities. It is noted that wastewater is indeed used by communities for non-potable purposes. However, the earlier studies have not established the perceptions of the communities using the wastewater. Therefore, before establishment or rehabilitation of the existing wastewater treatment facilities to cater for large wastewater reuse activities, perceptions of the public in reusing wastewater need to be established and addressed.

2.4 Public Awareness to Increase the Reuse of Wastewater

In most countries within the Sub-Saharan region, public awareness on wastewater reuse has been limited until recently when countries such as Namibia, South Africa and Botswana have set-up huge wastewater treatment plants (Van der Merwe, et al., 2008). This has caused delayed investment in wastewater treatment plants.

Factors influencing public acceptance of wastewater use were studied by Ajzen's Theory/Model (Ajzen, 2001). The application of Ajzen's theory of planned behaviour specifically to reuse of wastewater proposes that people's willingness to use recycled water is dependent on (1) their attitude towards using water; (2) their perception of what their other people think about treated wastewater and; (3) their perceived ease of difficulty in using recycled water. Their attitudes towards water reuse are in turn determined by their beliefs about the outcomes of using treated wastewater. The same principles underlie their subjective norm and perceived control over the use of treated wastewater (Ajzen, 2001). This is theoretical framework adopted in investigating people's willingness to use treated wastewater for domestic purposes in this research.

Weiping, et al. (2015) noted that public awareness to water shortage will promote reuse options for non-potable purposes and forms a critical element in achieving a sustainable wastewater reuse scheme and suggest that raising public awareness towards the importance of wastewater reuse and its economic benefits, should be prior or go in parallel of any planned wastewater reuse facility.

Public awareness efforts solely based on scientific data does not increase public acceptance of projects. Public policies on wastewater reuse options must include the human dimension since it is the public who will be served by and pay for the wastewater reuse option. Determinants associated with waste management issues are complex but that does not lessen the importance of fully understanding these concerns if interventions are to be successful. The real challenge lies in identifying the public knowledge and perceptions and systematically addressing concerns through a framework of educational, policy and management strategies (Marks, 2006).

From the literature it is observed that communities support the concept of water reuse as a means of responsible water resources management. However, reactions from people when it comes to actually using the treated wastewater are frequently quite different, particularly when it involves close personal contact or ingestion of the water. There is an information gap on how people make their decisions to accept or reject treated wastewater projects. This is happening amidst rapid population growth and increasing demands on water resources for domestic, commercial, industrial, and agricultural purposes, issues which make wastewater reclamation not just a disposal solution but an attractive option for conserving and extending available supplies. It is from this background that this study has been initiated to establish the public perceptions on wastewater reuse which may lead to successful implementation of wastewater reuse projects in Malawi.

2.5 Public Acceptance of Wastewater Reuse

The public attitudes toward urban wastewater reuse have been surveyed in the USA (Hartley, 2006), Australia (Hurlimann & Mckay, 2007), Africa (Adewumi, et al., 2010), and Thailand (Nitirach & Villas, 2011).Most studies investigating public acceptance of treated wastewater come to the same conclusion – that people are very open to using treated wastewater for purposes with low personal contact, such as watering trees and shrubs in their garden, but are reluctant to adopt treated wastewater for uses such as drinking or bathing one's baby(Marks, et al., 2006). The issue of public acceptance of treated wastewater has taken a number of directions. The majority of work has investigated the willingness of people to adopt treated wastewater (Bruvold & Ward, 2000). Outcomes of a survey in Israel showed that among 21 reclaimed water reuse options, 95% of the public supported those with low and intermediate risk of human contact, such as landscape irrigation and fire protection, while less than 15% of the public supported those with high risk for human contact, and 50% of the public in Israel would support irrigating field crops and orchards with treated wastewater (Friedler, et al., 2006).

A second direction of prior work is the investigation of concerns and perceived advantages of using treated wastewater. Bruvold (2005) identified the following concerns: negative environmental consequences, economic and health concerns. Dishman, et al., (1989) found public health concerns to be central to low acceptance levels. Higgins, et al. (2002) found “public health and environmental effect of microbiological agents” together with chemicals such as endocrine disrupters are prime concerns while Marks, et al. (2006) identified quality and cost as the two main concerns among users.Hamilton (1994) observed that opposition to potable reuse of treated wastewater is due to suspicion towards politicians and organisations involved in the projects.

Many studies have investigated the perceived advantages of using treated wastewater. Marks, et al. (2006) identified three perceived benefits among users: cost savings, positive effect on the environment and the nutritional value of crops using reclaimed water. A number of studies have aimed at identifying market segments of adopters of treated wastewater (Alhumoud, et al., 2003). The one personal characteristic that was found consistently over a number of studies related to acceptance levels of treated wastewater was education, followed by age and knowledge about reuse, income and gender (Marks, et al., 2006).

While a significant amount of research has been conducted in developed countries to ask respondents directly about their willingness to use treated wastewater, only a small amount of work has attempted to identify personal characteristics associated with a high or low level of acceptance towards treated wastewater. Marks, et al.(2006) state that key characteristic factors include trust (in water providers or public policy makers); knowledge and information; past experience with alternative water sources and perception of risk.

According to Dolnicar & Hurlimann (2009), the main limitations of this body of work, is that most studies investigate factors hypothesized to be associated with acceptance of treated wastewater in isolation from one another, thus risking that the association is over-interpreted. Po, et al. (2005) interacted effects of multiple factors in the context of the general public's acceptance of indirect potable reuse of wastewater. Statements of intended use were found to be related to positive attitudes towards indirect potable reuse, which, in turn, were influenced by a number of factors including subjective norms, trust in authorities, risk perceptions, sense of obligation to protect the environment and their perceived control over the source of their drinking water.

Marks (2006) published a more comprehensive study of the acceptance of treated wastewater and alternative water uses. The study showed that there were high levels of public acceptance of non-potable water reuse in industrial processing, and irrigating golf courses, public parks, and school grounds in five surveyed USA and Australian cities. However, the extent of public acceptance varied from non-potable reuse in irrigating vegetable crops and household gardens. For three California cities (Monterey, Irvine, and San Jose), the public acceptance levels varied from 47%-74%, while in

Sydney, Australia, it exceeded 95%. The media's use of ambiguous terms such as "recycled sewage" and "toilet-to-tap" in characterising treated wastewater, is considered a significant negative image to augment treated wastewater reuse, especially for potable and agricultural production purposes (Miller, 2006).

It can be noted from the literature that wastewater has been reused for non-body contact purposes across the world. While some similar key issues identified to affect public acceptance of wastewater reuse, not all of them can be applicable to the Malawian setting. Due to limited knowledge on water resource management, most residents within Lilongwe City may not relate environmental benefits to wastewater reuse. In addition, the public may not find the connection between political influence and a water reuse project since water infrastructure projects do not have similar political mileage like a road infrastructure project. The key aspect to be addressed in wastewater reuse and public acceptance is to enhance the public's knowledge on water reuse that promotes water conservation in the wake of fresh water scarcity across the world.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The chapter gives a description of Lilongwe City and the general characteristics of the social and economic activities in the area. This includes explanation on how the areas selected for the surveys were identified. The chapter describes the entire data collection and analysis process (type of data collected, sampling methods, and size of sample, and validation techniques).

3.1.1 Study Area

The study was conducted in Lilongwe City, the administrative capital of Malawi (**Figure 3-1**). The City lies at latitude 13.59^{o} south and longitude 33.47 ^{o} east with a total surface area of 393 km^2. The topography is mostly flat with an elevation ranging from 1,000 m to 1,200 m above sea level. The northern part of the City is relatively hilly with several small streams flowing southward. The southern part of the City, where Lilongwe River is running through to the north-eastern direction, is rather flat.

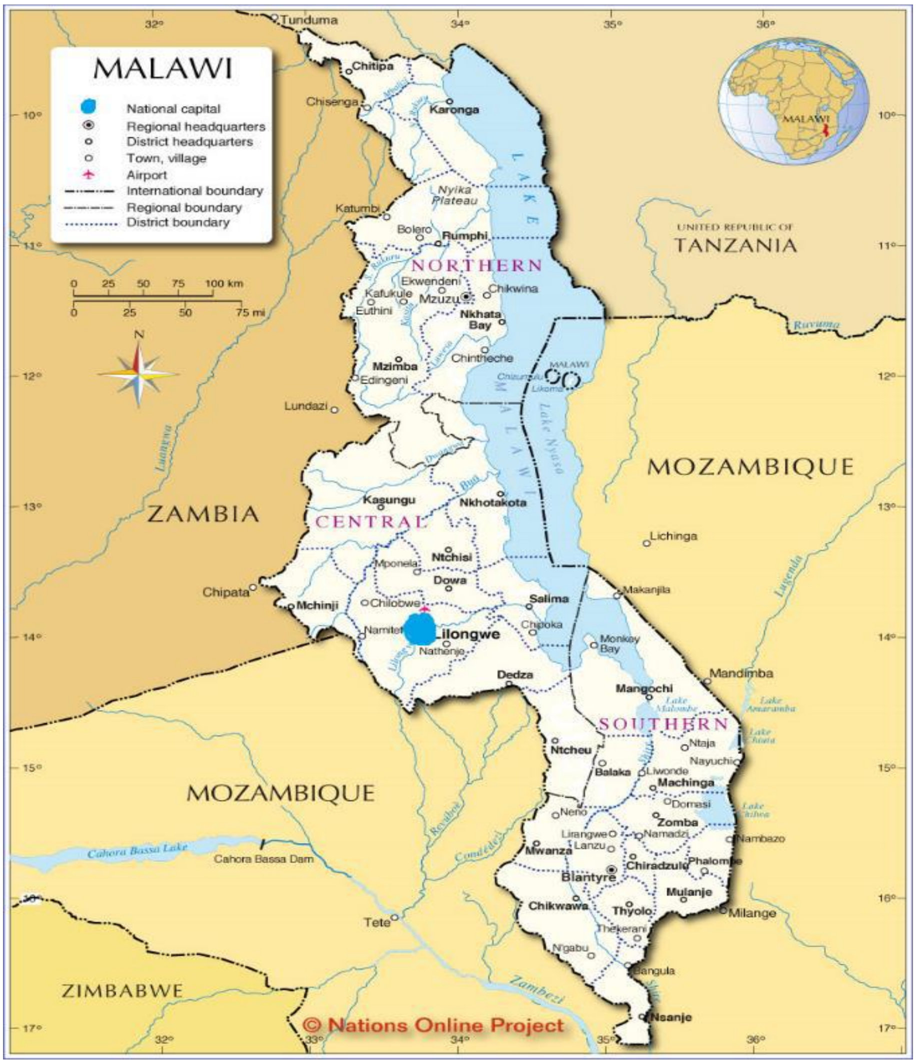

Figure 3-1: Map of Malawi indicating location of Lilongwe City
Source: JICA (2010)

3.1.2 Economic and Social Characteristics

Lilongwe City is one of the most urbanised and rapidly growing cities in Malawi. The 2017 projected population for the City was 1,128,419(NSO, 2008). The population of the City was 19,425 in 1966, an indication that it has grown by more than 50 times in the last 50 years. Together with the population growth, the population density has also increased from 43 persons/km^2 in 1966 to 1,702 persons/km^2 in 2008 (NSO, 2008).

