

**EVALUATION OF THE EFFECTIVENESS OF WATER SUPPLY
IMPROVEMENT PROJECTS**

A Case Study of Blantyre Water Board, Malawi

Judith Tembo

**Master of Integrated Water Resources Management Dissertation
University of Dar es Salaam
August, 2016**

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A Case Study of Blantyre Water Board, Malawi

By

Judith Tembo

**Dissertation Submitted in Partial Fulfillment of the Requirements for the
Degree of Master in Integrated Water Resources Management of the University
of Dar es Salaam**

**University of Dar es Salaam
August, 2016**

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the University of Dar es Salaam a dissertation entitled: *Evaluation of the effectiveness of Water Supply Improvement projects: Case study Blantyre Water Board, Malawi* in partial fulfillment of the requirements for the Award of Degree of Master in Integrated Water Resources Management of the University of Dar es Salaam.

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DEDICATION

I would like to dedicate this report to my daughter Hairoon and my son Russell for bearing my absence while I was doing my study and to my sister Linda for standing in for me.

LIST OF ABBREVIATIONS

AV	Annual Value
BWB	Blantyre Water Board
CRF	Cost Recovery Factor
DMA	District Metered Area
EIB	European Investment Bank
EU	European Union
IWA	International Water Association
IWRM	Integrated Water Resources Management
KPI	Key Performance Indicators
MIWD	Ministry of Irrigation and Water Development
NRW	Non Revenue Water
O&M	Operation and Maintenance
OPC	Office of the President and Cabinet
PV	Present Value
SDG	Sustainable Development Goals
SIUWM	Sustainability Index for Integrated Urban Water Management
SLB	Service Level Benchmarking
SWOT	Strength Weaknesses Opportunity Threats
TWL	Top Water Level
UfW	Un-accounted for Water
UN	United Nations
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Emergency Fund

WDM	Water Demand Management
WE	Water Efficiency
WHO	World Health Organization
WTP	Willingness to Pay

ABSTRACT

Blantyre water board is mandated by the Malawi water Works Act no 17 of 1995 to supply potable water for commercial, industrial, institutional and domestic use in the supply area of Blantyre City and surrounding areas. The board has been facing challenges in executing its duties mainly due to; ageing infrastructure, increase in demand due to urbanization, high non-revenue water figures. The Government of Malawi through funding from EU, EIB and World Bank embarked on projects to improve water supply services for Blantyre city which were implemented from the year 2007 to 2015. The projects in question included; Rehabilitation and capacity increase of Walkers Ferry treatment plant, Rehabilitation and renewal works at Chileka pumping station and NRW reduction. This project aimed at evaluating the effectiveness of these projects.

The objectives were to assess the service level of the water utility before and after rehabilitation works and also the sustainability of the rehabilitated system. Research tools used include, field tests, Questionnaires to customers, Interviews and review of reports. The results show that: The service level of the water utility is intermediate and the utility is well established in the infrastructure quality (from 3.5-3.7) and accessibility indices but needs improvement in the affordability and infrastructure efficiency (2.24-2.22). The Utility is sustainable (81% in 2010 and 84% in 2015) according to the results and its sustainability is well established in the Environmental, institutional and political dimensions and there is need to improve the social and economic dimensions. The project achieved the goals except for NRW%.

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CHAPTER ONE

INTRODUCTION

1.1 General Introduction

Potable water supply is vital for all human life and development of all nations. However, according to WHO and UNICEF (2006), at the beginning of the Water for Life decade, about 1.1 billion people did not have safe drinking water worldwide. It was further reported that the number of people without access to safe in the Sub-Saharan Africa increased by 23% and hence this remained the area of greatest concern. Efforts were put in place by the world leaders in order to improve water supply access after the UN summit in 2003.

Grady *et al.*, (2014), reports that the United Nations definition for access focuses on three different measurable characteristics of water sources which include; the quantity of water, or quality of water and the collection distance of the water. They further report that agricultural activities, industrial production, and urbanization influence the status of access to water. Human activities affect the quality of water and hence the need for treatment of water before use and this is done by water service providers.

Water treatment is done in order to remove objectionable constituents in the raw water and raise the quality of water to drinking standards. This is done to prevent spreading of related diseases like diarrhea, cholera, dracunculiasis, hookworm, schistosomiasis etc. Howard *et al.*, (2003) concurs that without water, life can only be sustained for a few days and the lack of access to adequate water supplies leads to

the spread of diseases. Water treatment technologies have developed over the past few centuries to secure public health from pathogens and chemicals (Ray *et al.*, 2011). Some of the technologies available include; membrane filtration, ultraviolet irradiation, advanced oxidation etc.

Water supply and sanitation services in urban areas have commonly been provided by state-owned, monolithic water organizations (Baitti *et al.*, 2006). Most water utilities in Africa are state owned and are facing a lot of challenges some of which include; the increase in demand due to urbanization and population growth. According to UNEP (2010), more than 40 percent of Africans lived in arid, semiarid, and dry sub-humid areas. The available amount of water per person in Africa is far below the universal average and is diminishing with per capita availability annually at 4,000 cubic metres compared to a global average of 6,500 cubic metres (UNEP, 2010). Jacobsen *et al.*, (2012), reported that water demand is growing at a higher rate than population growth as urban dwellers' income levels rise and the demands for better services increase while availability of water is decreasing due to competing demands from mining, agriculture, and industry and from deteriorating water quality and climate change.

Malawi like many developing countries has water supply services to the urban areas provided by public authorities which are continuously facing challenges in meeting the demands of the growing urban populations (Kalulu, 2009). There are five water boards in Malawi that are mandated to supply potable water to the urban centres of the country namely; Northern Region Water Board, Central Region Water Board,

Lilongwe Water Board, Southern Region Water Board and Blantyre Water Board (BWB). The vision of Malawi's water policy is "water and sanitation for all, always" and seeks to provide every Malawian with "equitable" access to water and sanitation services for sustainable socio-economic development of the country (MIWD, 2007; Pritchard *et al.*, 2007). Kang *et al.* (2013) reported that 100 non-governmental organizations and 100 donors were working on sanitation and hygiene wash sector and had an estimation of over 100 million USD annually and they managed to implement, influence and fund projects but they were yet to achieve the most important result which is sustainable services.

This study focuses on the City of Blantyre which is one of the 3 major cities in Malawi. The reported challenges with regard to the water supply and treatment plants are;

- High demand as compared to the available supply due to population growth and urbanization (volume produced daily 86,000 m³/day and daily demand was estimated at 125,000m³/day 2013).
- Pressure variations due to terrain hence the need for pumping which then leads to high pressures outside design limit of the range of (50-160m).
- High non-revenue figures (average of 33% in 2014).

Through funding from the European Union (EU) and European Investment Bank EIB, BWB embarked on projects to; increase capacity, rehabilitation of treatment works, increasing coverage to low income areas among others. The projects were

undertaken in order to try to bridge and solve the problems of water supply as stated above.

1.2 Statement of the Problem

Blantyre Water Board embarked in a big project for rehabilitation of water supply network in the wake of solving the challenges of water supply aforementioned. Projects on Rehabilitation of treatment works and the distribution system undertaken by the European Union, European Investment Bank and World Bank have been completed and the effective delivery during the project implementation had not been assessed. It is against this background that it was thought important to evaluate the effectiveness of the rehabilitated system to see if it meets the intended objectives of the project.

This study therefore aims at evaluating the effectiveness of the projects carried out and the areas that need focus in the future for planning purposes and to ensure efficiency of the organization and its sustainability

1.3 Objectives

1.3.1 General Objective

To evaluate the effectiveness of the Rehabilitation and capacity increase of Walkers Ferry treatment plant, Rehabilitation and renewal works at Chileka pumping station and Non-revenue reduction projects implemented by the Blantyre Water Board.

1.3.2 Specific Objectives

- (i). To assess the service level of the treatment works before and after rehabilitation.
- (ii). To assess the sustainability of the rehabilitated system; looking into institutional arrangement and cost recovery (both for the investment cost and operational and maintenance).

1.4 Research questions

- (i). What are the impacts of the water supply system rehabilitation projects implemented by Blantyre water board from 2010 to 2014 on the service level?
- (ii). How is the sustainability of the rehabilitated system?

1.5 Significance of the study

As already discussed BWB had been facing a lot of challenges in performing its duties of supplying water to the city of Blantyre. As such there were interventions put in place to overcome some of the problems at hand and among others were the capacity increase and rehabilitation of the Walkers Ferry treatment plant, Rehabilitation and renewal of the Chileka pumping station and non-revenue reduction. This study will assess the water utility on the effectiveness of the projects carried out and the areas that need focus in future for planning purposes so as to ensure efficiency of the organization. The results of this evaluation may help in highlighting on the necessary actions for further development.

1.6 Scope of Study

This research will focus more on the water supply system operations and performance after the rehabilitation works implementation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Water is important for supporting human life and it plays a crucial role in many human activities, some of which include industrial production, agriculture, energy, sanitation, and transportation, as it also maintains ecosystems that give valuable services to both the environment and human beings (CAP-Net 2003, World Bank Institute 2006). They further report that, even though water seems to be plentiful on the planet, 97% of it is seawater, which makes it not fit for most human application. Out of the remaining 3%, 87% is unattainable, because it is either in deep underground aquifers or locked in polar icecaps making, only 0.4% of all of the earth's water usable and accessible by human beings (CAP-Net 2003, World Bank Institute 2006).

Safe drinking water and sanitation are primary to health, growth, survival and development (UNICEF 2006). WHO (2009), indicated that Under Goal 7 (which was aiming at ensuring environmental sustainability), world leaders committed themselves to Target 10: which was to halve the proportion of people without sustainable access to sanitation and safe drinking water by 2015. WHO & UNICEF joint monitoring report 2014, indicated that this target was met by 2010 but 40 countries were still not on track to meet the target by 2015 and most of these were in sub-Saharan Africa.

The post 2015, agenda 2030 for sustainable development is now in place as the world leaders adopted the agenda in 2015. The SDGs cover a wide range of drivers across the three sustainable development pillars , and include a goal dedicated on water and sanitation (SDG 6) so as to “ensure availability and sustainable management of water and sanitation for all”(UN Water, 2015).

2.2 Evaluation

“Evaluation is the logical and objective assessment of an activity, project, strategy, programme, topic, policy, theme, sector, operational area or institution” (UNESCO, 2007). Furthermore, evaluation offers assessments of the efficiency, relevance, effectiveness, impact and sustainability of interventions over time. From the definition given it was deemed necessary to carry out the effectiveness of the projects in order to assess the impacts and sustainability of the same. This will then help the organization and donors to see the areas that need focus for future investment and also assess the success of the interventions. Assessment of the success will be achieved by the data collected from both the implementing organization and the beneficiaries.

According to the evaluation handbook by UNESCO 2007, the evaluation criteria is as follows;

Relevance: The degree to which the objectives of an intervention are in line with the organization’s goals and strategies, beneficiaries’ necessities, country needs and global priorities.

Efficiency: A measure of how economically inputs are converted to results.

Effectiveness: The degree to which the intervention's objectives were achieved, or are expected to be achieved, taking into account their relative importance. In this context, *cost-effectiveness* assesses whether the costs of an activity can be justified by the outcomes and impacts.

Impact: The primary and secondary, positive and negative, intended and unintended long-term effects of an intervention.

Sustainability: The continuation of benefits from an activity after major assistance has been completed.

2.3 Water Demand Management

The use of water resources sustainably to meet the demands of a growing population cannot be accomplished exclusive of a better understanding and the attentive management of urban water demands (Dziegielewski, 2011). The problem faced by most water utilities is the high demand as compared to their water production capacity due to population growth.

Water Demand Management (WDM) can be implemented in several ways with different policy tools being successful in a range of contexts. These policy tools include market mechanisms such as economic pricing, non-market mechanisms such as the application of standards, quotas and fines on water use and direct intervention

such as repairs to leaks, reduction of unaccounted for-water and promotion of water efficient technologies (Merwe, 1994).

2.4 Service level

Service levels are a utility's declared dedication to deliver service of specified level of reliability and quality (Shea-Beers, 2005). It is also pointed out that service levels can be regulatory/ customer related (response times, information availability, complaints etc) or performance related (asset performance driven by faults, equipment failure etc). The quality of service is assessed based on service indicators consisting of: Coverage of the Service Area, Continuity of service, Water quality, Water pressure, Coverage of service zone, Service Hours, Metering and billing and The degree of responsiveness of service providers to consumer's complaints (MoUD India, 2013). In order to assess the list of indicators composite indices are used as specified by Haarhoff *et al.*, 2004, composite indices are helpful in simplifying a long list of indicators and their complex relationship into one index. They also indicate that service level be assessed in four dimensions namely; infrastructure quality index, infrastructure efficiency index, accessibility index, affordability index. Service level parameters can either be measured from a consumer's perspective or a utility planner's/ manager's perspective or (MoUD India, 2013).

2.5 Sustainability of Water Utility

With the publication of the Brundtland commission's report "Our Common future" in 1987, a sustainability paradigm has influenced decision making in many fields (Simonovic, 2009). Sustainability as defined by Moe *et al.*, (2006), is termed as the

long term viability of the public water supply services and hence requires fees and input from the beneficiaries. Each utility has the responsibility to ensure that its system is in good working condition, regardless of availability of additional funds or the age of equipment (EPA, 2012). It is further reported that programs for asset management with good information including attributes of the asset (e.g., condition, age and criticality), life-cycle costing, maintenance (O&M) and proactive operations plus capital replacement plans based on cost-benefit analyses, can be the most efficient method of meeting the sustainability challenge (EPA, 2012). Berg (2010) pointed out the financial and water resources sustainability as areas for long term performances of water utilities that are often neglected. It is further enlightened that sustainability of water resources is important for both developed and developing countries because the long term cost are significant when the resources become contaminated or gets depleted. An enabling Institutional framework for operational and sustainable water and sanitation services requires a balanced policy, a legal and administrative framework and favourable informal institutions (Katko and Seppala, 2009). One example of the administrative framework is the statutory body which is described by Schwartz (2007), as an organizational mode whereby a public utility operates as an autonomous agency but still functions under public law and is financed either through tariffs collected from consumers or from the ‘general budget’ of the municipality, or a combination of these two.