The City has witnessed a high urbanisation rate ever since the Government administrative functions were relocated from Zomba in 1975. This has further been accelerated by the relocation of most government head offices from Blantyre to Lilongwe from 2005. Lilongwe is situated at the centre of a large agricultural area and there are many economic activities taking place in the City. Tobacco processing is the City's major industry.

3.1.3 Land Use Category

According to Japan International Corporation Agency (JICA, 2010) (**Table 3-1**), agricultural land use occupies 216km^2 which is more than 55% of the City. Majority of the agricultural land is seasonally used as arable land for agriculture. It is used for agriculture during the rainy season but unutilised in the dry season.

Table 3-1: Land use category for Lilongwe City

Item No.	**Land use category**	**Area (km^2)**
1	Residential	93.2
2	Industrial	4.6
3	Commercial	3.4
4	Government	9.3
5	Institutional	8.8
6	Transport	5.6
7	Infrastructure and Utilities	1
8	Water Bodies	27.5
9	Reserve and Green Areas	17.5
10	Leisure and Sport	1.5
11	Agriculture	216.5
12	Cemetery	3.1
13	Other Open Space	1.5

Source: JICA (2010)

With reference to the breakdown of residential land (**Table 3-2**), unplanned settlements occupy the largest share (approx. 39.7%), followed by traditional housing area (THA) sometimes referred to as Unplanned Traditional Housing Area (UTHA) at 18.9%, indigenous village (14.4%), low density permanent (13.9%), medium density permanent (9.1%) and high density permanent (3.7%).

Table 3-2: Residential land for Lilongwe City

Land use category	Sub category	Area (km^2)
Residential	Low density housing	13.4
	Medium density housing	8.5
	High density permanent housing	3.5
	High density traditional housing	17.6
	Unplanned settlements	37
	Indigenous village	11
	Institutional housing	2.3

Source: JICA (2010)

3.1.4 Selected Residential Areas

The study was conducted in all residential areas as demarcated by the Lilongwe City Council (LCC). The study targeted domestic consumers accessing potable water supplied by Lilongwe Water Board (LWB). The location of the residential areas in the context of LCC are shown in **Figure 3-2**. These residential areas were selected based on characteristics that included:

- Demarcated residential areas as established by the Lilongwe City Council.
- Lilongwe Water Board supplies water to the areas.

- The areas are in different administrative zones[1]which enabled matching of results.
- All the areas are a mix of low, medium and high-density areas

[1]Lilongwe Water Board operations are demarcated into three administrative zones (North, Central and South)

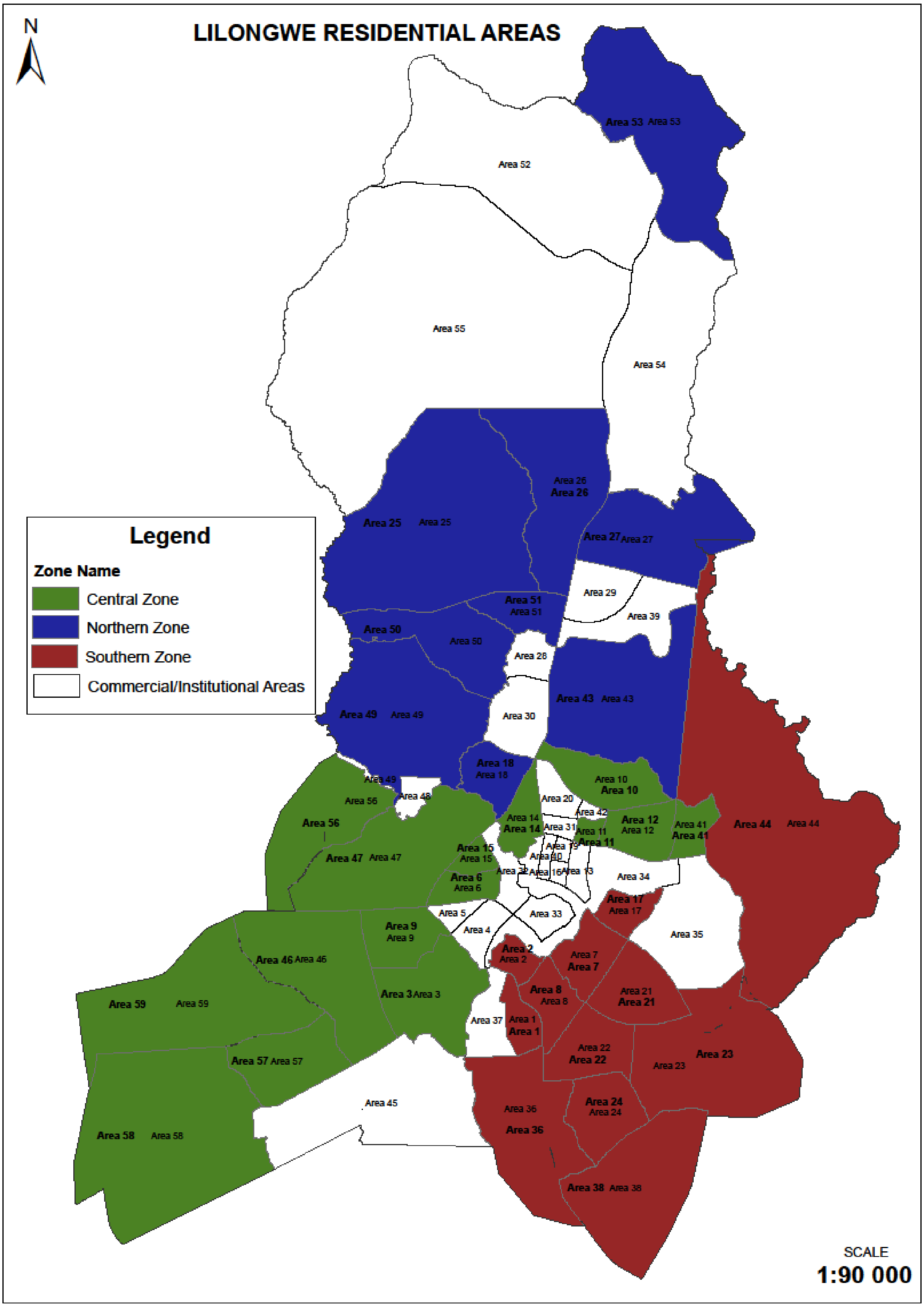

Figure 3-2: Lilongwe residential areas
Source: LWB (2017)

3.2 Study Design

The study used historical data review, literature review and household surveys. The data collected was mainly quantitative, however unstructured interviews data was also collected to validate some of the quantitative data. The study was carried out in Lilongwe City, an area under the water supply jurisdiction of Lilongwe Water Board (LWB), from May 2017 to July 2017. Data collection over this period entailed accessing water consumption data for the beginning of the summer season when it is hot and there is high water consumption, leading to high demand (April to November). This is the season when there are high amounts of wastewater discharge from domestic consumers.

The key components studied included current wastewater disposal practices by domestic water consumers, knowledge of wastewater treatment and reuse and acceptance to use wastewater for domestic purposes. In addition to the three specific study areas, the study also assessed personal characteristic information, age, level of education and willingness to pay for utility services in order to ascertain characteristics associated with acceptance and non-acceptance of wastewater reuse for domestic purposes.

3.3 Data Collection and Analysis

In order to achieve the specific objectives under the study, various data was collected with varying tools for data collection and sampling techniques.

3.3.1 Data Collection Methods

Water Connections

The total number and categories of connections for domestic consumers in the supply area was collected from Lilongwe Water Board's Billing Section as at May 2017. The study targeted residential consumers using potable water supplied by Lilongwe Water Board. The total number of residential customers at time of the survey was 62,698 as shown in **Table 3-3** below. A representative sample was calculated using ***Equation 1 and 2*** below and this sample proportionally divided to the number of residential customers in each area within the water supply area of LWB.

Table 3-3: Total number of customer accounts for LWB

Customer Category	Number of Customers
Residential	62,698
Institutional	940
Commercial	3,122
Community kiosks	677
LWB Kiosks	143
CRWB	1
TOTAL	**67,581**

Source: (LWB, 2017)

Household Survey

A household survey was conducted in all residential areas as demarcated by LCC and in households accessing potable water from LWB. The research used a questionnaire as an instrument for data collection. The survey instrument was designed according to the basic principles of the seven-step protocol for formulating social survey questionnaires, which included design preparation, structure plan, pre-test, questionnaire evaluation, finalising a manuscript, appearance design, and coding. The information captured by the questionnaire among others included demographic data, sources of water for the households, house ownership, status of Lilongwe Water Board water connection and average water consumption (**Appendix 1**).

The questions for deciphering the public perception of treated wastewater for domestic purposes included a knowledge question in which respondents were asked to state whether or not a number of statements are true for treated wastewater and a likelihood of use question in which respondents were asked on a five-point scale how likely they are to use treated wastewater for a list of domestic uses. The respondents were also asked to rank water uses separately for treated wastewater including in which order they would adopt listed domestic uses and some open-ended questions asking the respondents to state their primary concerns of using treated wastewater for domestic purposes.