2.6 Non-Revenue Water

NRW is a good indicator for performance of a water utility; high levels of NRW in general indicate a weak management (Frauendorfer *et al.*, 2010). In contrast,

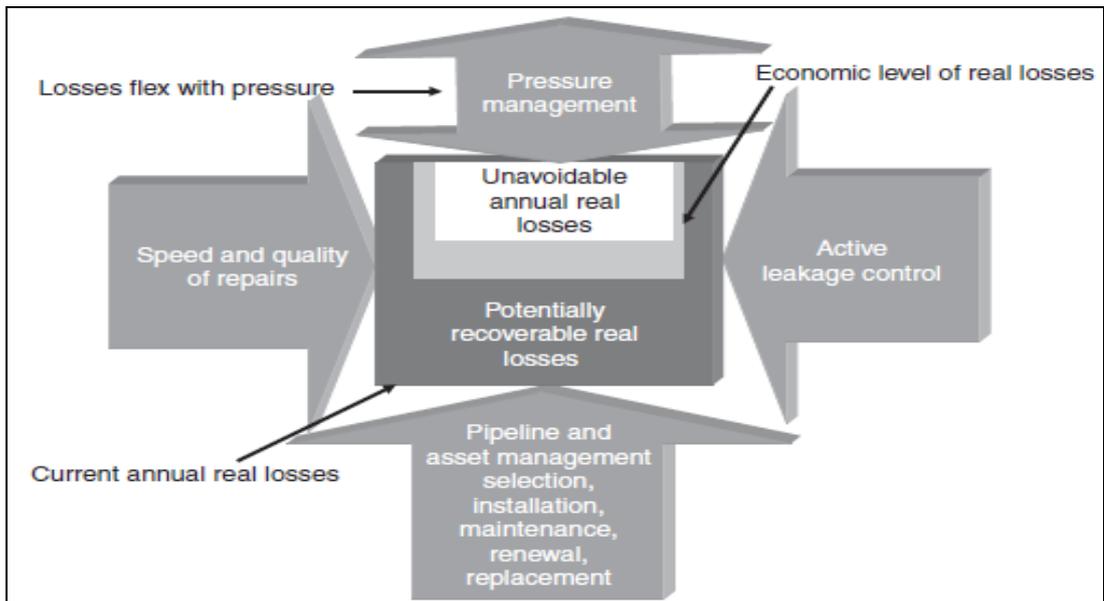
successful utilities address NRW actively by controlling physical losses, ensuring accuracy of customer meter and making all efforts to reduce and keep the number of illegal connections within limits (Frauendorfer *et al.*, 2010). According to Thornton *et al.* (2008), the International Water Association (IWA) defines two major classes under which all types of supplier water loss occurrences fall as:

Real losses are the physical escape of water from the distribution system, and include leakage from pipes, fittings and joints; leakage from reservoirs and tanks; and water losses caused by reservoir overflows. Real losses happen prior to the point of end use.

Apparent losses are caused by inaccuracies associated with customer metering, consumption and billing data handling error, assumptions of unmeasured use, and any form of unauthorized consumption (illegal use or theft).

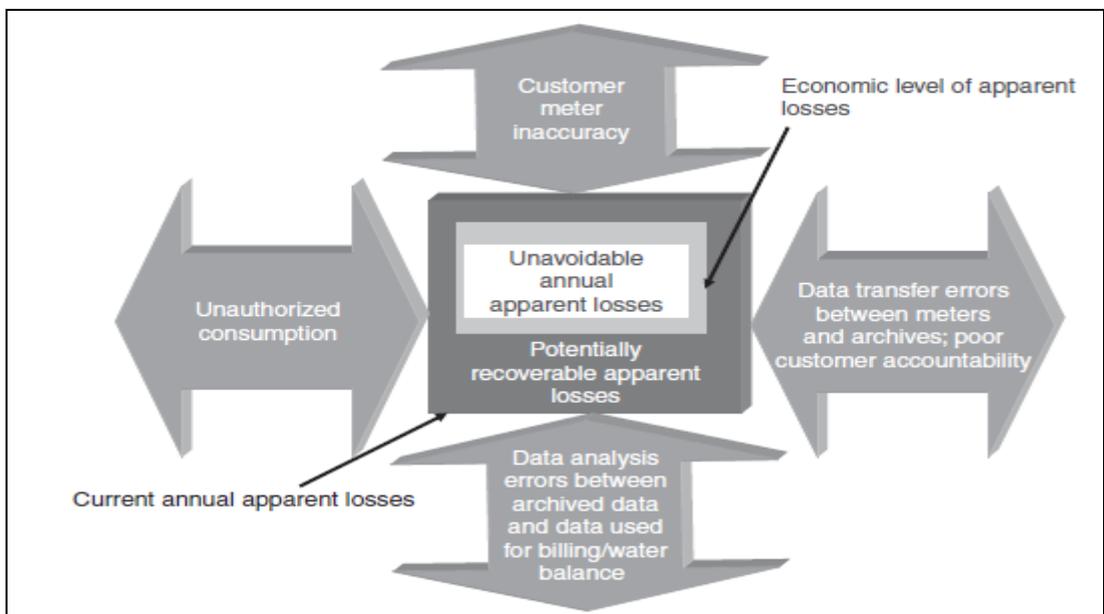
Management of non-revenue water is better done when the distribution network is divided into District Metered Areas for easy water balancing. Fanner *et al.*, (2007), emphasises that the leakage monitoring technique requires the installation of flow meters at planned points throughout the distribution system, with each meter recording flows into an isolated district with a defined and permanent boundary and such a district is called a DMA.

Figure 2.1 and Figure 2.2 illustrates the potential interventions that can be employed to overcome both apparent and real losses.



(Source: Thornton *et al.*, 2008.)

Figure 2. 1: Four potential intervention tools of an active real loss management program.



(Source: Thornton *et al.*, 2008)

Figure 2. 2: Four potential intervention tools of an active apparent loss management program.

2.7 Performance Indicators

Assessment of the water utilities performance is done with regards to the following indicators according to (Schwartz, 2007) as recommended by Tynan and Kingdom 2002 are;

Operational efficiency refers to the lowest cost of the day-to-day operation of a utility in terms of labour, energy, water and the materials, with the most resourceful combination partly dependent on local input prices and prior capital investment decisions. The ratios suggested for this indicator are the number of staff per 1000 connection and staff per 1000 population

Cost recovery; adequate funding to meet capital investments and the operational costs is fundamental for a utility to deliver water services of adequate quality.

Commercial Performance the indicator suggested for commercial performance is that of the collection period, which refers to the ratio of 'accounts receivable' to the annual revenues.

Coverage and Access Tynan and Kingdom (2002), suggest that appropriate levels of service means that not every household must have an in-house connection. Rather, each household should have access to a sufficient level of service (for example by way of yard connections, block connections, public stand posts, etc.).

Asset Maintenance; non-revenue water is often used as an indicator for the state of the service provision network. The idea is that the level of NRW will be lower when the condition of the service provision network is better. The target level of NRW, as proposed by Tynan and Kingdom is less than 23%.

Service Quality; can be indicated by such indicators as the quality of water supplied, the pressure at which the water is supplied, and the availability of services. Tynan and Kingdom forward 'continuity of service' as the main indicator with which to measure the level of service quality.

2.8 Willingness to Pay

For water supply services to be sustainable the utility has to be able to meet the operation and maintenance cost and in most cases this comes from revenues collected hence the need to assess the willingness to pay by the water users. Kadisa *et al.*, n.d, emphasizes that because of competition for use of water resources, it turns out to be important to study the willingness to pay of the different users for improved water supply services (both quality and quantity) in order to set appropriate tariff structures that are consistent with government policy. Household's demand for improved network water and sanitation services gauged through WTP surveys by presenting the consumers with a contingent scenario in which they can attain the described service (Pattanayak *et al.*, 2006). Improvement of water supply service by water supplier, has to take into consideration the public's ability to afford higher prices and hence decide how much to invest (Wang *et al.*, 2010).

2.9 Institutional Arrangement

Institutional arrangement is one of the IWRM pillars which are; enabling environment, institutional arrangement and management instruments. IWRM is “a process that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Xe, 2006).” Institutional arrangement is putting in place the *institutional framework* through which implementation of the policies, plans and legislation may be achieved.

2.10 National Water Policy

The Ministry of Irrigation and Water Development (MIWD) developed the National water policy which was approved in 2005. The policy has articulated a new water sector vision of ‘Water and Sanitation for All, Always’ which is based on the country’s central policy of poverty reduction and economic prosperity and the fact that water is potentially the engine for social and economic development in Malawi(MIWD 2005). The Policy broadly covers areas of development and water resource management, water utilization, water quality and pollution control, disaster management and institutional roles and linkages. In general national water policy goal is to attain sustainable management and utilization of water resources, so as to provide water of sufficient quantities and acceptable quality, and ensure availability of effective and efficient water and sanitation services that satisfy the basic requirements of every Malawian and enhance the country’s natural ecosystems.

CHAPTER THREE

METHODS AND MATERIALS

3.1 Introduction

This chapter outlines the methods that were employed in order to complete this survey and the second section 3.2 describes the study area. The other sections summarize the sampling methods and analytical methods used in this survey.

3.2 Description of the Study Area

3.2.1 Geographical Location

Blantyre is geographically located at 15° 47' S, 35° 0' E in the southern region of Malawi and it is the second largest urban centre located 311 kilometres southeast of the national capital, Lilongwe (Maoulidi, 2012). It is a city with rugged terrain as well as many hills and valleys. The hills are between 780 and 1,612 m above sea level, and a lot of streams originate from the hills and flow into the city. This scenery presents a distinctive problem because the water abstraction point is situated at Walker's Ferry, 48 km East of the City, and there is a 780m-altitude difference between Blantyre and Walker's Ferry with the source on the lower side (Maoulidi, 2012).

3.2.2 Socio-economic status

Blantyre is the commercial City and industrial capital for Malawi. Retail trade, finance, construction, food, transport, textile manufacturing, motor vehicles sales and maintenance, and the informal sector are the most significant economic sectors in the

city (UN-HABITAT, 2011). Blantyre has a population of approximately 1,000,000 people according to projected from the population of 661,256, 2008 at a growth rate of 4.1(Maoulid, 2012). About 18 percent of Blantyre's population is employed by the informal sector and plays a major role in the economy of the city, the private sector employs about 45 percent of the residents, 12 percent are working in the public sector, and 36 percent are self-employed and mainly working in the informal sector(UN-HABITAT, 2011).

3.2.3 Water Supply Services

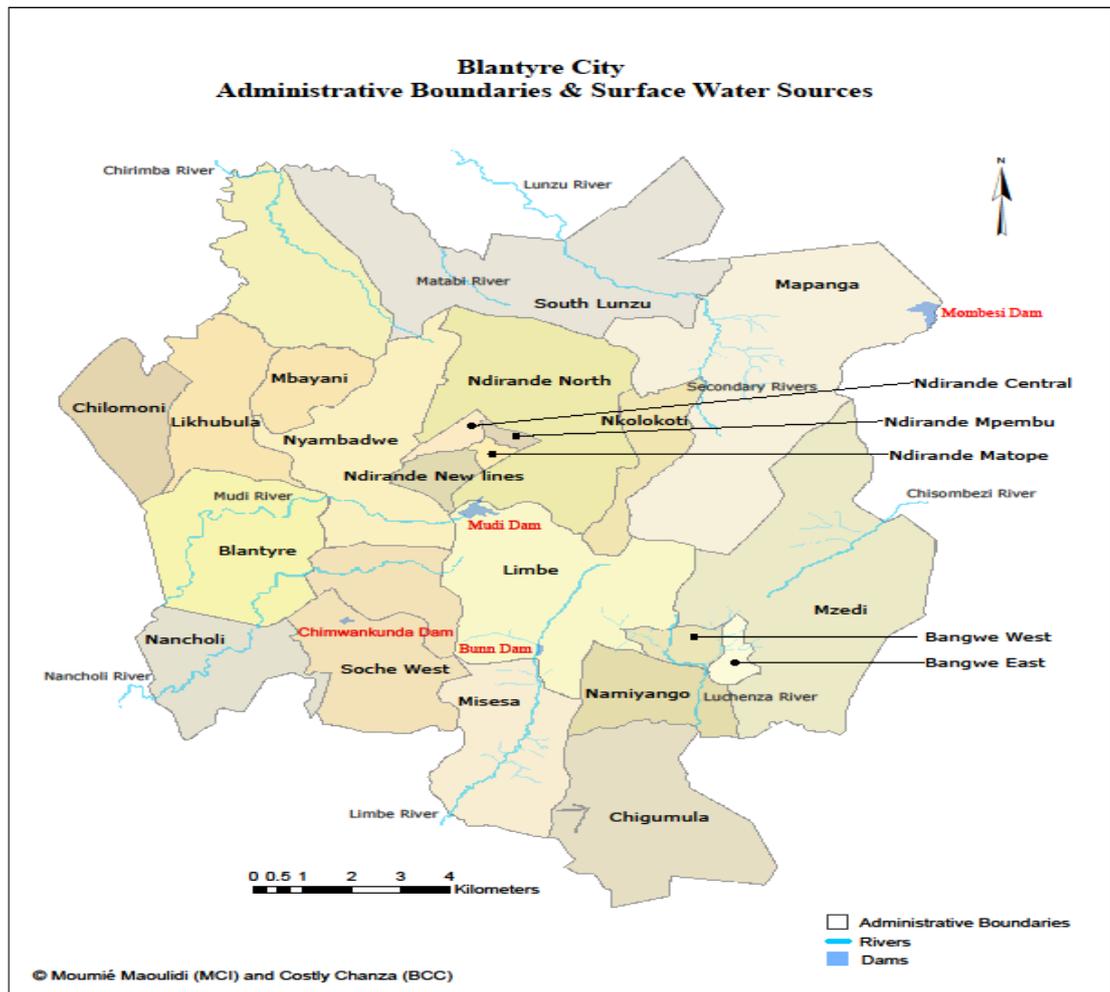
Blantyre Water Board is mandated by the Malawi water Works Act No 17 of 1995 to supply potable water for domestic, industrial, institutional and commercial use in the supply area of Blantyre City and surrounding areas over a total coverage area of 76,000 hectares of land. Water supply to individuals is on application basis where by the customers fill application forms with a sketch map. Upon assessment of the premises a quotation is issued and the connection is made within 28 days after payment. The Board was established in January 1929 after construction of Hynd dam as the first source. It provided first piped water to residents of Blantyre town in 1930. In 1954 Mudi dam was completed and is located downstream of Hynd dam. An increase in demand necessitated the construction of Walkers Ferry pumping station on the banks of Shire River which was commissioned in 1963 (BWB, 2010).

Currently, Blantyre Water Board has two main sources of water supply namely Walker's Ferry and Mudi dam. Walkers Ferry situated on the banks of the Shire River some 35km north-west of Blantyre City, which contributes approximately 90%

of the total potable water amount. Production at Walker's Ferry was initially estimated at about 78,000 m³/d which was the design capacity of the treatment plant then.

The second water source is Mudi within the City of Blantyre comprising Mudi reservoir with an original storage volume of 1.5 million m³ and a stated effective yield of approximately 8000 m³/day and a water treatment plant.

The primary water distribution network consists of 16 clear water reservoirs sets and a total of 9 pumping / booster stations. Top water levels (TWL) from the service reservoirs range from 1304 m asl down to 790 m asl at Chileka (Posch, 2008). The number of pumping stations and reservoirs has increased due to the construction of 3 additional storage tanks and pumping stations within the project period. Figure 3.1 depicts the administrative boundaries of the city of Blantyre.



(Source: Maoulid, 2012)

Figure 3. 1: Map of Blantyre city

Data collection for this report was done through three methods; documentation review, field tests and questionnaires /Interviews. The DMA's involved were Nkolokosa B, Mudi and Ndirande goliyo for questionnaires mainly because these are Medium density, low density and high density respectively and the research aimed at getting data from people with different income capacity so as to have a true picture of the perception from all angles. Pressure data was also collected in three DMA's

which are located in different pressure zones these areas were Mbayani, Chichiri and Sunnyside. The pipe reticulation map shown in Figure 3.2 point up measuring points for pressures and areas where questionnaires were administered.