The survey used random sampling technique. The sample size for the household surveys was determined using a formula according to Stattrek (2017) (Equation 1). This survey was designed to set benchmarks against which future assessments of the customer's perceptions of using treated wastewater would be evaluated. This ultimately required drawing of a representative sample of domestic customers using water from Lilongwe Water Board. To derive an adequate sample size for the survey, the following formula was adopted:

$ME = \frac{z\sqrt{p(1-p)}}{n}$..***Equation 1***

Where:

- ME is the desired margin of error. Typical surveys prefer ME of between 1-4%.
- n: required minimum sample size.

- Z: the Z-score corresponding to the degree of confidence and is 1.645 for a 90% confidence interval or 1.96 for a 95% confidence interval, 2.58 for a 99% confidence interval (Stattrek, 2017).

Since the study was aimed at deriving estimates of acceptance levels of reusing treated wastewater whose current values are not known, an indicator that would derive a higher sample size was used. Since there was no recent estimate at hand, a 'p' value of 50% was used to derive a higher sample size. A z-value of 1.96 for the 95% CI and a ME of 2.6% was used:

$$2.6 = \frac{1.96\sqrt{0.5(1-0.5)}}{n}$$ ....***Equation 2***

A sample size of 1,420 was derived using the parameters above. This sample size was proportionally sub-divided to the total number of residential customers per area.

3.4 Data Analysis

All the household interviews were held one-on-one involving the enumerator and the respondent. The responses were recorded on paper questionnaires. Each interview took 1 to 2 hours using the structured questionnaire. The field work in targeted areas finished within eight (8) weeks. Survey data was tabulated in Microsoft Office Excel format and statistically analysed using the SPSS Software (SPSS 17.0). Various statistical processes were used including means, frequencies and regression to determine variation significance and principal component analysis was used to determine most important factors relative to the key indicators of the study.

3.5 Ethical Considerations

All respondents were asked to consent to their participation in the study. No participant was forced to participate in this survey. Each respondent was told about the objectives of the study, the importance of their participation, the nature of voluntariness of their participation and how the data will be kept confidential during the field team's stay in the area and during data entry and analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The chapter undertakes an analysis of the collected data. The data is analysed and presented using graphs, charts and tables from which interpretations and discussions are made.

4.2 Socio-Economic Characteristics of Surveyed Population

4.2.1 Personal Characteristics

A total of 1,420 questionnaires were administered in residential areas of Lilongwe City and to households accessing potable water from Lilongwe Water Board. Forty four percent (44.4%) of the questionnaires were administered in the Southern Zone and this was followed by the Northern Zone at 31.9% and then the Central Zone at 23.7%. Most of the questionnaires (83.2%) were administered in high density locations and this was followed by medium density (10.3%) and low-density areas (6.5%). Most of the respondents were females (68.7%) and the rest (31.3%) were males. **Table4-1** below shows the relationship between the respondent and the head of the household as well as the relationship between the respondent and the payer of water bills.

Table 4-1: Relationship to head of household and payer of water bills.

Relationship to Head of household	**Percentage**	**Relationship to payer of water bills**	**Percentage**
Head	42.1	Payer	70.4
Spouse	31.4	Spouse	22.8
Child	16.5	Child	4.9
Other	10.0	Other	1.8
Total	**100.0**	**Total**	**100.0**

Data was collected on the relationship between head of household and payer of water bills to ascertain the respondents understanding between water usage and its impact on water bills as shown in **Table 4-1.** The study wanted to establish the impact of water bills on a household's water usage and could therefore lead to waste water reuse. Most of the respondents to the household questionnaire were either heads of the households (42.1%) or their spouses (31.4%). Most of the respondents (70.4%) were actually heads of households and also payers of water bills. Additionally, as shown in **Figure 4-1** below, most of the respondents had secondary school or tertiary level of education. Very few respondents (3.6%) never went to school. Thus, the respondents in this study were able to respond to questions on waste water reuse in relation to its use, and its impact on potable water bills.

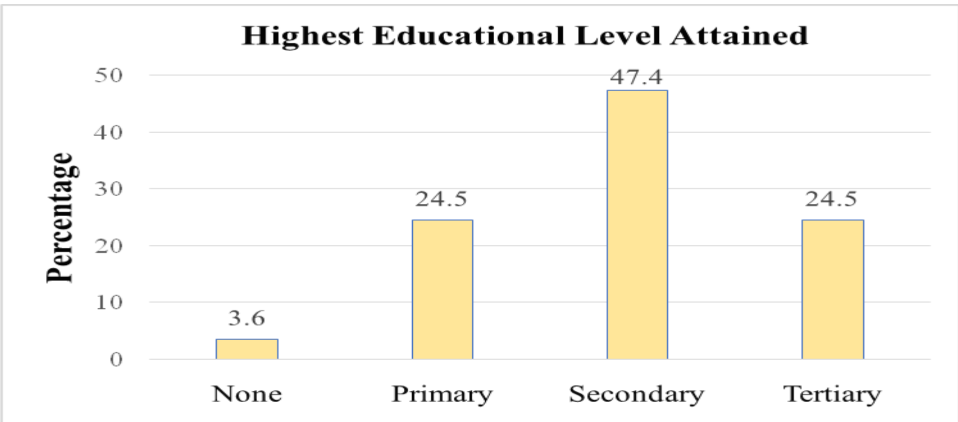

Figure 4-1: Highest educational level attained by respondents interviewed in the study.

The highest proportion of respondents were aged 20 – 30 and 11.3% of the respondents were aged more than 50 years of age as shown **Figure 4-2**below shows the age of the respondents. There were very few respondents (5.5%) who were aged less than 20 years of age. The age of the respondents was assumed to have an impact on awareness and acceptance to reuse treated wastewater. Since the majority of the respondents were aged between 21years and 50 years, the study was able to obtain information on waste water reuse from age groups that are currently using potable water in their households.

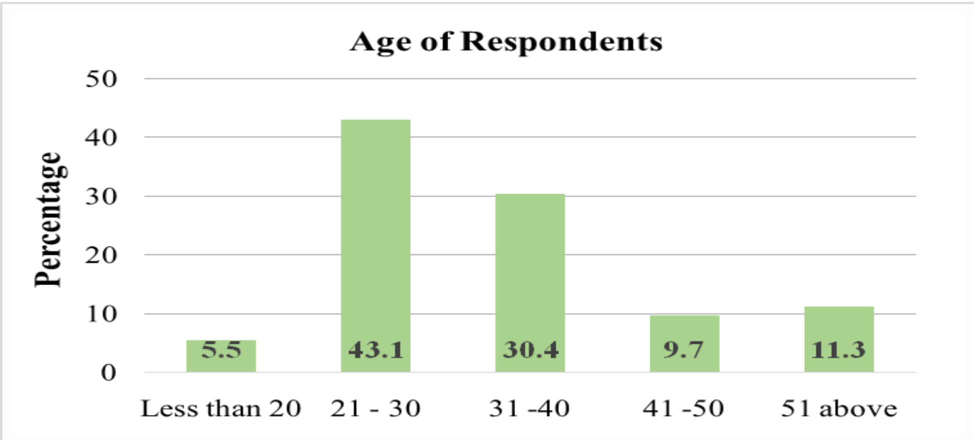

Figure 4-2: Age of respondents interviewed in the study.

4.2.2 Residential and Water Connection Status

The respondents' period of having a water connection, period of residence in Lilongwe City and period of using water supplied by LWBis shown in **Table 4-2** below. The respondents with the most recent connection below 3 months were 4.5%, above 3 months but below 6 months were 1.7%, above 6 months but below 9 months were 2.4% while the last category of those above 9 months were 91.5%. The respondents who have resided in the Lilongwe City for a period of less than 3 years were 9.4%, above 3 years but less than 6 years 5.8%, above 6 years up to 9 years were 5.4% and those above 9 years were 79.4%. Respondents who had used LWB water for a period less than 3 year were 16.8%, 3 years but below 6 years 7%, 6 years but below 9 years 5.5% and those above 9 years 68.8%.

Table 4-2: Period of having a water connection, period of residence and use of LWB water services

Most Recent Water Connection		
Period	**Frequency**	**Percent**
0-3 months	64	4.5%
3-6 months	24	1.7%
6-9 months	33	2.4%
Above 9 months	1299	91.5%
Total	1420	100.0%
Period of Residence in Lilongwe City		
Period	**Frequency**	**Percent**
0-3 years	134	9.4%
3-6 years	83	5.8%
6-9 years	76	5.4%
Above 9 years	1127	79.4%
Total	1420	100.0%
Period Using Water Supplied by LWB		
Period	**Frequency**	**Percent**
0-3 years	228	16.0%
3-6 years	95	6.7%
6-9 years	75	5.3%
Above 9 years	1022	72.0%
Total	1420	100.0%

The period of having a water connection with LWB and period of residence in Lilongwe was assumed to have an impact on usage of water from sources other LWB. Respondents with a recent water connection would have been using water from other sources before they got the water connection from LWB. This data was pertinent in obtaining information on sources of water other than LWB and its uses. The respondents were thus able to associate the uses of water from sources other than LWB for various domestic uses and at the same time determine domestic purposes of treated waste water.

In terms of ownership of the houses, 54% reported that they owned the houses they were living in and 37% lived in rented houses. There were very few respondents who reported that they lived in rented government houses (8%) and other (1%). Most of the respondents (92.3%) had active water connection accounts while the rest (7.7%) had their water disconnected. The respondents' way of disposing waste water was assumed to be affected by type of ownership of houses they lived in.

4.3 Sources of Water for Residents of Lilongwe City

According to this study, the residents of Lilongwe City use water from sources other than that supplied by LWB. Slightly above half of the respondents (50.93%) answered in affirmation while 49.07% indicated that they don't use water from other sources. The respondents who answered in the affirmative were further asked to state the other sources of water that they use. The majority of the respondents (86.5%) were getting water from boreholes and shallow wells, 12.9% were using bottled water while 1.3% and 0.2% of the respondents reported getting water from the rivers and collecting rainwater, respectively (**Figure 4.3**). Sinking of boreholes within LWB supply area requires approval from the Department of Water Resources, but respondents with borehole said they sank the boreholes without approval due to lack of knowledge of the approval process.