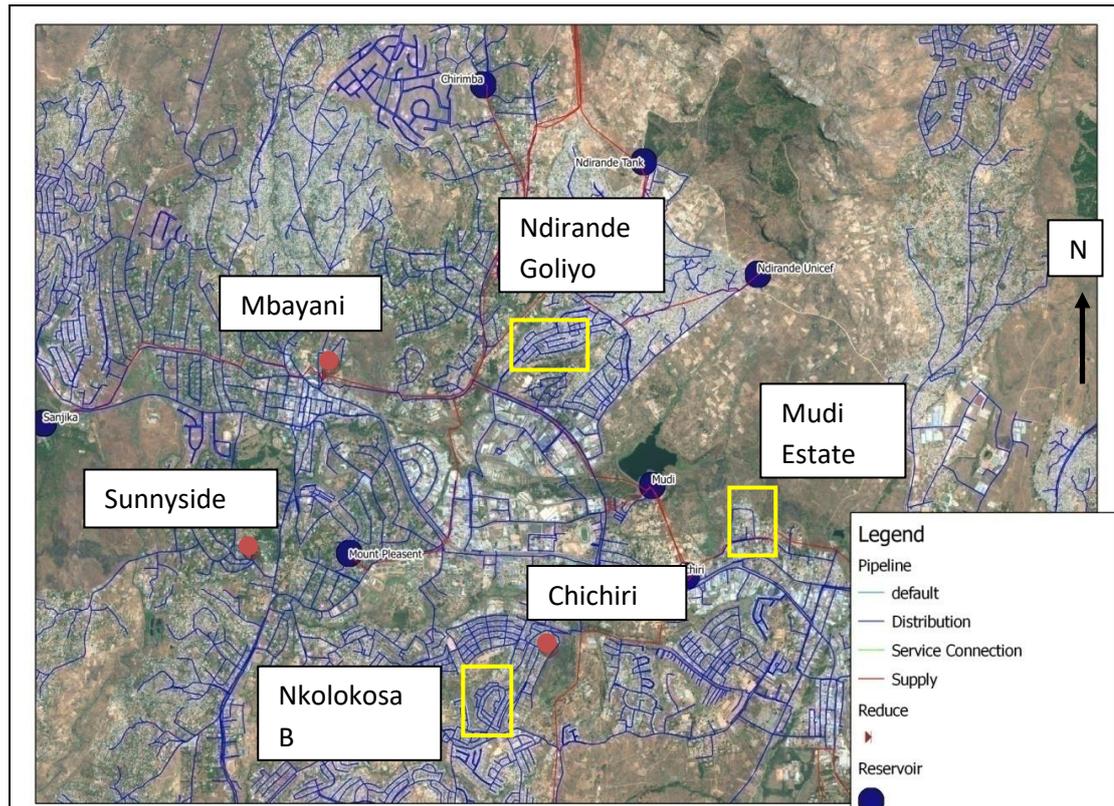


Figure 3. 2: Pressure measuring points and areas of questionnaire survey

The choice for pressure measuring points was influenced by;

- Availability of old data to allow for comparison of the pressures before and after rehabilitation works.
- Elevation difference

The specific data collected to achieve the objectives is explained below under each objective.

3.3 To assess the service level of the treatment works before and after rehabilitation

Service level assessment was done using service level indices and the following indicators as discussed in literature review were used; Coverage of the Service Area, Continuity of service, Water quality, Water pressure, Coverage of service zone, Service Hours, Metering and billing and The degree of responsiveness of service providers to consumer's complaints. Data was collected through desk study, interviews, field pressure test and the details of the data collected and assessment are as described below.

Data collected and tools

Service hours/continuity of service data was collected using pressure loggers and review of reports. Pressure loggers were installed in 3 DMAs at customer premises and programmed to record pressures after every hour (Mbayani area) and every minute for Chichiri and Sunnyside areas for 7 days. The measuring dates for Mbayani, Sunnyside and Chichiri were 27th January to 3rd February, 26th to 31st January 2016 and 28th January to 3rd February respectively. The data was used to assess the number of hours that the customers were getting pressurized supply within the day. The pressures from the previous years (2010 to 2013) before project completion were obtained from the reports. During analysis low pressure hours were to be excluded as it is only necessary to assess the number of hours the system is able to provide water supply at the recommended standard pressure as per Malawian piped water standards. Customers were also asked how often they get supply from the water utility through the questionnaires.

Coverage of service data was collected from review of reports as there is no recent data on the number of households within the supply area. The data obtained was from the water utility recorded since 2010 to 2016; however the current data is just an estimation of the coverage after completion of the project. Further assessment is done through data obtained from the customers through questionnaires. The coverage is presented as a percentage of number of households with access to water supply either through household connection or communal water points and the total number of households that were involved in the survey.

Water quality; according to Shea-Bears 2005, quality related service levels state the utility's commitment to deliver clean, contaminant free water. Data from the treatment plant water quality was collected through documentation review and interviews with the Laboratory staff. The data collected was from 2010 to 2015 before and after rehabilitation. This data is assessed to check on the percentage of samples collected that really meet the treated water standards for the water utility. The water quality parameters analysed included; turbidity, Temperature, residual chlorine, other quality aspects like odor, color and taste were also observed. Complimentary data was also obtained from the customers through questionnaire in order to assess their level of satisfaction with the water supplied by the utility

Metering and Billing; Data for metering and billing was obtained through interviews with the Planning manager, Accountant and review of annual reports from the Finance department in order to assess number of customers that are metered and billed every month. The data was analyzed in excel by use of tables and charts.

Degree of responsiveness of service to consumers complaints; data was collected from consumers through questionnaires and review of reports from the customer service unit. Only recent data for 2015 was collected from the customer service unit as it was difficult to retrieve the old data. Data to be collected included; the number of water supply related complaints received per month, number of complaints redressed within the month and the satisfaction of the consumers on how the complaints were handled by the utility.

Non-Revenue Water” (NRW) defined as the difference between the volume of water put into the distribution system and the volume of water billed to consumers (Frauendorfer *et al*, 2010). Data for assessment of NRW was collected from review of reports and the Finance section through interviews. The data collected include; monthly production figures and the monthly billed consumption for the years 2010 to 2015. The billed consumption volumes were deducted from the monthly production figures to get the non-revenue volumes which were then divided by the production figures and multiply by one hundred to get the NRW percentages. The trends were developed by plotting the NRW data in Microsoft excel. Service Level indices were used to assess service level looking at four dimensions namely; infrastructure quality index, infrastructure efficiency index, accessibility index and affordability index (Haarhoff, 2004).

3.4 To assess the sustainability of the rehabilitated system

Desk study/ report review, interviews and questionnaires were conducted to obtain data for this objective. Project data was collected from the Project Implementation

Unit's reports. The data collected include; investment cost, tariff setting, annual revenues collected, annual revenues billed, collection period, total annual expenses/operation maintenance cost (electricity cost, chemical, staff/outsourcing etc.) data was obtained from the Finance department. Data on Technical skills, equipment and spare parts availability was also obtained through review of reports and interviews. Water quantity data was be obtained from the treatment plant and from reports this is from 2010 to 2015 for comparison production before rehabilitation. This data was analysed using excel and tables and charts were produced.

The institutional and legal framework data was obtained through review of the administrative reports and interviews. Data collected included; the organizational structure, operational laws and regulations and management structure. Analysis of the institutional and legal framework was done using the SWOT analysis where the strengths, weaknesses, opportunities and threats are analyzed.

Willingness to pay by the customers was evaluated through the contingent valuation method. Data sought through questionnaires included; family size, number of adults, number of children under 5years, respondents education level, monthly consumption/daily consumption, monthly income, primary occupation, distance to water supply infrastructure.

Data for affordability and willingness to pay was obtained through questionnaires. Sustainability index was used to assess the sustainability indicators and service level indices to assess the service level.

Sampling Methods

Customer data obtained through questionnaires was done in 3 areas namely Ndirande Goliyo, Nkolokosa B and Mudi and the total number of households in these areas was estimated at 937. To come up with the number of questionnaires to be administered in these areas computations were made using the formula below adopted from Carvalho *et al.*, 2008.

$$n = \frac{NZ^2 * P * (1-P)}{Nd^2 + Z^2 * p * (1-p)} \quad (3.1)$$

Where,

n=sample size

N=total number of households

Z=confidence level (95% level Z=1.96

p=estimated population proportion (0.5, this maximizes sample size)

d=error limit of 5 %(0.05)

From the equation above the questionnaires recommended in this study were 272 and only 210 were responded to bringing the percentage of the successful questionnaires to 77%. Prior to the study 10 questionnaires were administered as a pilot survey and all of them were responded to. Data from the questionnaires was analyzed using

SPSS by coding all the data and input into the system and the analysis was done by producing charts and tables. Some of the indicators for service level assessment and sustainability are as presented in the Table 3.1.

Table 3.1: Showing indicators for data analysis

Indicators	units	Recommended level(MoUD India2013)	computations
Cost recovery	%	100	Total annual operating revenues/total annual expenses *100
Coverage	%	100	Total number of households with connection/total number of households in the supply area*100
Extent of non-revenue water	%	<20	(Total water produced - total water billed)/total water produced*100
Willingness to pay	%	100	Number of people willing to pay/ total number of people*100
Extent of metering connections	%	100	Total number of metered connections/total number of connections *100
Per capita supply of water	litres	120	Water supplied to the distribution system/population served
Continuity of water supply	hours	24	Number of hours of pressurized supply
Efficiency in collection of water supply charges	%	100	Revenues collected in the year/revenues billed *100
Quality of water supplied	%	100	Total number of samples that meet standards/total number of samples tested *100
Efficiency in redressal of customer complaints	%	100	Total number of complaints redressed in a month/Total number of complaints received *100

3.5 Sustainability Index

The list of indicators for sustainability was analysed using the Sustainability Index for Integrated Urban Water Management (SIUWM) adopted from Carvalho *et al.*, (2008), which comprises of 5 components namely;

- Social/cultural– social justice and equitable resource distribution.
- Economic – economically sound ethics, economic development and cost returns.
- Environmental – environmental protection and preservation of ecological systems.
- Political – support and international stewardship.
- Institutional/technological – capacity and progress.

Table 3.2 summarises the components and indicators that were used to assess each component.

Table 3. 2: Components and Indicators for SIUWM

Table Showing Components and Indicators for SIUWM	
Component	Indicators
Social	Coverage
	Continuity of water supply
	Complaints redressal efficiency
Environmental	water quality
	conservation masures
	per capita supply of water
Economic	Cost recovery
	Collection efficiency
	collection days
	Extent of metering
	Extent of NRW
	affordability
	willingness to pay
	Sources of investment
	income levels
	% of people with secondary education
Institutional	staff per 1000 connections
	Adoption of IWRM
	Corresponding education levels for O&M
	spares availability
Political	Measure of corruption
	Defined roles and responsibility
	Compliance with policy

The indicators were then grouped into the 5 components as described above and weighted and normalized following the multi criteria analysis. The formula for normalization is as below adopted from Gallego-Ayala *et al.*, 2014;

$$I_k = \frac{x_k - \min(x_k)}{\max(x_k) - \min(x_k)} \text{ 'more is better' } \quad (3.2)$$

$$I_k = \frac{\max(x_k) - x_k}{\max(x_k) - \min(x_k)} \text{ 'less is better' } \quad (3.3)$$

where:

I_k refers to the normalised value of the indicator k

x_k is the value of indicator k without being normalised

$max(x_k)$ is the maximum value of k without being normalised

$min(x_k)$ is the minimum value of k before the normalisation

Prioritizations was done with the most important indicators given higher weights, this exercise is normally done with the stakeholders involved. However due to time constraints this was done under the discretion of the researcher. Then aggregation was done as recommended by Carvalho 2008 and is defined as below;

Aggregation is the grouping of indicators according to the fundamental theoretical framework. A complex index approach was used to calculate the overall sustainability index score for a specific year (SI_i), as the summation of all the weighted components (Eq. (3.2)). The standardised value for each variable, X_i , was multiplied by the attributed weight, w_{xi} , to give a value on a scale of 0 to 1. The score for each indicator was then determined from the sum of the variable values multiplied by their respective weightings, expressed as a percentage. The scores for all the 5 components and finally the SIUWM were determined in a like manner.

$$SI = \frac{\sum_{i=1}^N w_{x,i} \cdot X_i}{\sum_{i=1}^N w_{x,i}} \times 100 \quad (3.4)$$

A sensitivity analysis was done to assess the robustness of the complex index with regard to the primary assumptions made in its construction, as well as the

'sensitivity' to changes in such supposition. Varying the prioritisation of individual variables and indicators was adapted to examine whether component and index scores varied considerably in response.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Background

The customer survey was successful as 77% of the questionnaires administered were responded to. Characteristics of the respondents were as follows; Most of the respondents were females representing up to 70.5%, the average number of residents in the households visited was 5. Education of the respondents showed that 20% went up to primary school level, 36.7% secondary level, 1.9% vocational training, 28.1% college level and 13.3% attained university qualification. A non-parametric, test one-sample χ^2 was run to check if any relationship existed among these categories as Bhandari and Grant (2007) indicated. Table 4.1 shows the results, where B is a logistic regression coefficient, df is the degrees of freedom and SE is the standard error. Logistic re-gression showed that no important association existed between the level of satisfaction and respondents' demographic characteristics. The demographic data details are shown in Table 8 in the appendix B. The customer data obtained from questionnaires is analyzed in comparison with the water utility data obtained through interviews, field tests and desk reviews. The water utility data is presented in Tables in the appendix A.

Table 4. 1: Logistic regression

Variables	B	S.E.	Wald	df	Sig.	R
Step 1 ^a education	-.372	.124	9.050	1	.003	.091
income	-.171	.271	.400	1	.527	.091
Number of residents	.016	.051	.099	1	.753	.091

a. Variable(s) entered on step 1: education, income, number of residents.

4.2 Assessment of the Service Level Before and After Rehabilitation

4.2.1 Coverage

Service level assessment was done through primary data from customers collected through questionnaires and data from the water utility which was collected through interviews with the water utility personnel and secondary data through desk study/ review of the reports. From the questionnaires, data was collected from three areas low density, medium density and high density the response in the low density area was very poor as people did not have interest in the study so the results may be biased towards the high and medium density.

From the 210 households that were involved in the survey, 69.38% have individual connections while 30.62% depend on other sources as shown in Figure 4.1.

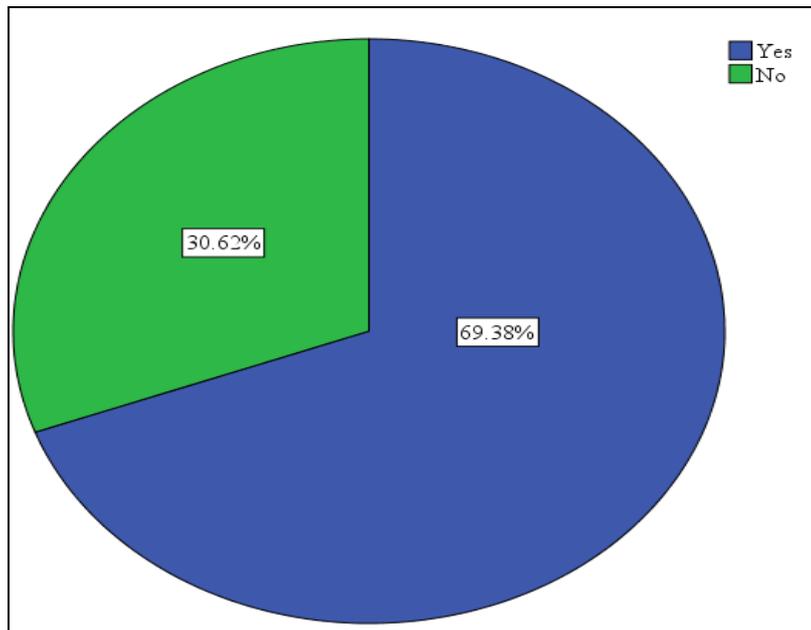


Figure 4. 1: Household data on water connections according to the areas surveyed

Of the population without connections 96.88% depend on kiosks as a source of water while 3.12% depend on boreholes as depicted in Figure 4.2. Service coverage for the water utility before the projects implementation was estimated at 75% according to Annual KPI report 2014. And from the results of this study the current coverage can be estimated to be above 90% which could be mainly due to construction of 363 kiosks in low income areas and pipe network extension during the project period which brought the number of kiosks to 740. As Tynan and Kingdom (2002) stipulates that appropriate levels of service means that not every household must have an in-house connection. Rather, each household should have access to a sufficient level of service (for example by way of yard connections, block connections, public standposts, etc.). However the utilities estimation of the coverage is currently maintained at 85% until further study is conducted.

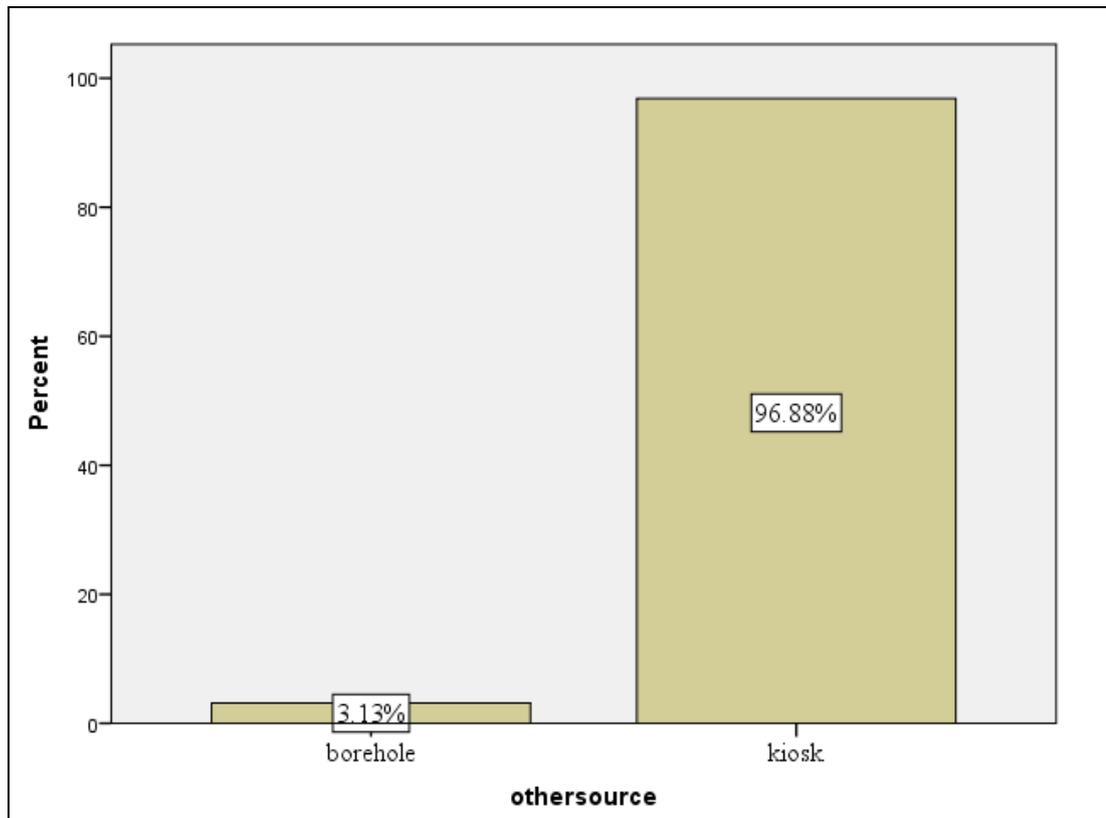


Figure 4. 2: Other sources of supply for the household without in house connections

4.2.2 Continuity of Supply

To establish the continuity of supply, field tests were conducted in 3 areas differing in elevations. Pressure data loggers were installed for 7 days in order to check the 24 hour pressure variations at customer premises. And the results were as in Figure 4.3 and 4.4 which show that most of the customers in the areas of study were able to get pressurized supply 24 hours before and after the rehabilitation works. However the pressures have greatly improved since the commissioning of the rehabilitated system as evidenced by the consistency in the pressure reading throughout the day. This data was also complimented by the customers' response from the questionnaires as seen on Figure 4.5, which shows that 90% were satisfied with the pressures.

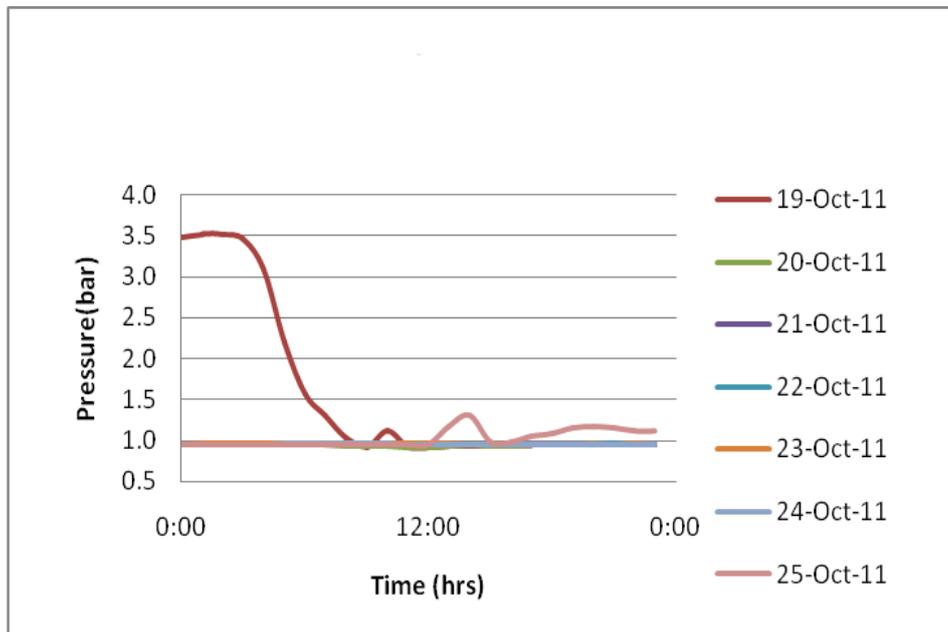


Figure 4. 3: Pressure results for Chichiri station before rehabilitation (2011)

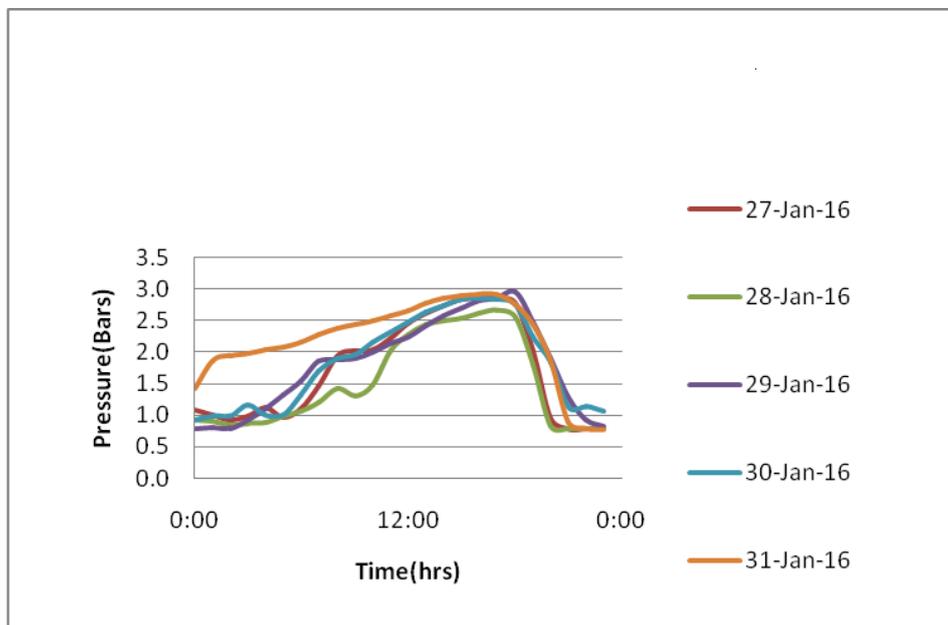


Figure 4. 4: Pressure results for Chichiri station after rehabilitation (2016)

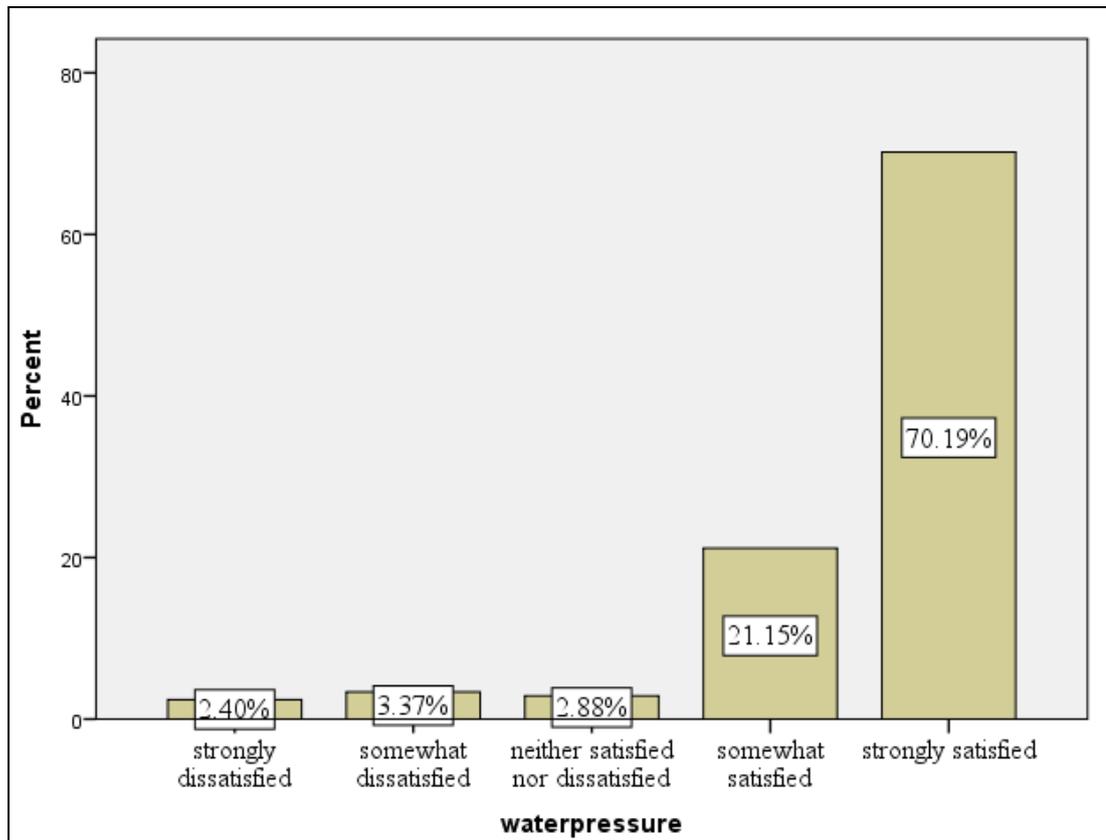


Figure 4. 5: Customers satisfaction on the water pressure

4.2.3 Efficiency in Redressal of Customer Complaints

One way of assessing the service level of a water utility is by studying the efficiency in attending or resolving customer complaints. This data was collected through desk study which was done by going through the customer service reports. The only data available was the current reports from July 2015 to January 2016 which is plotted in Figure 4.6. From the reports it can be drawn that on average only 51% of the complaints logged within a month are resolved within the month. It is further noted that the number of complaints recorded are less than what is really on the ground so the redressal efficiency is only concluded from the available data.

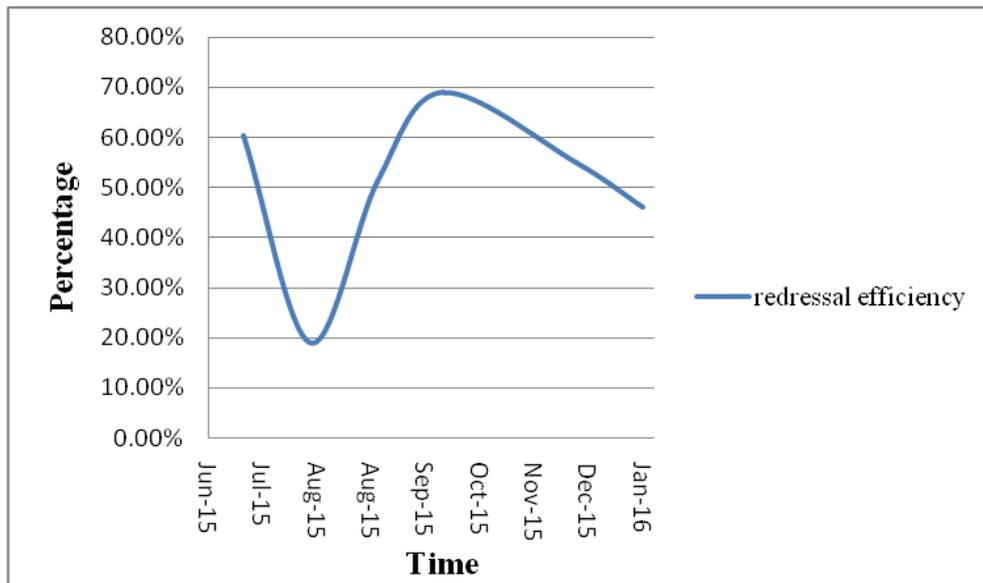


Figure 4. 6: Efficiency in redressal of customer complaints

From Figure 4.7, only 48.31% of the customers interviewed were satisfied by the way the organization handles their complaints; this does not reflect well with the water utilities mission to provide reliable and affordable water supply services.

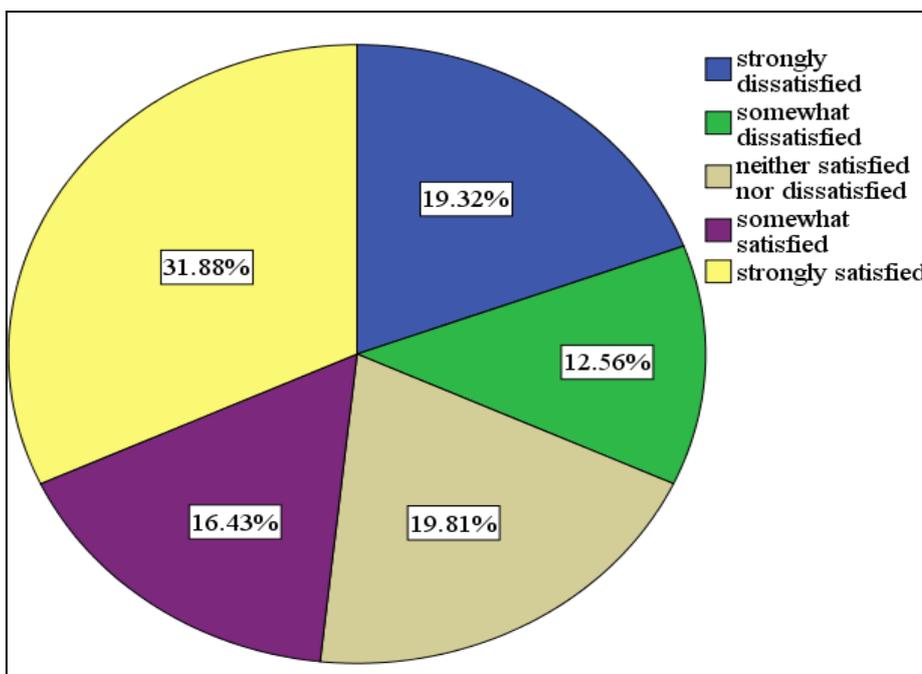


Figure 4. 7: Customers perspective on how the utility handles the complaints

4.2.4 Water quality

The water quality data was collected from the water quality section monthly reports because the focus was on the rehabilitated treatment plant and this is done on daily basis at the plant which is 45km away from the supply area. The data assessed is from 2010 to 2015 and the water quality parameters in focus were Turbidity, pH and Residual Chlorine. The Treatment standards used by Blantyre water board are in line with WHO standards. From the data provided, all the samples meet standards which represents 100% adherence to standards. The water quality improved more on turbidity after rehabilitation of the treatment plant as shown in Figure 4.8. This may be because of the installation of the Lamella tubes in the Pre-settling tanks which provides a large settling area of the suspended matter in addition to the other rehabilitation works like change of filter material and replacement of the filter collection pipes and nozzles among others. Figure 4.9 shows the pH results which also reflects that pH is maintained within the required limits.