The respondents using water from other sources were also asked to state the domestic uses of water from other sources. Most of the respondents (71%) use the water for washing clothes and cleaning utensils, 13% for home gardening, 10% for all domestic purposes, 3% for construction purposes whereas another 3% of the respondents use water from other sources for drinking and cooking food (**Figure 4-4**). In the research, data on uses of water from other sources other than LWB, was collected to compare with uses of treated waste water as they all form alternative water sources to water supplied by LWB to residents of Lilongwe.

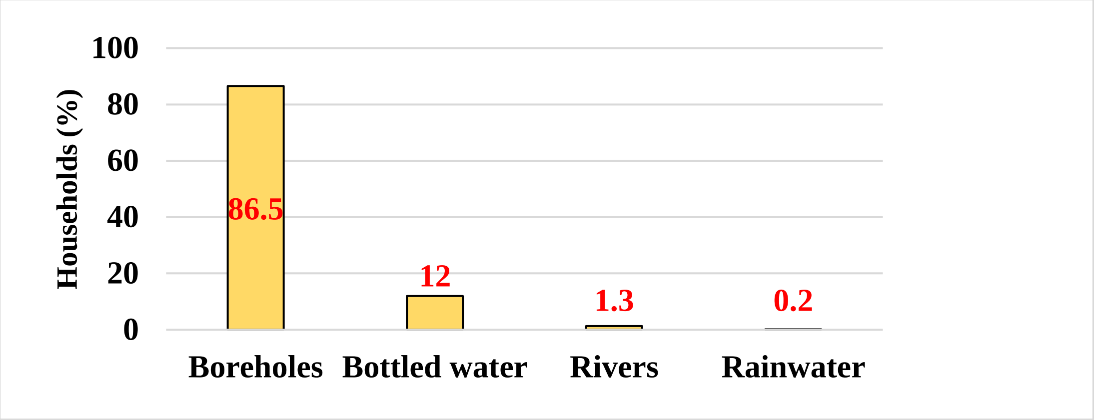

Figure 4-3: Sources of water for Lilongwe Residents other than water from LWB

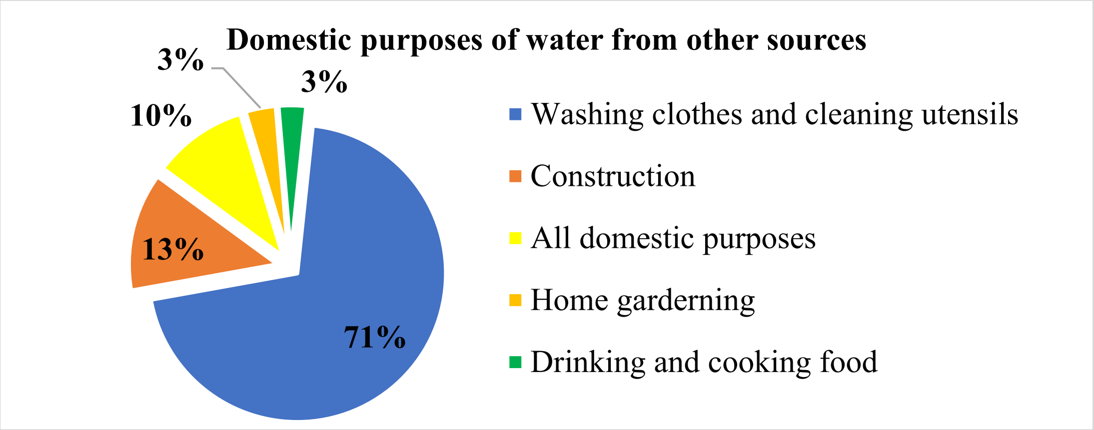

Figure 4-4: Domestic household uses of water from other sources other than LWB

On the reasons for using water from other sources, the majority of the respondents (83.3%) use water from other sources when water from LWB is not available, 10.3% of the respondents want to save on water bills whereas 6.4% said both reasons above applied to them.

A study by Chidyaet.al (2016) found that 65% of the residents of Lilongwe relied on boreholes and shallow wells as an alternative source of water for household use in all areas of the City while this study found that 86.5% of the residents of Lilongwe use boreholes and shallows wells. The use of boreholes in the City is attributed to intermittent water supply from LWB and the growth of population within the city.The findings in this study are not remarkably different from those of Manda (2009) in a study on water and sanitation in the informal settlements of the cities of Blantyre, Lilongwe and Mzuzu where73.6% of respondents used water from boreholes and shallow wells for “bathing, washing clothes and plates” and when there are dry taps, 7.6% of respondents used water from boreholes and shallow wells for drinking.Chidyaet.al (2016) noted that some polices like prohibition of boreholes and shallow wells in Lilongwe City locations were in conflict with other provisions of water supply in the light of intermittent water supply in Lilongwe City. Overall, the public uses water from other sources as cover in times of inadequate water supply from Lilongwe Water Board.

4.4 Wastewater Disposal Practices

4.4.1 Current and Preferred Ways of Getting Rid of Wastewater

One of the areas of this study was to assess the current wastewater disposal practices by domestic customers accessing potable water from LWB. The respondents were firstly asked to state whether they separate blackwater (wastewater from toilets); and greywater (relatively clean wastewater from baths, sinks, washing machines and other kitchen appliances); as they dispose wastewater from their homes (**Figure 4-5**) (Paulo et al., 2013). According to Imhof and Muhlemann (2005), improper greywater and black water management is one of the most important causes of environmental pollution and diseases. At the same time, there is an increasing international recognition that greywater reuse has a great potential as an alternative water source for such activities as irrigation, toilet flushing and other purposes.

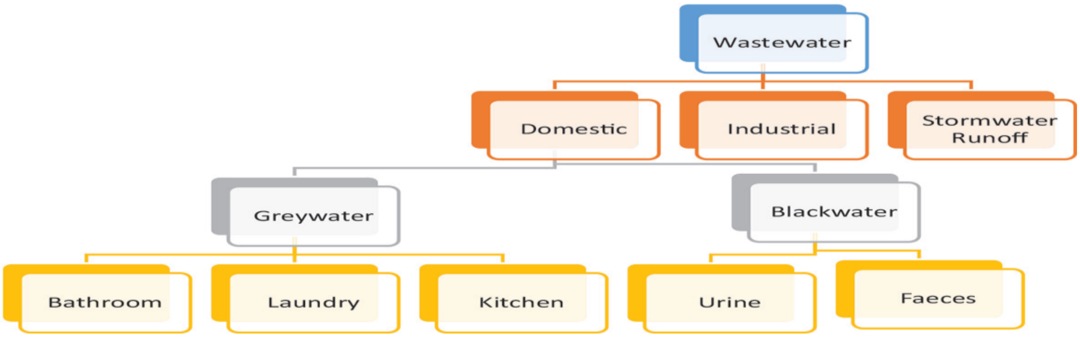

Figure 4-5: Types of waste water.

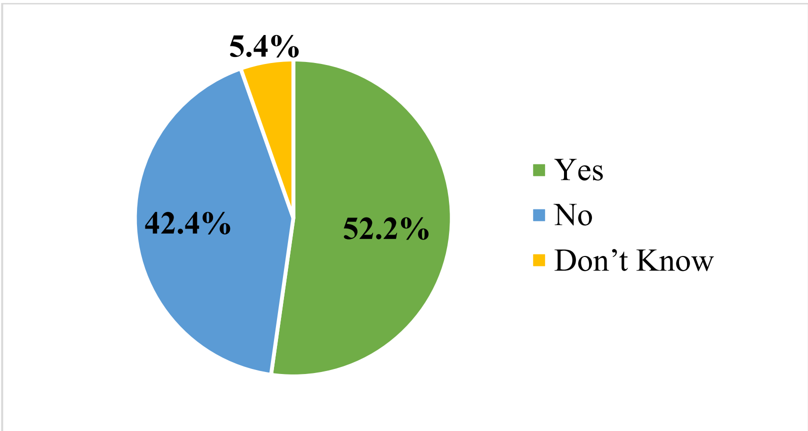

Figure 4-6: Separation and disposal of blackwater and greywater from households.

This research was observed that 52.2% of the respondents separate blackwater from greywater, 42.4% do not separate blackwater from greywater while 5.4% did not know about the separation. A case study by Iiberg (2012) on low cost greywater treatment for households in Lilongwe, showed that domestic greywater is usually not separated where households use a septic tank for disposal. The study by Iiberg (2012) further noted that greywater is allowed to flow in household premises causing smelly and hazardous, unhygienic standing waters, which is especially problematic during rainy season when plots and public streets are flooded. The revelation from this study that more than half of the respondents separate blackwater from greywater is attributed to the high use of pit latrines and standpipes in most of the THAs.

This study's finding that 52.2% of the respondents separate blackwater from greywater during disposal of waste water does not mean that the respondents were aware of the difference between blackwater and greywater. The level of education of the respondents showed that 3.6% of the respondents had not attended formal education and 24.5% had only attended primary school education. Despite the fact that 47% of the respondents had secondary education, the secondary education curriculum in Malawi does not include waste water treatment course to equip students with knowledge on separation of blackwater from greywater. As noted by Msilimba and Wanda (2014), the awareness and skills on the safe use of wastewater, wastewater disposal and management are generally poor in Malawi.

The separation between greywater and blackwater as noted in **Figure 4-6** above is not done due to knowledge of the difference between the two types of water but rather because of the use of pit latrines and standpipes where greywater and blackwater doesn't mix. Unlike cisterns, there is no water usage in the use of pit latrines hence no black water emanating from the same. The standpipes allow households to use water for cleaning utensils and washing clothes and there after the same water can be reused for gardening. Therefore, the separation is not based on prior knowledge but rather due to the purpose for which the water serves around the homes.