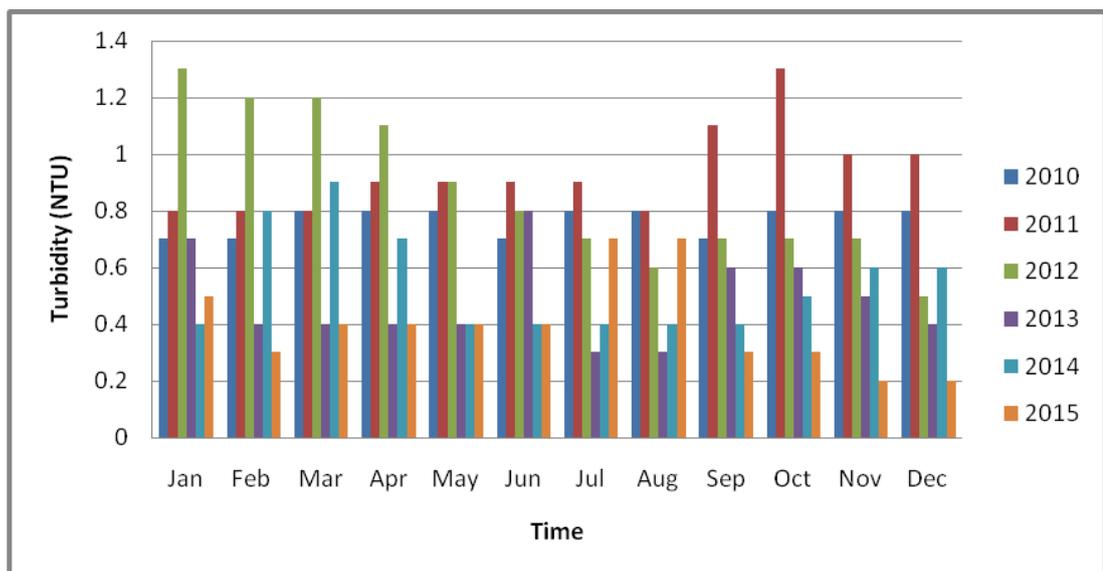


Figure 4. 8: Water quality results for turbidity of the treated water

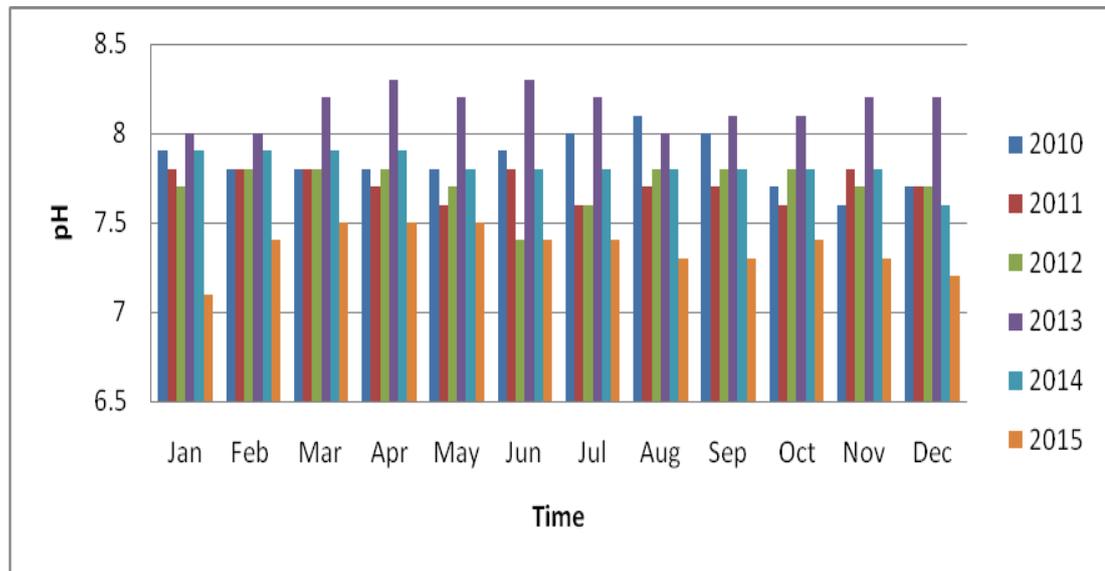


Figure 4. 9: water quality results for pH of the treated water

Residual Chlorine at the source is 1mg/l this is the maximum allowable level which is more than the recommended limit 0.2mg/l WHO standard because the water is pumped 45 km into the supply system and the content of chlorine is altered during transportation of the water. In order to maintain the water quality in the distribution system the utility has several dosing points within the distribution systems and also carry planned cleaning schedules for all the reservoirs.

4.2.5 Metering and Billing

The information for metering and billing was collected through interviews with the utility's employees in the Planning section and review of reports from the revenue section. Total number of customers had increased from 34,468 in 2010 to 41,794 in 2016 as shown in Figure 4.10. All these connections were metered bringing the extent of metering to 100% which is also the recommended standard. All the customers' meters are read monthly and billed accordingly. The only setback will be

the meters that are not operating normally as the board is not currently doing any meter replacement. Meter exchange were done earlier in the Project between 2013 and 2014, however this is supposed to be a continuous process in order to maintain a lower no revenue water percentage.

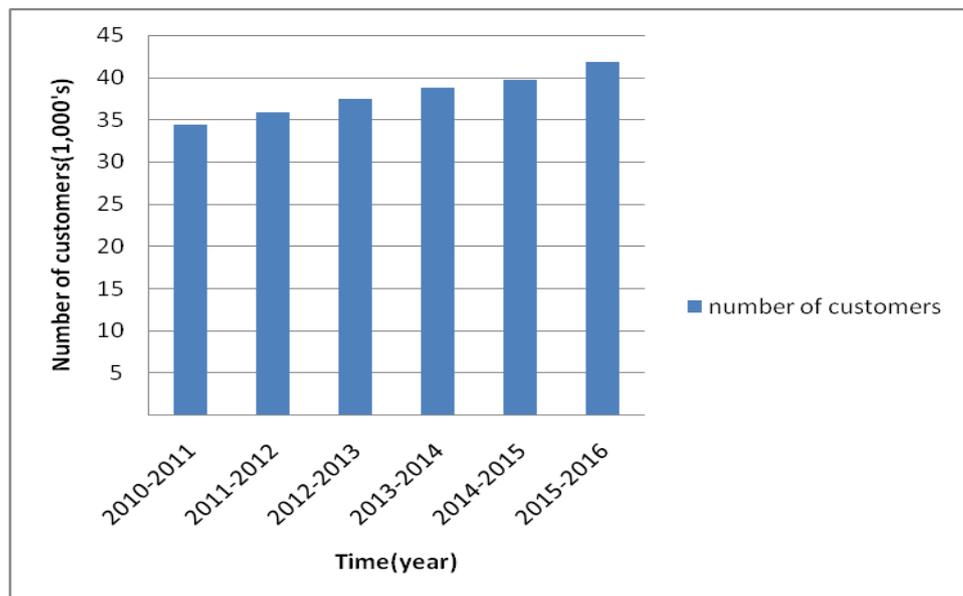


Figure 4. 10: Number of customers with connections (2010-2016)

4.2.6 Non Revenue Water

Data for volume of water produced and volume of water billed monthly was collected from interviews with the finance personnel and review of reports from the revenue section. From the onset of the project the average non-revenue water percentage was about 40%. The target for the project was to reach 25% by end of 2014 and several activities were done including; customer meter replacements, pipe replacements and leak detection exercises. Management of non-revenue water was being done per District Metered Area. The working average reached 33% in 2014.

Towards the end of the project on Capacity increase at the source in 2015 Non revenue water percent increased to above 50% and is currently at 56% as shown on Figure 4.11. This indicates that the increase in production led to an increase in NRW percentage. However it is also evident from the data that the volume of the water sales has been decreasing as in Figure 4.12 and this should be an area of focus as it implies that there are more apparent losses, hence the need to do demand management project. The increase in NRW can be attributed to the increase in pressures and hence the increase in pipe burst as most of the pipes in the system are aged. On the other hand there could also be an increase in illegal water use by the customers and also rise in faulty water meters as at the time of data collection there were no meters in stock and hence some customers may have been undercharged.

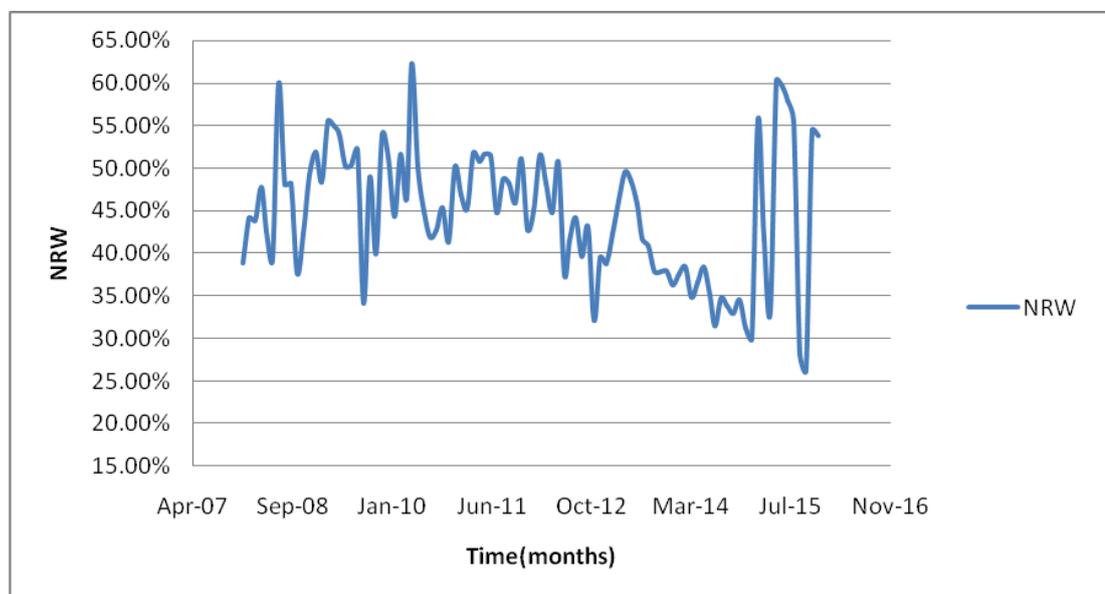


Figure 4. 11: NRW percentage trend

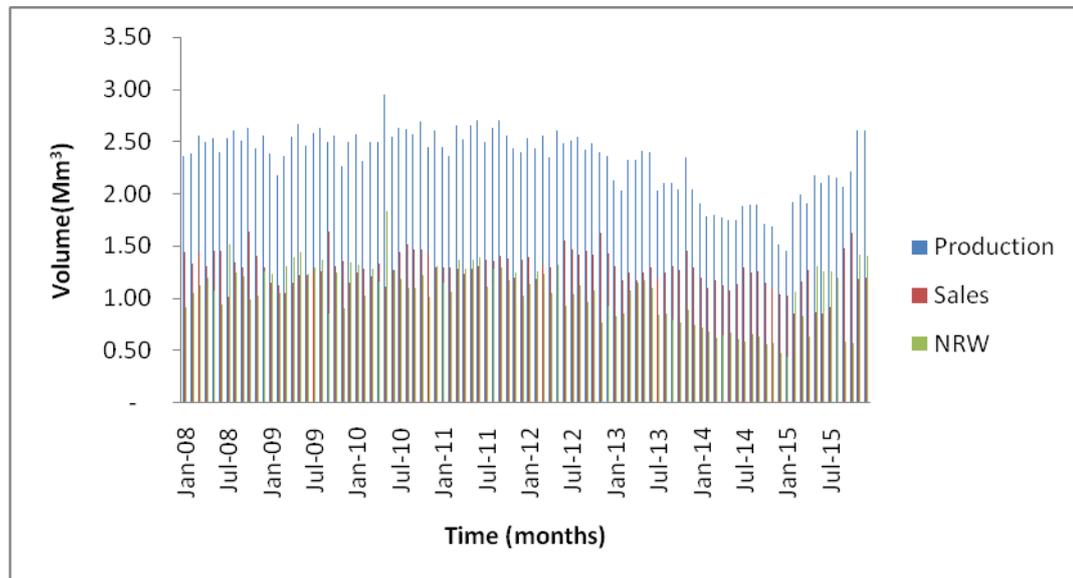


Figure 4. 12: Volume of monthly water production, sales and NRW

Service Level Indices

Service level assessment was done looking at the four dimensions, infrastructure quality index, infrastructure efficiency index, accessibility index and affordability index as defined by Haarhoff, 2004.

Infrastructure quality index, the level of service is classified as

1=minimal 2=basic 3=intermediate 4=full (World banks classification of infrastructure). Calculations were done using the formula in Table 4.2.

Table 4. 2: Service level indices calculation

Service quality	No. of users	Value	Index Calculation
Minimal	Nmin	1	$I_{min} = N_{min} \times 1 / N_{tot}$
Basic	Nbas	2	$I_{bas} = N_{bas} \times 2 / N_{tot}$
Intermediate	Nint	3	$i_{int} = N_{int} \times 3 / N_{tot}$
Full	Nfull	4	$I_{full} = N_{full} \times 4 / N_{tot}$
Total	Ntot		$i = i_{min} + i_{bas} + i_{int} + i_{full}$

According to the findings in this research, the water utilities level of service was intermediate as the infrastructure level in 2010 was 3.5 and 2016 is 3.7. There was a slight improvement in the infrastructure level of service but the system is within the intermediate level which means there is more that needs to be done in order to provide full service. Infrastructure Efficiency is classified as below;

1 = no service, 2 = major problems, 3 = minor problems, 4 = no problems

The water utility's infrastructure efficiency is 2.28 and it is evident that the system has major problems which can be attributed to the high non revenue water both before and after the project. However, the water quality is good both after and before the project as evident from the results from the treatment plant which shows that 100% of the samples meet the required standards which are in line with the WHO guidelines.

Accessibility Index classified as;

1 = no access, 2 = limited access, 3 = Part access, 4 = Full access. Scores for the Utility before and after rehabilitation are within the part access therefore the system provides part access to water services just as in the infrastructure service level.

Affordability index classified as;

1 = unaffordable, 2 = expensive 3 = affordable 4 = cheap. According to the customers perception the water services are affordable as the score is 2.9.

In summary the water utility's service level was intermediate both before and after the projects there is still need for infrastructure improvements especially on the water distribution system in other words there is no significant change in the service level and the overall results are as summarised in Figure 4.13.

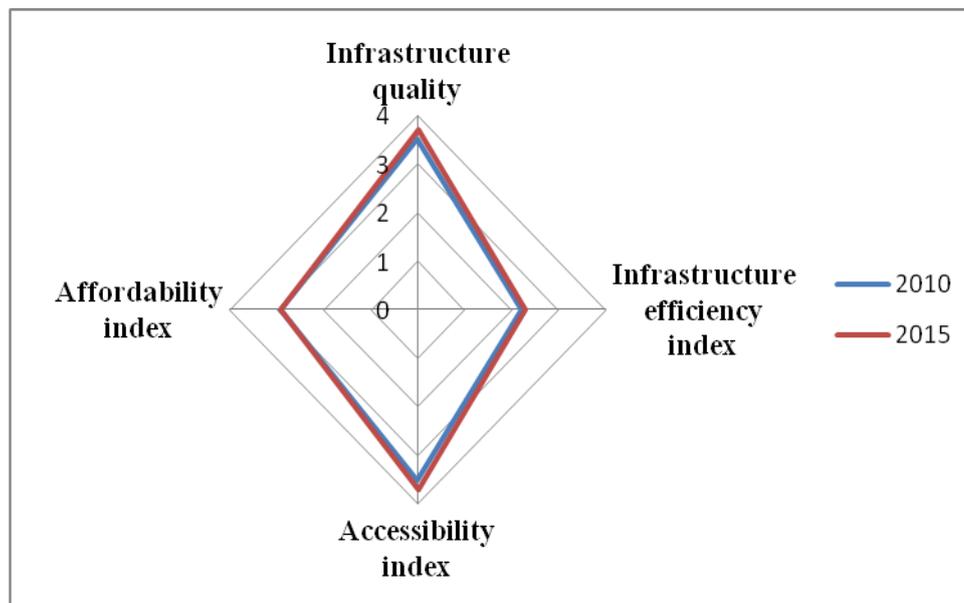


Figure 4. 13: Results for service level indices

4.3 Assessment of the Sustainability of the System

4.3.1 Investment Cost

Table 4. 3: Projects investment amounts

Project name	Total Cost
Rehabilitation and Capacity increase(treatment plant)	\$ 3,119,183.21
Rehabilitation and Renewal works Walkers Ferry Intake	£4,077,094.23
Rehabilitation and Renewal Works at Chileka Pumping Station	\$ 7,857,861.18

The total investment cost for these three projects converting all the currencies to USD is \$15,610,106.02 thus *Fifteen million, six hundred and ten thousand one*

hundred and six dollars, two cents. A cost benefit analysis is done by converting the investment cost into annual costs using the capital recovery factor. The project is analysed for 50 years because the old system also survived for more than fifty years, the interest rate used is the applicable bank repo rate for Malawi which was at 27% as at April 2016. The formula used below was adopted from Reynders, 2015;

$$A = P \times CRF$$

$$CRF = \left[\frac{i(1+i)^n}{(1+i)^n - 1} \right] \quad (4.1)$$

Where:

P = Present value

A = Annual value

i = Interest rate or rate of return in % for particular interest period (practical value to use as indicator for government type projects is bank Repo rate being the cost of money to banks)

n = Number of interest periods (years, months, days etc)

CRF =Capital recovery factor

Using the formula above the annual cost for the investment for the three projects is at

$$A = \$ 4,214,755.83$$

Conducting a cost benefit analysis for the year 2015 yields 0.75 which is less than the recommended >1. The analysis is done by adding the annuity to the annual expenses and then computing a ratio of benefits/cost. This analysis was done on

assumption that the system will survive for 50 years and the annual cost as well as the interest rate of return is kept constant over the years.

4.3.2 Tariff Setting

Tariff setting for BWB is categorized into domestic (Communal water points and kiosks), domestic consumption, Institution, commercial and Industrial. The Table 4.4 summarizes the tariff setting for the year 2010 and 2016. The tariff setting has gone up by up to 300% and this could be due to kwacha depreciation and hence the increase in order for the organization to meet the operational expenses.

Table 4. 4: Tariff setting for the years 2010 and 2016 adopted from BWB reports and converted to dollar as per June 2016 exchange rate.

Category	Year	Cost for 10litres (communal/kiosk)(MK)	Cost for the first 5m ³ (5,000L) (MK)	Cost for 1m ³ consumption above 5m ³ up to 10m ³ (M)	Cost for 1m ³ consumption above 10m ³ up to 40m ³ (M)	Cost for 1m ³ consumption above 40m ³ (M)
Domestic	2010	0.59(US\$0.0008)	501.00(US\$0.75)	103(US\$0.15)	123(US\$0.18)	136(US\$0.20)
	2016	1.41(US\$0.002)	1446.40(US\$2.16)	310(US\$0.46)	360(US\$0.54)	400(US\$0.6)
	proposed	1.55(US\$0.0023)	1591.04(US\$2.38)	340(US\$0.51)	400(US\$0.6)	440(US\$0.66)

4.3.3 Working Ratio

The average working ratio for the years 2010 to 2015 (Table 4.5) were within the acceptable range which is above 1 as recommended by Tynan and Kingdom (2002).

This is less than the target for the water utility and as presented in the data below the

ratio for 2010 and 2013 are less than the recommended which shows that the annual expenses were higher than the annual collected revenues and hence the organization made losses within these years. The possible reason for decrease in annual collected revenues was the low billed consumptions which could be due to meter reading errors or faulty meters in the system.

Table 4. 5: Working ratios from 2010 to 2015

Year	Total annual revenues(MK)	Total annual operational expenses(MK)	Working ratios
2010	2,112,416,610.15	2,158,041,000.00	0.98
2011	2,575,966,418.94	2,447,198,000.00	1.05
2012	3,157,178,409.19	2,869,338,000.00	1.10
2013	4,173,716,933.69	4,879,912,000.00	0.86
2014	7,086,145,874.03	6,056,925,000.00	1.17
2015	7,677,276,633.49	7,471,398,000.00	1.03

4.3.4 Technical Skills

The board employs qualified personnel for all its positions and has a training programme for its employees every year for capacity building. This information was obtained from the human resource department. During the execution of the project some members of staff went to India in order to attain the necessary skills for repair of the new pumping system which was manufactured there.

4.3.5 Equipment and Spare Parts

The board keeps stock of all spare parts needed for repair of its equipment and for the newly installed pumps the spare parts were purchased from the manufactures and they are already at the boards stores. However in the recent years the boards has been running out of stock of vital fittings as well as water meters which is not good for the sustainability of its operations.

4.3.6 Number of Employees per 1000 connections

Number of employees per 1000 connections has been above 5 as recommended by Tynan and Kingdom (2002). However, the number has been going down from 2010 to date as in Table 4.6 and it is currently within the limit of less than 20 employees per 1000 connection recommended for developing countries (Alegre *et al.*, 2000). The target for Blantyre water board is 12 and has been achieved recently.

Table 4. 6: Number of customers and staff over the years 2010 to 2015 and ratio of staff per 1000 connection

year	number of customers	number of staff	staff per 1000 connections
2010-2011	34,468	554	16.07
2011-2012	35,834	555	15.49
2012-2013	37,421	522	13.95
2013-2014	38,764	491	12.67
2014-2015	39,726	475	11.96
2015-2016	41,794	525	12.56

4.3.7 Collection Efficiency

Throughout the project period the collection efficiency has been above 100% except for the year 2013 where it was 94% as evidenced by the data collected from the planning section and review of the reports from the finance department shown in Table 4.7. The collection period was higher in the beginning of the project and improved in the recent years this could be due to the disconnection campaigns enhanced by the organization in order to encourage the customers to pay for the services. Recommended number of collection days is 90 days and the boards target was 120 days. Data in this section was collected from the revenue section and review of reports from the finance department. The annual expenses and revenues shown in Figure 4.14, indicates that there has been an increase in the expenses as well as the revenues explains why the working ratio is always maintained at 1 or even lower. There is also data from the questionnaires that were given to customers and this gives a picture of the customers' perception on the water charges as shown in Figure 4.15.

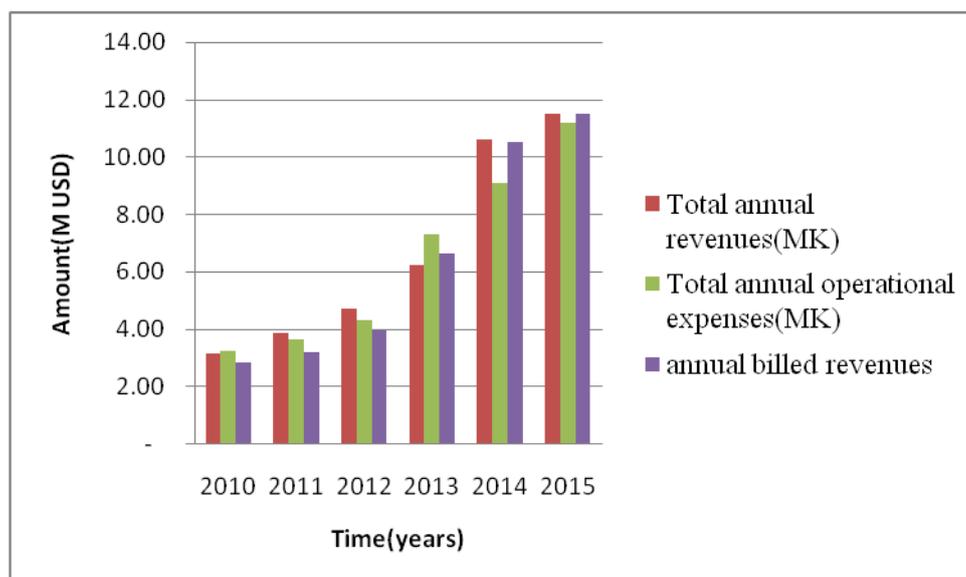
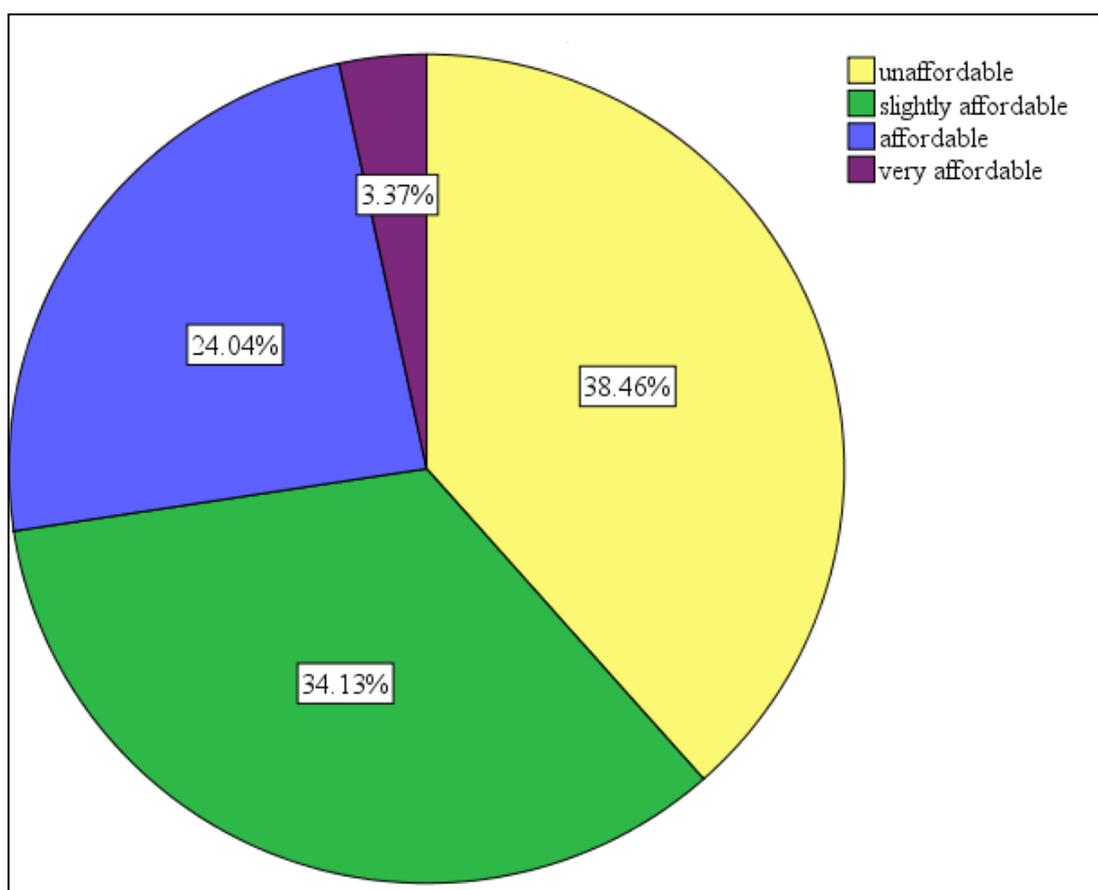


Figure 4. 14: Annual revenues and expenses from 2010 to 2015

Table 4. 7: Summary of collection efficiency and collection days

Year	Total annual revenues(MK)	annual billed revenues(MK)	collection efficiency	Collection Days
2010	2,112,416,610.15	1,889,827,000.00	111.78%	228
2011	2,575,966,418.94	2,153,735,000.00	119.60%	187
2012	3,157,178,409.19	2,657,811,000.00	118.79%	200
2013	4,173,716,933.69	4,434,550,000.00	94.12%	68
2014	7,086,145,874.03	7,010,193,000.00	101.08%	103
2015	7,677,276,633.49	7,677,255,388.00	100.00%	

**Figure 4. 15: Perception of customers on affordability of the water services**

4.3.8 Willingness to pay

Willingness to pay was assessed by use of 210 questionnaires which were administered to customers in three DMA's. The three DMA's Mudi, Nkolokosa and Ndirande were chosen because they are in different zones and are in low density, Medium density and high density respectively. Out of 75 questionnaires to the low density only 15 were responded to and hence the results may be biased to high and medium density population. Only 27.14 % of the population interviewed said they will be willing to pay more than what they are paying now as shown in Figure 4.16. It should be pointed out that the charges in question were presented per 20litre buckets cost while most of the people who have house connections get the bills in m³. It is also noted that the cost water from kiosks is more than what people with connections pay hence the percentage of unwilling to pay population is on the higher side. The average willingness to pay computed using the random utility model is 73%.