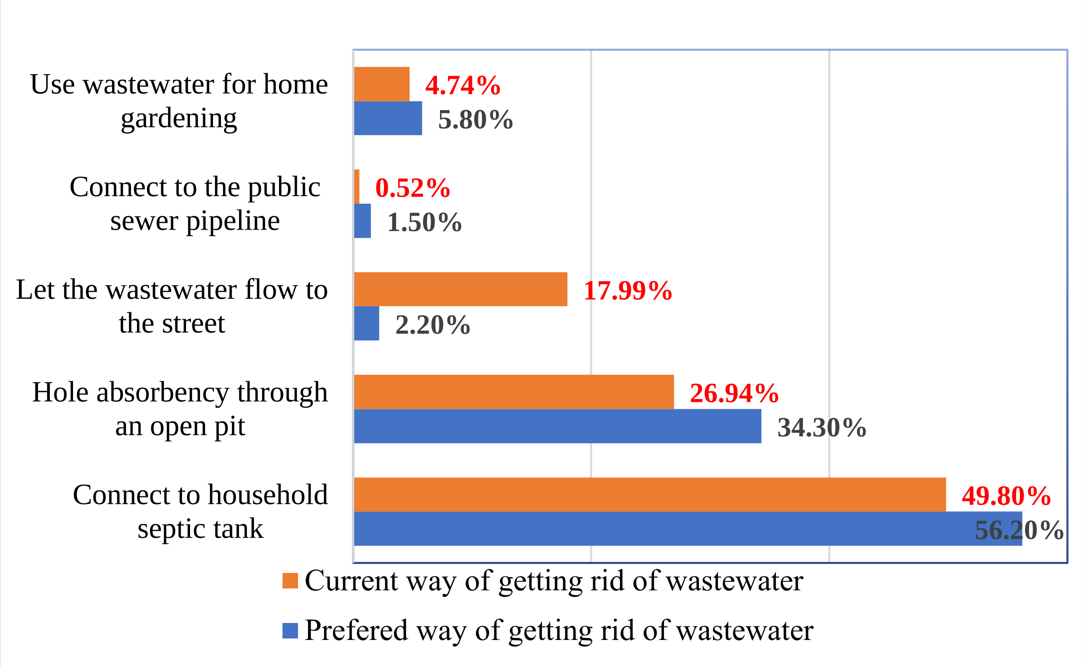

Figure 4-7: Current and preferred ways of getting rid of wastewater from households.

The research assessed the households' current and preferred ways of getting rid of wastewater. It was observed from **Figure 4-7** that most of the respondents (49.81%) are getting rid of wastewater using a septic tank and 61.2% would prefer connecting to a household septic tank in order to get rid of wastewater. It is further observed that 26.94% of the respondents are using hole absorbency through an open pit and this wastewater disposal practice is preferred by 35.1% of the respondents. Approximately 18% of the respondents let wastewater flow to the street but only 2.2% of respondents would prefer letting wastewater flow to the street. Reuse of wastewater for home gardening of food crops is being done by 4.7% of the respondents and preferred by 5.8% of the respondents. Only a few respondents (0.5%) are connected to the public sewer pipeline although 1.5% of the respondents would prefer connecting to the sewer pipeline.

According to the Urban Structure Plan of Lilongwe City (LCC, 2013), the population of Lilongwe City receiving sanitary wastewater treatment services stands at 30%, out of which 9% have access to piped sewer service while 20% use septic tank as on-site sanitation measure. This is in sharp contrast with the results from this study which shows that only 0.5% are connected to sewer piped service and 49.8% use septic tank on-site sanitation system. According to the World Bank Lilongwe Citywide Sanitation Survey Report (2017), only 5% of the city population is served by a sewer system, while the majority relies on on-site sanitation systems (70% percent pit latrines and 25% septic tanks).

A JICA study on urban development master plan for Lilongwe City (2010) estimated domestic wastewater generation at 5,280m^3/day. The wastewater treatment plant for Lilongwe City is at Kauma and the plant has a capacity to cater for 6,100m^3/day of liquid waste but currently it is running at 1,560m^3/day (approximately 25% of its capacity) Mtethiwa et.al (2007). This low utilization of the Kauma Wastewater Treatment plant could be attributed to the lower coverage of the sewer pipeline across the city.

Additionally, the preference by most of the respondents (56.2%) to connect to a household septic tank in disposing wastewater could also be attributed to low coverage of the sewer pipeline. The World Bank Lilongwe Citywide Sanitation Survey Report (2017) indicates that existing sewers and sewage treatment plants are dilapidated due to lack of maintenance resulting in environmental pollution, as most of the sewage ends up in the environment without treatment. Further to that, recent case of contamination of the City's drinking water pipeline by a leaking sewer pipeline in Area 18 have created a sense of urgency to fix the city's ailing sewerage system. The Lilongwe City Council has since received a Grant from the World Bank to rehabilitate the sewerage pipeline system and expand the Kauma Waste Water Treatment Plant (World Bank, 2017).

Although the septic tank system is the most preferred way of disposing wastewater in the households, the JICA study on urban development master plan for Lilongwe City noted that the removal and treatment of the septage in the tanks is inadequately managed by LCC and recommends LCC handing over the sewerage task to LWB as designated in the Water Works Act No. 17 of 1995 (JICA, 2010). From this study, it can be concluded that household wastewater is mostly disposed through septic tank systems due to inadequate coverage of the sewer pipeline system in Lilongwe City.

4.5 Public Knowledge on Wastewater Treatment and Reuse

The residents of Lilongwe City are not cognizant of the city's wastewater treatment and reuse situation: 59.4% of the respondents do not know about wastewater treatment and reuse while 40.6% realise that the city has a wastewater treatment facility and that household wastewater can be reused. **Table 4-3** below presents a comparison between the respondents' level of education and knowledge of wastewater reuse.

Table 4-3: Respondent's level of education and knowledge of wastewater reuse

Education		None (%)	Primary (%)	Secondary (%)	Tertiary (%)	N
Knowledge	Yes	16.4	20.7	28.4	56.0	431
	No	83.6	79.3	71.6	44.0	989

It was noted that the lower the level of education, the less knowledgeable the respondents are about wastewater treatment and reuse as shown **Table 4-3**above.As noted by Msilimba and Wanda (2014) the status of knowledge and skills on the safe use of wastewater, its disposal, management and use practices are generally very poor in Malawi. The knowledge on waste water reuse slightly improves as it transcends form respondents with no formal education to those who attained secondary school education. As noted earlier, the education curriculum in Malawi does not include waste water treatment courses and therefore most people are not aware of it despite attaining secondary or even tertiary level education. In contrast, Weiping et.al (2015) found out that the proportion of respondents knowledgeable on water resources and water reuse in Beijing, China was 70% which is far much higher than the situation in this study mainly because Beijing is a much more developed city than Lilongwe and runs civic education programmes to equipment residents with knowledge on waste water reuse.

The respondents were further asked if they would support the establishment of a wastewater treatment plant to treat effluent water to be used for domestic purposes: 64.6% were in agreement while with the suggestion while 35.4% declined. Those in agreement stated intermittent potable water supply from LWB as the reason they would support the establishment of wastewater treatment plant. The respondents therefore did not really appreciate the need for waste water reuse but rather to access alternative water sources to meet their daily demands. These findings suggest that while setting up a waste water treatment facility for the sole purpose of treating waste water would be acceptable among the respondents, the use of the water will only be to augment available potable water. In addition, where the cost of accessing the treated waste water is high, most of the respondents would not be able to use it.

As the capital of Malawi, Lilongwe City may represent the optimistic case of public awareness on water resources, wastewater reuse and support for a wastewater treatment facility. Lilongwe City has had years of modernization and economic expansion since the decision to move the Capital from Zomba to Lilongwe was made in 1965. The growing population of the City has increased demand on urban utilities like water supply, sewerage/sanitation and solid waste management (LCC, 2013). Improvement of urban utility services is of paramount importance for the enhancement of urban environment in the City, and therefore reusing treated wastewater presents a viable option for water conservation in the City.

4.6 Willingness to Reuse Treated Wastewater

The extent of Lilongwe City residents' willingness to accept treated wastewater reuse for domestic for purposes is remarkably high with 63.8%of the respondents are willing to reuse treated wastewater for domestic purposes while the rest (36.2%) deemed treated wastewater reuse unacceptable. The respondents' acceptance and non-acceptance to reuse treated wastewater according to gender was quite similar while on the basis of level of education, the less educated were more willing to reuse waste water then then more educated (**Table 4-4**).

Table 4-4: Respondents' acceptance and non-acceptance to reuse treated wastewater.

	Response	**Gender**		**Level of Education**			
		Male (%)	Female (%)	None (%)	Primary (%)	Secondary (%)	Tertiary (%)
Acceptance	Yes	65.7	64.9	72.4	52.3	49.4	41.9
	No	34.3	35.1	27.6	47.7	50.6	58.1

However, willingness to reuse treated wastewater appears as a descending trend as it transits from respondents with no formal education to those with tertiary education. The reason is that the well-educated individuals are better informed and have more reasonable expectations of what the water supply system can deliver to them and hence find treated wastewater unsafe for domestic use. Water reuse is perceived to be more acceptable if the risk involved is seen to be more under the direct control of an individual rather than if the risk is controlled by others (Aertgeerts & Angelakis, 2003). In this case, the more educated individuals are more concerned with risk aversion when it comes to waste water reuse, hence their low rate of acceptance to reuse waste water for domestic purposes. For the less educated individual, water availability is of greater need and issues of quality do not rank highly as compared to having treated waste water for use around the home.

In addition, Ajzen's theory of planned behaviour specifically to reuse of wastewater proposes that people's willingness to use recycled water is dependent on (1) their attitude towards using water; (2) their perception of what other people think about treated wastewater and; (3) their perceived ease of difficulty in using recycled water. Their attitudes towards water reuse are in turn determined by their beliefs about the outcomes of using treated wastewater (Ajzen, 2001). In line with Ajzen's theory, the more educated people decline to reuse waste water is attributed to their attitude towards using the water and their perception of what other people think about treated wastewater. The more educated people's risk perception and the potential severity of that risk makes waste water reuse unfavourable to them and they judge it as high risk and of low benefit.

4.6.1 Domestic Uses of Treated Wastewater

The respondents' domestic uses of treated wastewater varied from washing clothes and utensils to drinking and food preparation.