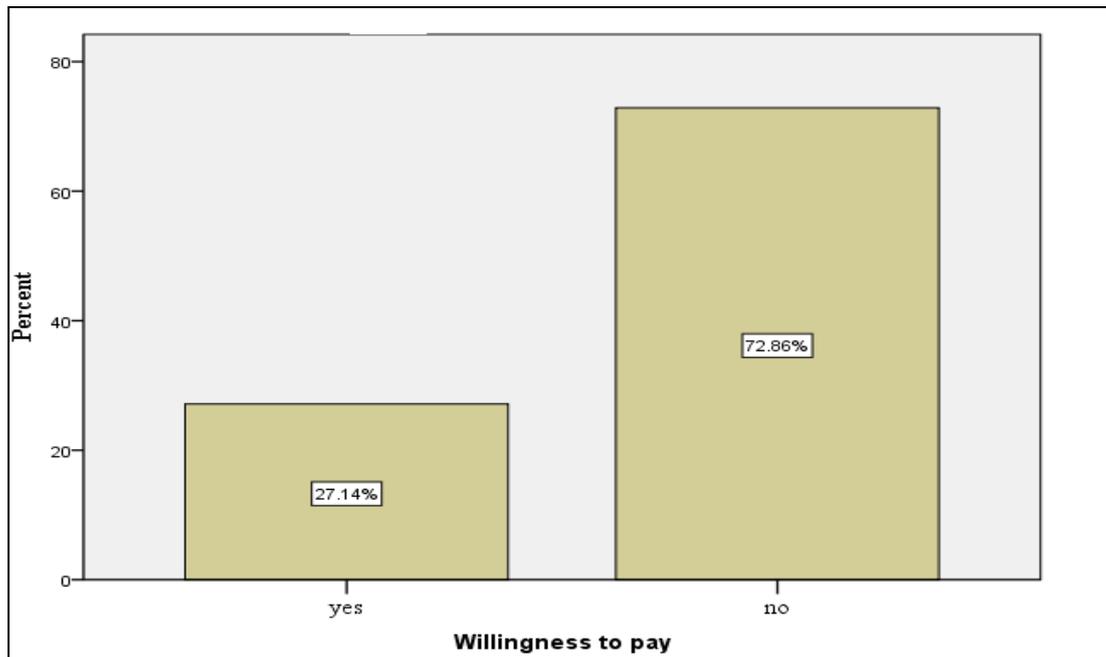


Figure 4. 16: Customers Willingness to pay more for water services

4.3.9 Organizational structure

The Water Resources Act (1969) and the Waterworks Act (1995) provide the regulatory framework for water resources, supply and sanitation in Malawi. Malawi's institutional framework for the water supply sector is centred around the Ministry of Irrigation and Water Development (MIWD), five government-owned Water Boards, and local/rural District Assemblies (DAs).

The Ministry developed a National Water Policy that was approved by the Government of Malawi in August 2005. The policy promotes an integrated approach to water resource management, and a draft Integrated Water Resources Management/Water Efficiency (IWRM/WE) Plan for Malawi was developed in 2007 by MIWD.

Blantyre water board is one of the 5 water boards mandated by the Malawi water Works Act No 17 of 1995 to supply potable water for commercial, industrial, institutional and domestic use in the supply area of Blantyre City and surrounding areas. The Board operates as a statutory body and it is funded through revenues collected as well as transfers from Government agency. A statutory body operates as an autonomous agency but still functions under public law (Schwartz, 2007).

The partial organizational structure is as shown in Figure 4.17, the board of directors appointed by the Office of the President and Cabinet (OPC) governs the organization. And the executive management comprises of Chief executive and three department headed by directors namely; Director of Distribution and commerce, Director of Technical services and Director of Finance and administration. Below these there are the managers and then middle managers. Reporting lines are from top to bottom as it is an autocratic system.

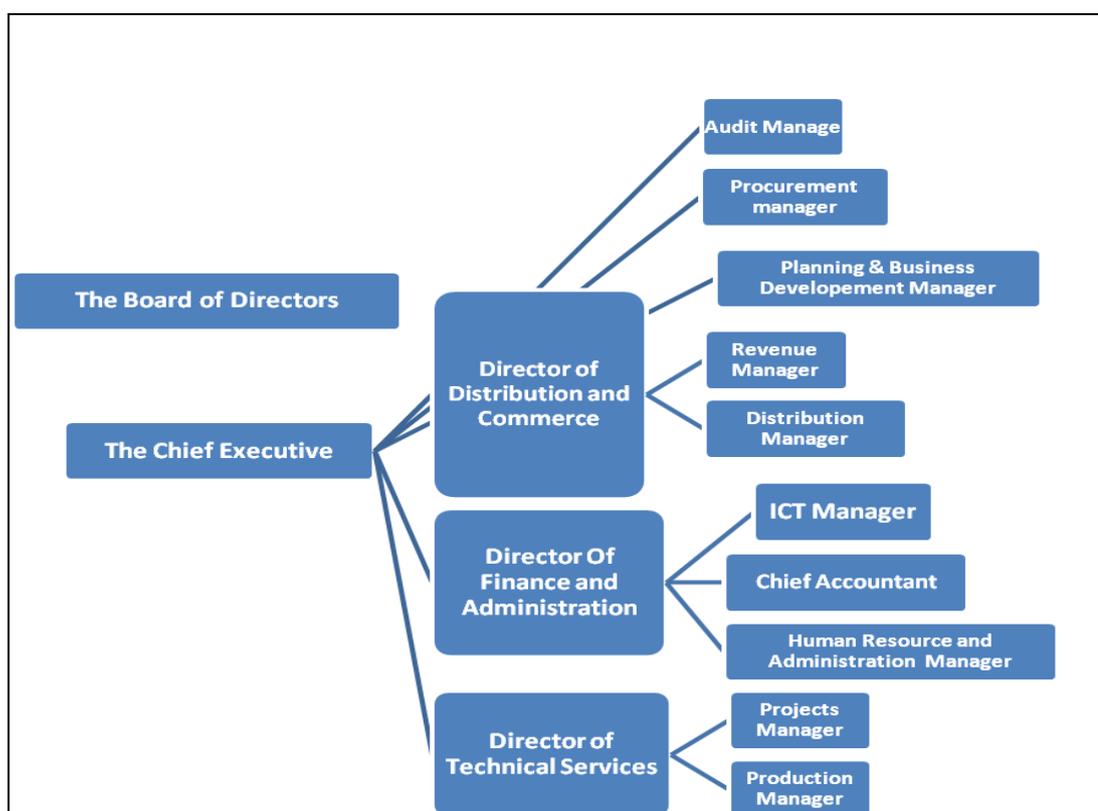


Figure 4. 17: Partial organization structure for BWWB adopted from human resources department (This study, 2016)

4.3.9.1 SWOT analysis

<p>Strengths</p> <ul style="list-style-type: none"> ➤ The public sector has control over an essential service ➤ The autonomous status provides the utility with beneficial autonomy ➤ Water supply coverage is high within the formal settlements of the city 	<p>Weaknesses</p> <ul style="list-style-type: none"> ➤ The actual autonomy of the utility is limited ➤ High non-revenue water ➤ Low water coverage area ➤ Poor coordination and communication within the utility and with external stakeholders.
<p>Opportunities</p> <ul style="list-style-type: none"> ➤ Growing customer base ➤ Existence of training opportunities for capacity building ➤ Plans for additional water source are underway 	<p>Threats</p> <ul style="list-style-type: none"> ➤ Increasing operation and maintenance costs ➤ Outstanding /non-payment of water bills by some customers including government institutions ➤ Illegal use of water supply by some residents increasing NRW

Sustainability Index

Sustainability of the water utility was assessed looking at 5 components Environment, social, economic, political and institutional. Tables in appendix c shows all attributes for the social, environment, economic, institutional, political and aggregation to the final figures indicated and some of the indicators used are as presented in the first objective. According to the results in this research the water utility's overall sustainability in 2010 and 2015 was 81% and 84%, respectively. Looking at the sustainability components separately the results are as shown in Table 4.8 and Figure 4.18. The Utility is sustainable according to the results and its sustainability is well established in the Environmental, institutional and political dimensions and there is need to improve the social and economic dimensions. The areas of great concern are non-revenue water and collection efficiency for economic aspect and the complaints redressal efficiency in the social aspect.

Table 4. 8: Sustainability index results

Component	Year 2015	Year 2010
Social	77%	70%
Environmental	81%	78%
Economic	79%	73%
Institutional	92%	92%
Political	92%	92%
Total	84%	81%

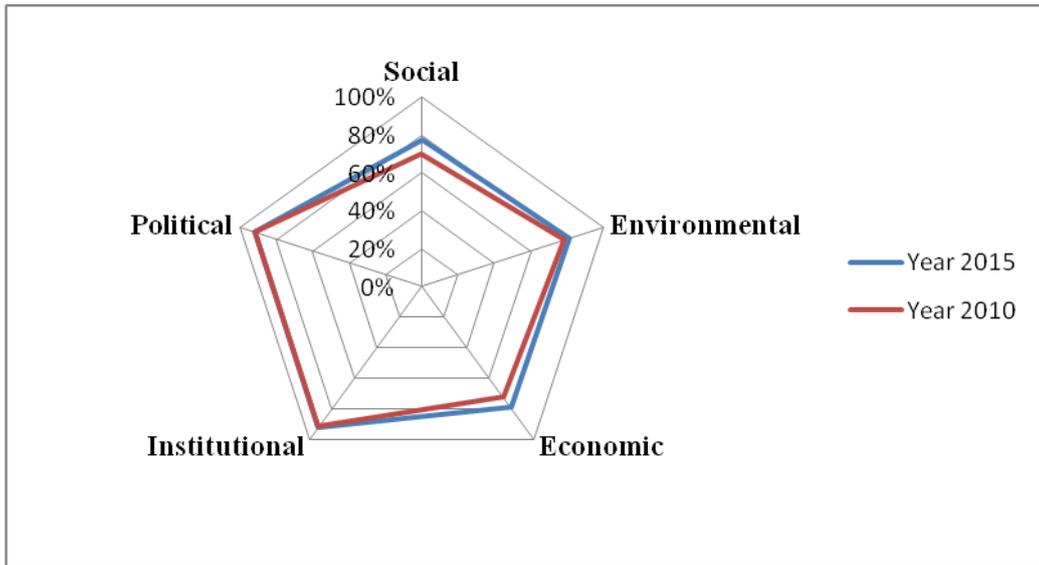


Figure 4.18: Sustainability index Results graph

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From this study the following conclusions can be drawn:

- (i). The projects executed by the water utility from 2010 to 2016 were successful in terms of infrastructure quality index as it improved from 3.5 to 3.7 and accessibility index. However, the infrastructure efficiency is still low 2.26 to 2.22 which is attributed to NRW and affordability index is also constant at 2.9 the cost of water keeps increasing with the depreciation of the currency. Therefore the service level of the water utility improved slightly in the infrastructure quality and accessibility dimension and not the infrastructure efficiency and affordability dimensions.
- (ii). The sustainability of the water utility increased from 81% to 84% and the water utility's sustainability is well established in the Institutional, Political and environmental dimensions. Social and economic dimensions increased within the project but there is still need for further improvement.

5.2 Recommendations

- (i). There is need to source funds for improvement of the distribution system in order to reduce non-revenue water percentage and some of the activities to be carried out are ; conduct water balancing in all DMA's to determine which areas need urgent attention and then; replace pipelines, replace meters, uproot illegal connection, updating customer data base e.t.c.
- (ii). It is recommended that the water utility adopts the water demand management strategies to ensure that the available resources are well utilized instead of investing in new water sources that may also face the same infrastructure efficiency challenges.
- (iii). Further studies should be done to assess the customer meters age and age of pipelines so as to update this data in the system and the meter replacement program should follow that pattern.
- (iv). Enhance coordination between the sections and efficient information transfer so that the customer data is well updated and all the new connections are billed and revenues are collected.

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APPENDICES

Appendix A: Water Utility Information

Questionnaire to the water Utility

Questions to the Water Utility

Water Quantity

What is the total number of customers served by Blantyre Water Board (before and after rehabilitation)?

2010-2011	<input type="text"/>	2011-2012	<input type="text"/>
2012-2013	<input type="text"/>	2013-2014	<input type="text"/>
2015 December	<input type="text"/>		

How many connections are there within the service area (before and after rehabilitation)?

.....

How many connections within the service area are metered?

.....

How many connections are billed every month?

.....

What were the monthly billed consumption for the years 2009 and 2015 (i.e. before the rehabilitation and after rehabilitation)?

.....

What were the production figures for the years 2010 to 2015?

.....

What was the capacity of the Water treatment plant before and after rehabilitation?

.....

What is the total yield that the water source is capable of producing?

.....

Water Quality

What are the water quality results in terms of turbidity, Ph, residual Chlorine from the sampling points and the treatment plant before and after rehabilitation?

.....

Customer service

What is the total number of complaints received per month (before and after rehabilitation)?

.....

What is the total number of complaints redressed within a month?

.....

What is the target response time to faults?

.....

What is the actual response time to faults?

.....

What are the outage durations per month before and after rehabilitation?

.....

What is the recommended pressure in the distribution system?

.....

Accounts

What was the investment cost for the recent projects Capacity increase and rehabilitation of Walkers Ferry and Chileka?

.....

What was the tariff setting before and after rehabilitation?

.....

What are the total annual revenue collections for the years 2010 to 2015?

2010	<input type="text"/>	2011	<input type="text"/>	2012	<input type="text"/>
2013	<input type="text"/>	2014	<input type="text"/>	2015	<input type="text"/>

.....

What are the total annual Operation expenses (e.g. electricity cost, chemical, staff/outsourcing) for the years 2009 and 2015?

Electricity

2010	<input type="text"/>	2011	<input type="text"/>	2012	<input type="text"/>
2013	<input type="text"/>	2014	<input type="text"/>	2015	<input type="text"/>

What is the collection period for the revenues for the period 2010 to 2015?

.....

Did the project provide for spare parts for the rehabilitated water supply system?

.....

Human Resource

What is the total number of employees for the years 2010-2015?

2010	<input type="text"/>	2011	<input type="text"/>	2012	<input type="text"/>
2013	<input type="text"/>	2014	<input type="text"/>	2015	<input type="text"/>

Did the recent project provide for training for the operation and maintenance of the rehabilitated system?

.....

What other trainings are provided for capacity building?

.....

What is the organization structure of Blantyre Water board?

Direct public utility government owned

Statutory body joint venture

How is BWB financed?

(a) Revenue generated from sales (b) transfers from government agencies (c) Both a and b

How are the policies and procedures of the organization formulated?

.....

On a scale from 0 to 1 how can you rate the corruption rate by the water utilities employees?

Table 1: Pressure results for Mbayani area

	1/6/2016	1/7/2016	1/8/2016	1/9/2016	1/10/2016	1/11/2016	1/12/2016
0:00		0.877	0.873	0.873	0.877	0.877	0.877
1:00		0.877	0.877	0.877	0.877	0.877	0.877
2:00		0.877	0.877	0.873	0.877	0.877	0.877
3:00		0.877	0.873	0.877	0.877	0.877	0.877
4:00		0.877	0.873	0.877	0.877	0.877	0.88
5:00		0.877	0.877	0.877	0.877	0.877	0.88
6:00		0.877	0.877	0.877	0.877	0.877	0.877
7:00		0.88	0.877	0.88	0.877	0.877	0.877
8:00		0.877	0.877	0.873	0.877	0.88	0.877
9:00		0.877	0.873	0.877	0.877	0.88	0.877
10:00		0.873	0.873	0.877	0.873	0.877	0.877
11:00		0.877	0.873	0.877	0.877	0.88	0.877
12:00	0.94	0.873	0.877	0.877	0.877	0.877	0.877
13:00	0.93	0.877	0.877	0.873	0.873	0.877	0.877
14:00	0.917	0.873	0.867	0.87	0.877	0.877	0.873
15:00	0.907	0.873	0.873	0.873	0.873	0.877	0.873
16:00	0.86	0.877	0.873	0.873	0.877	0.877	0.873
17:00	0.873	0.873	0.873	0.873	0.873	0.877	0.873
18:00	0.873	0.87	0.873	0.87	0.877	0.877	0.877
19:00	0.873	0.873	0.873	0.877	0.877	0.877	0.877
20:00	0.873	0.873	0.877	0.873	0.877	0.873	0.877
21:00	0.873	0.877	0.877	0.877	0.877	0.873	0.873
22:00	0.877	0.877	0.877	0.877	0.877	0.877	0.877
23:00	0.873	0.877	0.877	0.877	0.877	0.877	0.877

Table 2: Pressure results from Sunnyside.