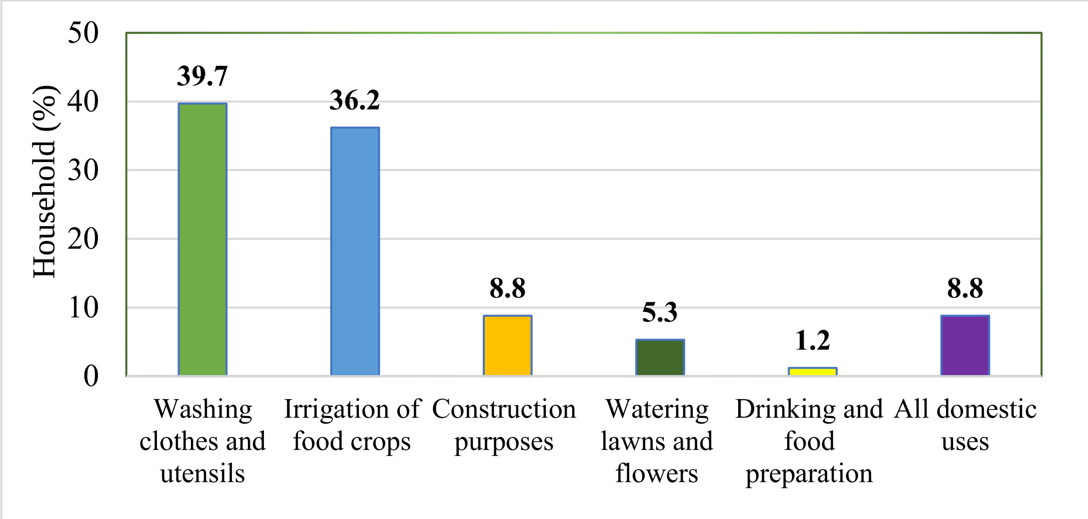

Figure 4-8: Domestic uses of treated wastewater.

It is observed that the respondent's willingness to use treated wastewater for non-body contact and non-potable reuse is overwhelming (**Figure 4-8)**. Overall, 90% of the respondents are willing to accept or strongly endorse use of treated wastewater for following domestic purposes: washing clothes and utensils (39.7%), irrigation of food crops (36.2%), construction purposes (8.8%) and watering lawns and flowers (5.3%). Drinking and food preparation was ranked lowest with only 1.2% of the respondents willing to use treated wastewater for this purpose. A section of the respondents (8.8%) expressed willingness to use treated wastewater for construction purposes.

The results are in agreement with other findings in China, Oman, Thailand and Ghana that willingness to reuse appears as a descending trend as treated wastewater use transits from public to private (Wu, et al., 2010). According to Weiping, et al. (2015) over 90% of Beijing's residents are willing to use treated wastewater for non-body contact and non-potable activities such as toilet flushing, fire protection, landscape irrigation, street cleaning, industrial cooling, ornamental lakes, and car washing. The findings in this study are not remarkably different from those of Newcomer, et al. (2017) where they observed that reducing the burden of rural water supply through greywater reuse in Northern Malawi where the most favourable source-application combinations of wastewater reuse by respondents were washing clothes (46%) and growing food (41%)with treated bath water, followed by growing food (39%) and washing clothes (33%) with treated wastewater from cleaning/washing clothes.

The results of this study also compare well to observations in Oman, which found that 76% of respondents also perceived reusing greywater for gardening as acceptable (Jamrah, et al., 2007), and peri-urban Bangkok, where 74% of respondents found reuse of treated greywater acceptable for watering plants (Jiawkok, et al., 2013). Results from work in Accra, Ghana, showed 40% of urban respondents who consumed street food would eat salad that had been irrigated with wastewater (Antwi-Agyei, et al., 2016). A comparison between domestic uses of treated wastewater and domestic uses of water from other sources is presented in **Table 4-5** below. This comparison is made based on results on uses of water from other sources other than LWB presented in **Figure 4-3**.

Table 4-5: Domestic uses of treated wastewater and water from other sources

Treated Wastewater		**Water from sources other than LWB**	
Domestic Uses	**Proportion (%)**	**Domestic Uses**	**Proportion (%)**
Washing clothes and utensils	39.7	Washing clothes and utensils	71
Construction	8.8	Construction	13
All domestic uses	8.8	All domestic purposes	10
Watering lawns and flowers	5.3	Home gardening	3
Drinking and food preparation	1.2	Drinking and food preparation	3
Irrigation of food crops	36.2		
Total	**100**	**Total**	**100**

It is observed from **Table 4-5**, that domestic uses with low and intermediate risk of human contact are supported (90% for treated wastewater and 87% for water from sources other than LWB) while less than 13% of the public supported those with high risk of human contact. This data compares very well with data from literature which showed outcomes of a survey in Israel that among 21 reclaimed water reuse options, 95% of the public supported those with low and intermediate risk of human contact, such as landscape irrigation and fire protection, while less than 15% of the public supported those with high risk for human contact such as food processing (Friedler, et al., 2006). The respondents perceived advantages of reusing treated wastewater are presented in **Figure 4-9**.

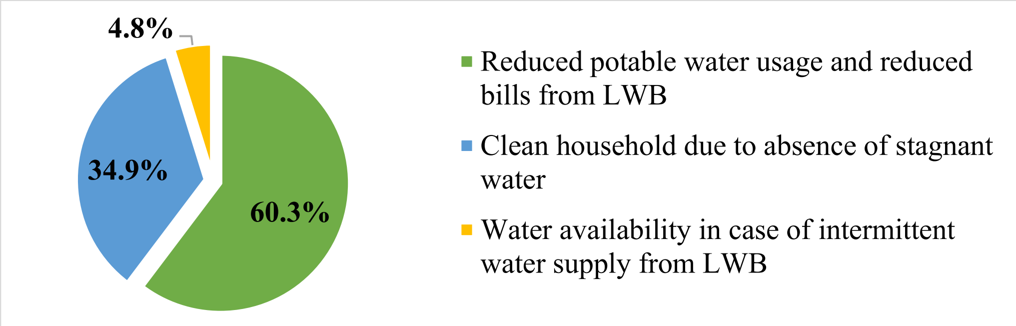

Figure 4-9: Advantages of using treated wastewater for domestic purposes.

Most of the respondents (60.3%) cited reduced potable water usage and reduced bills from LWB whereas 34.9% and 4.8% indicated clean household due to absence of stagnant water and water availability in case of intermittent water supply from LWB respectively, as the benefits of using treated wastewater for domestic purposes (**Figure 4-9**). This compares very well with the respondents perceived advantages of using water from alternative sources to LWB where the majority of the respondents (83.3%) use water from other sources when water from LWB is not available. Then 10.3% of the respondents want to save on water bills whereas 6.4% mentioned that both reasons above applied to them.

These findings suggest that water rates (bills) may influence domestic water consumption and may be a means to encourage water conservation. Most of the respondents in this research (92.3%) had active water connection accounts while the rest (7.7%) had their water disconnected. This means that with increasing water prices in recent years, residents are paying more attention to water conservation thereby making water price critical in expanding water reuse. Overall, improving wastewater quality and expanding the knowledge-related publicity are effective ways to increase the degree of willingness to use treated wastewater.

4.6.2 Non-Acceptance of Treated Wastewater Reuse

Respondents' reasons for declining reuse of wastewater are presented in **Figure 4-10** below. This study has revealed that more than one-third (36.2%) of the respondents declined to use wastewater for domestic purposes. It was observed among the respondents who declined to reuse wastewater, most of them (64.47%) found treated wastewater to be unsafe for domestic purposes, 19.92% of the respondents noted that it would be costly to pay for treated wastewater and 8.08% of the respondents observed that they get enough water from LWB.

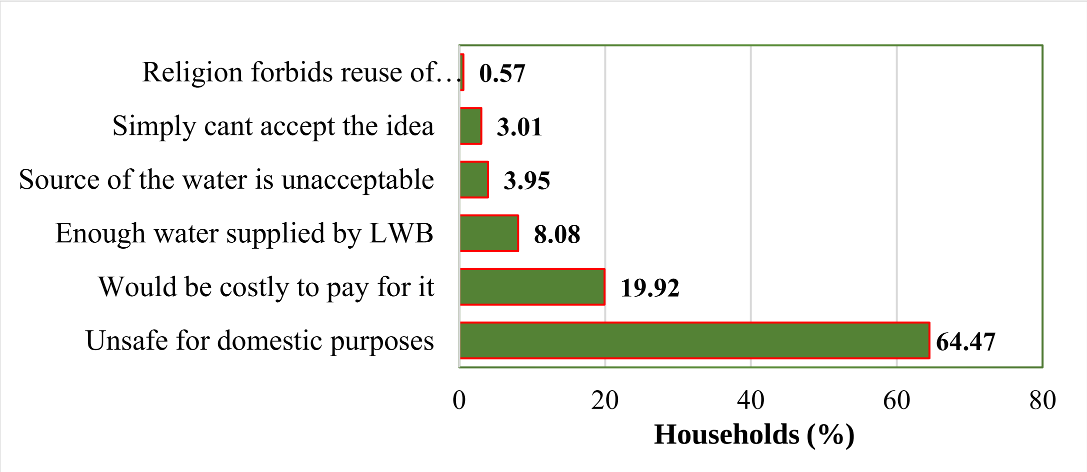

Figure 4-10: Reasons for non-acceptance to reuse wastewater for domestic purposes.

The other reasons for rejecting use of wastewater were that the source of the water is unacceptable (3.95%), idea of using wastewater was simply unacceptable (3.01%) and that their religion forbids the reuse of wastewater as it is perceived to be unclean (0.57%). The religions cited were Islam (67.3% and Jehovah's Witnesses 32.7%). Weiping, et al. (2015)results suggest that the proportion of households declining to reuse treated wastewater because they consider it unsafe for domestic purposes in the city of Beijing was 63.3% which is slightly lower than the findings of this study.Multiple analysis of variance was used to determine whether respondents differed on the reasons for declining to reuse treated wastewater for domestic purposes based on their demographic characteristics (gender, age and educational level).

Gender: The reasons for declining treated wastewater reuse among males and females in the study are shown in **Figure 4-11** below. It is observed that both male and female respondents declined to reuse treated wastewater because they consider it unsafe for domestic uses and that it would be costly to pay for it.

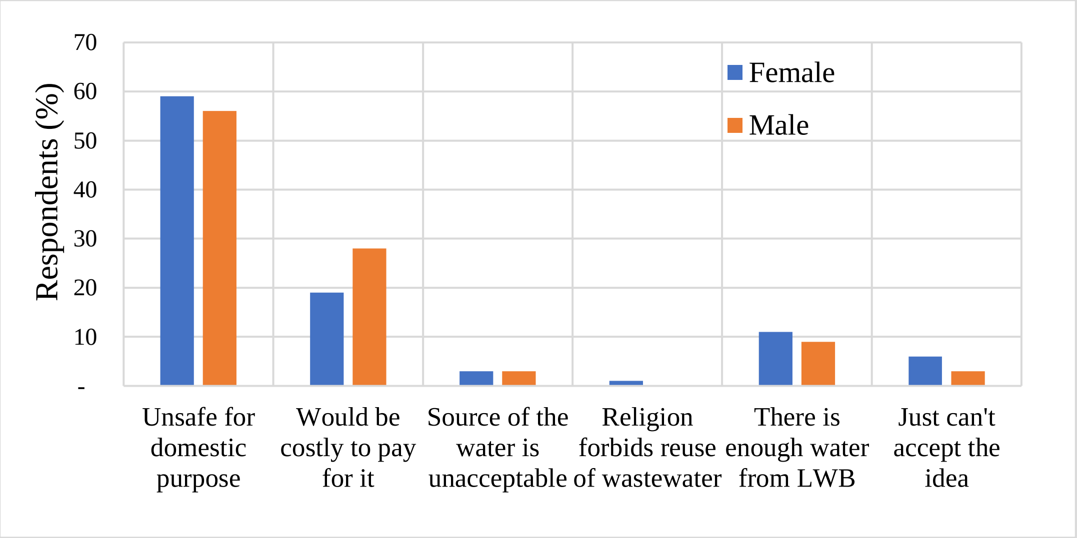

Figure 4-11: Reasons for declining reuse of treated wastewater based on respondents' gender.

Age: The reasons for declining treated wastewater reuse among different age groups are illustrated in **Figure 4-12** below. Across all the age groups, the main reason cited for declining to reuse treated wastewater was that it is unsafe to use for domestic purposes.

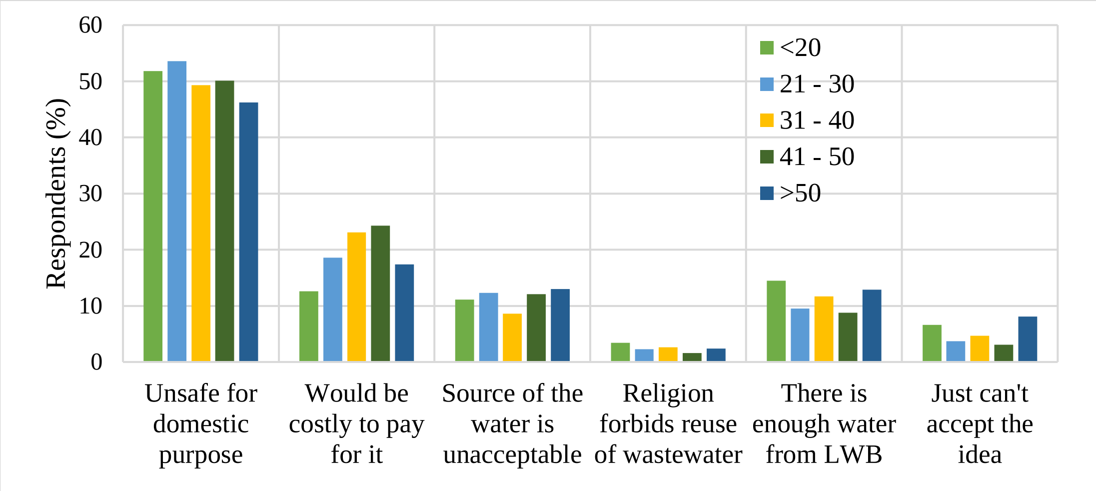

Figure 4-12: Reasons for declining reuse of treated wastewater based on respondents' age.

Education: The reasons for declining treated wastewater reuse based on level of education are shown in **Figure 4-13** below. It is observed that well-educated respondents declined to reuse treated wastewater mainly because they considered it unsafe for domestic uses while the less-educated respondents noted that treated wastewater would be costly.

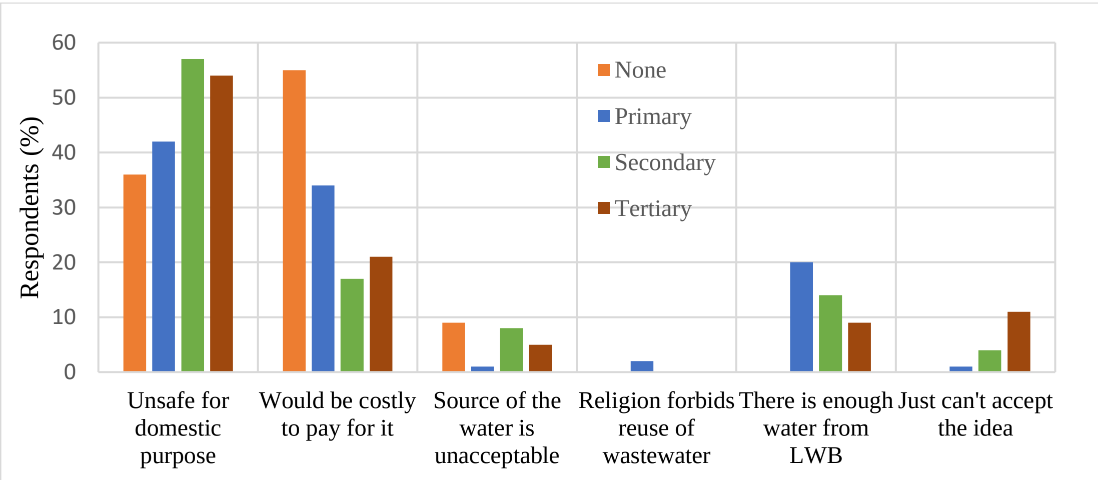

Figure 4-13: Reasons for declining reuse of treated wastewater based on respondents' level of education.

The study observed that reuse of treated wastewater was declined mainly because it is considered unsafe for domestic uses by all three personal characteristics (gender, age, education (**Figures 4-11, 4-12 and 4-13**). It can thus be concluded that quality and safety of treated wastewater is the main risk concern among the public in rejecting the use of treated wastewater for domestic purposes.

4.7 Personal Characteristics Affecting Reuse of Treated Wastewater

The general public's responses to the different survey questions were affected by personal factors (gender, age and level of education) as shown in **Table 4-6** below.

Table 4-6: Personal characteristics that affected views on treated wastewater reuse.

Category	**Significant Demographic Factor[2]**
Awareness of wastewater treatment	Education Level**
Acceptance of domestic use of treated wastewater	None
Non -acceptance of domestic use of treated wastewater	Education Level*

The level of education is a significant factor (at $p< 0.01$) for the public being aware of wastewater treatment and reuse (**Table 4-6**). Respondents with tertiary level of education appear to be more knowledgeable about wastewater treatment than those with secondary or primary education. The public's acceptance to use treated wastewater for domestic purposes was not significantly affected by any of the three personal characteristics.

[2]Notes: Linear correlation between the response of each participant and their demographic factor was conducted. Statistical inferences: * and ** denote the factor earmarked is correlated to the category at $p< 0.05$ and $p< 0.01$ significant levels, respectively.

However, non-acceptance of domestic use of treated wastewater was significantly affected ($p<0.05$) by the level of education of the respondents. The lesser-educated respondents appear to be more willing to reuse treated wastewater than those who are well-educated as can be observed from **Table 4-4** above.The reason is that the well-educated individuals are better informed and have more reasonable expectations of what the water supply system can deliver to them and hence find treated wastewater unsafe for domestic use as can be observed from **Figure 4-13**. Gender and age did not significantly affect any of the key categories of the study, namely, awareness of wastewater treatment and reuse, acceptance and non-acceptance to use treated wastewater for domestic purposes.

Overall, the extent of Lilongwe City residents' willingness to accept treated wastewater reuse for domestic purposes is remarkable with 63.8% of the respondents expressing such willingness while the rest (36.2%) deemed treated wastewater reuse unacceptable. The results of this research were in line other findings in literature that the willingness is high for non-contact and non-potable uses (Dolnicar, et al. (2011), Miller,2006, Hurlimann,2006 and Marks, 2006). The willingness appears as a descending trend as treated wastewater reuse transcends from residents with no formal education to those with tertiary education. Improving treated wastewater quality, expanding knowledge of the users and properly setting water rates are effective ways to increase the degree of willingness to use treated wastewater.

CHAPTER FIVE

CONCLUSIONS

5.1 Introduction

The purpose of this study was to investigate public perceptions of using treated wastewater for domestic purposesand how these perceptions can potentially impact on future water reuse projects in Malawiin the context of growing demand against dwindling water resources. Specifically, the research examined public awareness on treated wastewater reuse, demographic characteristics associated with use of treated wastewater and the main concerns with using treated wastewater for domestic purposes.

While most studies have focussed on the physical and chemical properties of wastewater generated in Malawi and some studies have shown that there is usage of wastewater by communities downstream of rivers from wastewater treatment facilities for non-potable purposes; there have been few studies to investigate attitudes of the public on wastewater reuse for domestic purposes (Msilimba & Wanda, 2014;Chipofya, et al., 2010; Mtethiwa, et al., 2007; Kuyeli, 2007; Blanca et.al., 2008). Prior to this study, wastewater reuse has focussed on use for agriculture purposes and this has missed out on opportunities to utilise wastewater for domestic use as a key water demand management aspect that stresses on making better use of existing supplies rather than developing new ones.

Marks, et al., (2006) in study on public acceptance of waste water reuse in Ghana, noted that one personal characteristic that was found consistently related to acceptance levels of treated wastewater was education, followed by age and knowledge about reuse, income and gender. This is contrary to the findings of this study where acceptance levels were high according to gender, followed by age and level of education. This entails that high level of education among the respondents did not lead to acceptance to reuse treated waste water.

Although this study was limited to the residents of Lilongwe, the findings can be applied to Malawi as Lilongwe is an optimistic case of public awareness on water resources due to its growing population and economic activities. The growing population of the City has increased demand on urban utilities like water supply, sewerage/sanitation and solid waste management (LCC, 2013). Improvement of urban utility services is of paramount importance for the enhancement of urban environment in the City, and therefore reusing treated wastewater presents a viable option for water conservation in the City which can further be replicated in other cities in Malawi.

This study has illuminated public perceptions, concerns and demographic characteristics which may affect reuse of wastewater for domestic purposes. The research presented in this thesis contributes to knowledge and suggests broader policy processes in the following ways:

(1) The majority of the respondents (59.4%) are not knowledgeable about wastewater treatment and reuse but are willing to use treated wastewater for domestic purposes (63.8% of the respondents). Nonetheless, 90% of the respondents are willing to reuse treated wastewater, will use it mainly for non-body contact and non-potable. In addition, willingness to reuse treated wastewater is a descending trend as it transits from respondents with no formal

education (72.4% acceptance) to those with tertiary education (41.9% acceptance). The study has revealed that the less-educated respondents are less knowledgeable about wastewater treatment and reuse but are more willing to reuse treated wastewater and the converse is also true. It is thus concluded that knowledge about wastewater treatment and reuse does not lead to acceptance to use treated wastewater for domestic purposes. This study suggests that there is need to improve the knowledge of the public on wastewater reuse through targeted information dissemination and awareness programs for the public as well as inclusion of wastewater reuse in education curriculum.

(2) The main perceptions negatively affecting acceptance to use treated wastewater include safety and quality of the water and the cost associated with accessing treated wastewater as cited by 64.47% and 19.92% of the respondents respectively. Nonetheless, the positive perceptions about reusing treated wastewater include reduction in potable water usage and bills (60.3% of the respondents) as well as improved sanitation of the households (34.9% of the respondents). These findings entail that water rates (bills) influence domestic water consumption while quality of water affects reuse of wastewater. The study suggests that improving wastewater quality and expanding the knowledge-related publicity are effective ways to increase the degree of willingness to use treated wastewater. In addition, there is need to properly set water rates to promote water conservation and encourage water reuse.

(3) All personal characteristics (gender, age and level of education) investigated in this research, declined to reuse treated wastewater because they consider it unsafe for domestic uses and that it would be costly to pay for it. Acceptance and non-acceptance of treated wastewater reuse was not affected by the gender

and age of the respondents. Level of education of the respondents was the most significant statistical factor in terms of awareness of wastewater treatment and non-acceptance of domestic use of treated wastewater. There is an inverse relationship between level of education and willingness to use treated wastewater. This entails that the higher the level of education, the lower the acceptance to use treated wastewater as well-educated professionals hold the opinion that risk aversion and management are imperative in treated wastewater reuse. There is need to improve the publics' understanding of treated wastewater in order to smoothen the implementation of water reuse. Furthermore, there is need for innovative solutions for on-site low-cost wastewater treatment facilities which can be operated by the households to treat wastewater thereby reducing on potable water usage for non-potable uses.

5.2 Limitations of the Study

The following were the limitations of the study:

1. The likelihood of using treated wastewater was hypothetical given that most of the respondents had no prior experience with using treated wastewater;
2. A comprehensive list of every factor that can be expected to affect people's acceptance of treated wastewater was not included in the fieldwork as evaluation criteria;
3. The perceptions identified to affect wastewater reuse for domestic purposes are not stable and cannot be generalized beyond Malawi.

5.3 Future Areas of Research

The following are areas of future research:

1. The study has established that most people do not have adequate knowledge about wastewater treatment and reuse and therefore do not associate it with good potable water management practices. Rigorous academic research should be carried out to understand how adequate knowledge on wastewater management and reuse can assist in water demand management.
2. The study has established that higher level of education has a significant impact on the non-acceptance to use wastewater for domestic purposes. Further research however can establish at what level of the country's education system can wastewater management be taught so as to have a significant impact on the reuse of wastewater.
3. The study established that cost of accessing treated waste water has an impact on the acceptance to use treated wastewater for domestic purposes. Further research is required to establish the cost of constructing and operating a wastewater treatment facility which would treat wastewater to potable use standards and establish an appropriate tariff for consumers.

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APPENDIX

RESEARCH TITLE: PUBLIC PERCEPTIONS ON THE USE OF TREATED WASTEWATER FOR DOMESTIC PURPOSES: THE CASE OF LILONGWE CITY

STRUCTURED QUESTIONNAIRE

Aim

The purpose of this research is to investigate public perceptions on reusing treated wastewater for domestic purposes. It will assist in pinpointing stakeholders' views on and risks they associate with using treated or partially treated wastewater and how these can impact on future water reuse projects in Malawi.

The Researcher

The Researcher is Stevie Kazembe who works for Lilongwe Water Board and is currently pursuing a Master of Science in Water Resources Modelling and Governance program with the University of Malawi, Chancellor College. The research is being conducted in partial fulfillment of the requirements by the University of Malawi to award an MSc to Stevie Kazembe

Research Ethics

Privacy, confidentiality and anonymity of the participants will be safeguarded in the course of conducting the research. In addition, data will be collected and reported in a manner that will not cause embarrassment, stress, discomfort, pain and harm to the participants.

SECTION A: GENERAL QUESTIONS

1.	**Date of Interview** DD_____MM_____YR_ __	2.	**Zone** 1. North 2. Centre 3. South	3.	**Name of location** ________________________ __
4.	**Category of location** 1. Low density 2. Medium density 3. High density	5.	**Gender of respondent** 1. Male 2. Female	6.	**Age of respondent** 1. 20-30 years 2. 30-40 years 3. 40-50years 4. 50 years above
7.	**Highest education** 0. None 1. Primary 2. Secondary 3. Tertiary	8.	**Relationship to head of household** 1. Head 2. Spouse 3. Child 4. Other, specify ________________________ __	9.	**Relationship to payer of water bills** 1. Payer 2. Spouse 3. Child 4. Other, specify ________________________ __
10.	**How long have you had the most recent connection?** 1. 0-3 months 2. 3-6 months 3. 6-9 months 4. 9 months above	11.	**For how long have been a resident of Lilongwe?** 1. 0-3 years 2. 3-6 years 3. 6-9 years 4. 9 years above	12.	**For how long have you been using water supplied by LWB** 1. 0-3 years 2. 3-6 years 3. 6-9 years 4. 9 years above
13.	**Ownership of house** 1. Own building/house 2. Rented house (government) 3. Rented house (private) 4. Other, specify ________________________ __	14.	**Status of LWB Account:** 1. Active 2. Disconnected 3. Meter Removed 4. Not applicable	15.	**How do you receive your water bills?** 1. By door to door (LWB field staff) 2. By post 3. By SMS 4. By internet Other, specify ____________________ __

SECTION B. WASTEWATER DISPOSAL PRACTICES

16. What is the average monthly water consumption rate for the household?
    a. Less than $5m^3$
    b. Between $6m^3 – 15m^3$
    c. Between $16m^3 – 30\ m^3$
    d. More than $31m^3$

17. Are black water (toilet) separated from grey water (Kitchen and bathroom) as they are disposed?

    a. Yes
    b. No

18. How do you get rid of wastewater in your home?

    a. Hole absorbency through an open pit
    b. Connected to the household septic tank
    c. Leave it to flow to the street
    d. It's used for home gardening
    e. Connected to public sewer system
    f. Other, specify

    ____

19. What is your preferred way of getting rid of wastewater?

    a. Hole absorbency through an open pit
    b. Connect to a household septic tank
    c. Household processing water treatment unit
    d. Connect to the public sewer system
    e. Other, specify

    ____

SECTION C: KNOWLEDGE ON WATER MANAGEMENT PRACTICES

20. Do you use water from other sources apart from water supplied by LWB?

    a. Yes
    b. No → **Q23**

21. What are these other sources of water?

    a. Borehole
    b. River
    c. Rainwater
    d. Other, Specify

    ____

22. What domestic purposes does the water collected from these other sources serve?

    a. Washing clothes and cleaning household utensils
    b. Watering flowers
    c. Drinking and cooking

d. Other, specify

____

23. What are the benefits of using water from other sources in addition to water supplied by LWB?

a. Saving on the money to be paid to LWB for water bills
b. The water can be used when LWB water is not available
c. Other, specify

____

SECTION D: ACCEPTANCE TO USE TREATED WASTEWATER

24. Are you aware of wastewater (black and grey water) treatment?

a. Yes
b. No

25. Would you support establishment of a wastewater treatment plant for the wastewater coming from your household?

a. Yes
b. No

26. Would you use water coming from the wastewater treatment plant for domestic purposes?

a. Yes
b. No → **Q31**

27. What domestic purposes would you use the treated wastewater?

a. Washing clothes and cleaning household utensils
b. Watering flowers
c. Drinking and cooking
d. Other, specify

____

28. Why are you willing to use this treated wastewater?

a. Reduce clean water usage hence reduce water bills to be paid to LWB
b. Clean household due to non-availability of stagnant wastewater
c. Other, specify

____

29. Would you make a financial contribution towards the establishment of wastewater treatment plant?

a. Yes
b. No

30. Do you have a willingness to pay a monthly fee to the City Council against the exchange services of having your household wastewater treated?

a. Yes
b. No

SECTION E: NON – ACCEPTANCE TO USE TREATED WASTEWATER

31. Why wouldn't you use water coming from the wastewater treatment plant for domestic purposes?

a. It is unsafe for domestic purposes
b. It would be costly to pay for it in addition to the water bill from LWB
c. The source of the water is socially unacceptable
d. Religion forbids the reuse of wastewater as it is considered dirty
e. There is enough clean water from LWB
f. Other, specify
   ____

32. If you were trained on how to use treated wastewater, would you use it for domestic purposes?

a. Yes
b. No

33. Other information you would want to share on this study

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THANK YOU VERY MUCH FOR YOUR COOPERATION