Time	28-Jan-16	29-Jan-16	30-Jan-16	31-Jan-16	1-Feb-16	2-Feb-16
0:00	3.051	2.981	3.539	3.638	3.504	3.211
1:00	3.113	2.861	3.591	3.675	3.594	3.184
2:00	3.106	2.888	3.606	3.684	3.612	3.180
3:00	3.148	2.850	3.611	3.668	3.578	3.157
4:00	3.076	2.784	3.534	3.615	3.482	3.055
5:00	2.311	2.104	3.195	3.250	3.091	2.533
6:00	1.810	1.707	2.712	2.654	2.458	2.008
7:00	1.855	1.604	2.485	2.369	2.226	1.935
8:00	1.726	1.690	2.231	2.471	2.066	1.861
9:00	2.132	1.570	2.471	2.426	2.137	1.777
10:00	2.413	1.594	2.594	2.396	2.042	2.090
11:00	2.511	1.562	2.735	2.746	2.124	2.174
12:00	2.386	1.389	2.727	2.807	1.985	2.394
13:00	2.374	1.170	2.771	2.812	2.153	2.299
14:00	2.411	1.160	2.750	2.855	2.271	2.414
15:00	2.321	1.587	2.736	2.993	2.334	2.460
16:00	2.236	1.950	2.630	2.938	2.292	2.305
17:00	2.248	2.325	2.807	3.060	2.462	2.351
18:00	2.327	2.504	2.834	3.053	2.495	2.525
19:00	2.445	2.567	2.978	3.115	2.540	2.569
20:00	2.501	2.915	3.149	3.155	2.606	2.796
21:00	2.678	3.173	3.336	3.347	2.781	2.913
22:00	2.615	3.294	3.525	3.447	3.064	3.174
23:00	2.778	3.411	3.575	3.514	3.162	3.271

Table 3: Pressure results from Chichiri Prison

Time	26-Jan-16	27-Jan-16	28-Jan-16	29-Jan-16	30-Jan-16	31-Jan-16
0:00	0	1.080	0.923	0.794	0.925	1.427
1:00	0	0.998	0.903	0.796	0.992	1.868
2:00	0	0.920	0.843	0.795	0.992	1.948
3:00	0	0.988	0.868	0.919	1.164	1.972
4:00	0	1.116	0.877	1.099	1.003	2.035
5:00	0	0.963	0.983	1.321	1.010	2.083
6:00	0	1.101	1.066	1.547	1.326	2.152
7:00	0	1.466	1.198	1.854	1.694	2.286
8:00	0	1.946	1.425	1.887	1.904	2.390
9:00	0	2.027	1.313	1.908	1.971	2.449
10:00	0	2.040	1.492	1.999	2.156	2.492
11:00	0	2.224	2.027	2.139	2.331	2.571
12:00	0	2.469	2.283	2.245	2.471	2.651
13:00	2.565	2.610	2.438	2.427	2.634	2.784
14:00	2.653	2.745	2.504	2.589	2.742	2.856
15:00	2.744	2.844	2.533	2.693	2.845	2.901
16:00	2.792	2.863	2.617	2.817	2.862	2.926
17:00	2.789	2.857	2.671	2.854	2.840	2.913
18:00	2.600	2.781	2.554	2.962	2.753	2.768
19:00	1.841	2.021	1.804	2.482	2.241	2.433
20:00	0.927	0.951	0.823	1.900	1.838	1.870
21:00	0.782	0.781	0.784	1.294	1.135	0.893
22:00	0.787	0.785	0.788	0.931	1.141	0.793
23:00	0.791	0.786	0.791	0.822	1.068	0.783

Table 5: Complaints logged and redressed

Complaints	logged	resolved	outstanding
Jul-15			
no water	45	22	23
high bill	47	19	28
broken pipe	55	27	28
leaking meter	25	17	8
not getting bills	130	97	33
Total	302	182	120
	60.26%		
Complaints	logged	resolved	outstanding
Aug-15			
no water	71	7	64
high bill	162	46	116
broken pipe	59	2	57
leaking meter	25	12	13
not getting bills	53	3	50
Total	370	70	300
	19%		
Complaints	logged	resolved	outstanding
Sep-15			
no water	71	66	5
high bill	101	38	63
broken pipe	93	75	18
leaking meter	27	14	13
not getting bills	98	7	91
Total	390	200	190
	51%		
Complaints	logged	resolved	outstanding
Oct-15			
no water	89	69	20
high bill	163	92	71
broken pipe	70	61	9
leaking meter	27	18	9
not getting bills	100	70	30
Total	449	310	139
	69%		
Complaints	logged	resolved	outstanding
Dec-15			
no water	48	42	6
high bill	116	62	54
broken pipe	28	26	2
leaking meter	10	8	2
not getting bills	141	51	90
Total	343	189	154
	55%		
Complaints	logged	resolved	outstanding
Jan-16			
no water	20	17	3

high bill	67	23	44
broken pipe	33	22	11
leaking meter	9	7	2
not getting bills	77	26	51
Total	206	95	111
	46%		

Table 6: Production figures and sales from 2008 to 2015

Description	Production (m³)	Gross Sales (m³)	NRW m³	NRW as a percentage
Jan-08	2,366,948	1,446,711	920,237	38.88%
Feb-08	2,389,559	1,335,473	1,054,086	44.11%
Mar-08	2,561,185	1,438,305	1,122,880	43.84%
Apr-08	2,499,946	1,306,522	1,193,424	47.74%
May-08	2,538,727	1,456,398	1,082,329	42.63%
Jun-08	2,397,363	1,456,398	940,965	39.25%
Jul-08	2,529,755	1,012,873	1,516,882	59.96%
Aug-08	2,602,009	1,349,831	1,252,178	48.12%
Sep-08	2,514,029	1,303,156	1,210,873	48.16%
Oct-08	2,635,609	1,641,423	994,186	37.72%
Nov-08	2,436,221	1,405,967	1,030,254	42.29%
Dec-08	2,555,181	1,297,695	1,257,486	49.21%
Jan-09	2,383,864	1,146,913	1,236,951	51.89%
Feb-09	2,175,703	1,122,212	1,053,491	48.42%
Mar-09	2,367,993	1,052,717	1,315,276	55.54%
Apr-09	2,544,408	1,146,699	1,397,709	54.93%
May-09	2,661,953	1,221,439	1,440,514	54.11%
Jun-09	2,464,988	1,224,852	1,240,136	50.31%
Jul-09	2,577,788	1,278,370	1,299,418	50.41%
Aug-09	2,626,108	1,256,796	1,369,312	52.14%
Sep-09	2,493,660	1,641,340	852,320	34.18%
Oct-09	2,556,851	1,304,655	1,252,196	48.97%
Nov-09	2,268,867	1,361,463	907,404	39.99%
Dec-09	2,496,268	1,150,824	1,345,444	53.90%
Jan-10	2,569,936	1,252,043	1,317,893	51.28%
Feb-10	2,309,636	1,285,275	1,024,361	44.35%
Mar-10	2,497,532	1,209,248	1,288,284	51.58%
Apr-10	2,498,826	1,336,563	1,162,263	46.51%
May-10	2,954,963	1,115,108	1,839,855	62.26%
Jun-10	2,545,475	1,269,325	1,276,150	50.13%
Jul-10	2,627,449	1,446,342	1,181,107	44.95%
Aug-10	2,617,231	1,521,602	1,095,629	41.86%

Sep-10	2,569,933	1,471,118	1,098,815	42.76%
Oct-10	2,697,026	1,474,119	1,222,907	45.34%
Nov-10	2,446,863	1,434,186	1,012,677	41.39%
Dec-10	2,610,921	1,302,852	1,308,069	50.10%
Jan-11	2,441,717	1,296,384	1,145,333	46.91%
Feb-11	2,363,305	1,293,563	1,069,742	45.26%
Mar-11	2,655,649	1,281,466	1,374,183	51.75%
Apr-11	2,518,663	1,238,337	1,280,326	50.83%
May-11	2,655,365	1,283,325	1,372,040	51.67%
Jun-11	2,710,186	1,315,259	1,394,927	51.47%
Jul-11	2,490,409	1,374,949	1,115,460	44.79%
Aug-11	2,633,386	1,352,466	1,280,920	48.64%
Sep-11	2,702,757	1,401,457	1,301,300	48.15%
Oct-11	2,554,254	1,381,263	1,172,991	45.92%
Nov-11	2,440,121	1,193,766	1,246,355	51.08%
Dec-11	2,392,946	1,369,448	1,023,498	42.77%
Jan-12	2,535,173	1,394,483	1,140,690	44.99%
Feb-12	2,440,451	1,183,948	1,256,503	51.49%
Mar-12	2,561,340	1,327,378	1,233,962	48.18%
Apr-12	2,353,733	1,298,735	1,054,998	44.82%
May-12	2,604,780	1,285,372	1,319,409	50.65%
Jun-12	2,485,973	1,554,014	931,959	37.49%
Jul-12	2,503,098	1,466,325	1,036,773	41.42%
Aug-12	2,544,206	1,419,491	1,124,715	44.21%
Sep-12	2,421,577	1,460,723	960,855	39.68%
Oct-12	2,488,122	1,415,231	1,072,891	43.12%
Nov-12	2,397,914	1,627,694	770,220	32.12%
Dec-12	2,361,832	1,428,771	933,061	39.51%
Jan-13	2,132,047	1,304,470	827,577	38.82%
Feb-13	2,025,568	1,169,209	856,359	42.28%
Mar-13	2,327,319	1,253,041	1,074,278	46.16%
Apr-13	2,327,319	1,174,594	1,152,725	49.53%
May-13	2,415,479	1,244,557	1,170,922	48.48%
Jun-13	2,404,377	1,303,135	1,101,242	45.80%
Jul-13	2,027,305	1,181,022	846,283	41.74%
Aug-13	2,101,904	1,242,555	859,349	40.88%
Sep-13	2,101,904	1,306,447	795,457	37.84%
Oct-13	2,044,318	1,271,458	772,860	37.81%
Nov-13	2,348,871	1,458,778	890,093	37.89%
Dec-13	2,044,024	1,302,490	741,534	36.28%
Jan-14	1,913,570	1,194,268	719,302	37.59%
Feb-14	1,792,805	1,104,449	688,356	38.40%

Mar-14	1,798,664	1,171,695	626,969	34.86%
Apr-14	1,780,531	1,129,531	651,000	36.56%
May-14	1,745,876	1,076,000	669,876	38.37%
Jun-14	1,751,722	1,135,508	616,214	35.18%
Jul-14	1,886,465	1,292,970	593,494	31.46%
Aug-14	1,902,763	1,243,215	659,548	34.66%
Sep-14	1,896,958	1,256,271	640,687	33.77%
Oct-14	1,713,408	1,149,092	564,316	32.94%
Nov-14	1,682,796	1,102,492	580,304	34.48%
Dec-14	1,516,530	1,042,952	473,578	31.23%
Jan-15	1,459,823	1,021,887	437,936	30.00%
Feb-15	1,922,713	852,125	1,070,588	55.68%
Mar-15	1,994,365	1,164,140	830,225	41.63%
Apr-15	1,904,248	1,272,451	631,797	33.18%
May-15	2,177,207	863,748	1,313,459	60.33%
Jun-15	2,107,141	851,996	1,255,145	59.57%
Jul-15	2,175,157	912,879	1,262,278	58.03%
Aug-15	2,152,966	958,419	1,194,547	55.48%
Sep-15	2,065,325	1,483,476	581,849	28.17%
Oct-15	2,212,360	1,631,864	580,496	26.24%
Nov-15	2,603,312	1,185,254	1,418,058	54.47%
Dec-15	2,612,165	1,204,951	1,407,214	53.87%

Table 7: Number of customers

Number of customers from 2010 to 2015			
year	number of customers	number of staff	staff per 1000 connections
2010-2011	34,468	554	16.07
2011-2012	35,834	555	15.49
2012-2013	37,421	522	13.95
2013-2014	38,764	491	12.67
2014-2015	39,726	475	11.96
2015-2016	41,794	525	12.56

Appendix B: Data from customers

Questionnaire to customers

Questionnaire for Determining Customers Willingness to Pay for Water Supply from Blantyre Water Board

We would like to know your satisfaction level and willingness to pay for the water services provided by Blantyre Water Board.

Questions to the Water users/Customers

1. Household Characteristics

(i). Sex of the respondent. Male Female

(ii). Number of people in the household

(iii). Number of adults in the house

(iv). Number of children under 5 years

(v). How long does it take to reach the water source /what is the distance to the nearest source

(vi). Monthly income or worth(MK)

5000-10000 10000-50000 50000-Above

(vii). Level of education (for this question tick where appropriate)

Primary school

Secondary school

Vocational training

College

University

2. Water use

(i). What is the daily/monthly consumption for your household.

litres m³

(ii). What is the daily consumption per person?

litres m³

(iii).Do you have a household water connection?

Yes No

(iv).If the answer to (iii) is no what source of water do you use?

Borehole kiosk vendors river

(v). How often do you get water supply from Blantyre Water Board?

daily weekly monthly

3. Willingness to pay

(i).How would you rate the water charges by Blantyre Water Board?

Unaffordable cheap

Affordable expensive

(ii).If a bucket of 20litres is sold at MK 30 would you be willing to pay?

Yes No

4. Service level

Could you express how satisfied you are with the ways the utility handles the following water service issues? (For this question tick where appropriate)

	Strongly Dissatisfied	Somewhat Dissatisfied	Neither Satisfied nor Dissatisfied	somewhat Satisfied	Strongly Satisfied
Water pressure					
Water quality					
Water restrictions					
Water interruptions					
Handling of queries					
No water complaints					

Table 8:Customer data summary from SPSS

Demographics and Socio economics	Overall(n=210)
% male	29.5
% female	70.5
Family size	4.8
% have children	87.5
% have university qualification	13.33
% college qualification	28.1
% vocational training	1.9
% secondary education	36.67
% with individual connection	69.38
% income <= MK 10,000	10
% income between MK10,000 and MK50,000	32.4
% income between above MK50,000	57.6
% using water Kiosks	29.62
% using boreholes	1

Appendix C: Sustainability Calculation Results

Table 9: Results for the sustainability calculations for the year 2015

Socio-	Ranking	Wt	Rec	result	normalized	Score	Total	PERCENTA
Coverage	1	0.5	100	85	0.85	0.43	0.5	
Continuity of water supply	2	0.33	24	19	0.791667	0.26	0.33	
Complaints redressal efficienc	3	0.17	100	51	0.51	0.09	0.17	
						0.77	1	77%
environmental								
water quality	1	0.5	100	100	1	0.50	0.5	
conservation masures	3	0.17	100	65	0.65	0.11	0.17	
per capita supply of water	2	0.33	150	90	0.6	0.20	0.33	
						0.81	1	81%
Economic								
Cost recovery	2	0.16	100	100	1	0.16	0.16	
Collection efficiency	6	0.09	100	100	1	0.09	0.09	
collection days	3	0.15	90	103	0.87	0.13	0.15	
Extent of metering	4	0.13	100	100	1	0.13	0.13	
Extent of NRW	1	0.18	23	56	0.44	0.08	0.18	
affordability	5	0.11	100	61.64	0.62	0.07	0.11	
willingness to pay	7	0.07	100	73	0.73	0.05	0.07	
Sources of investment	8	0.05	100	70	0.7	0.04	0.05	
income levels	9	0.04	100	73	0.73	0.03	0.04	
% of people with secondary ec	10	0.02	100	80	0.8	0.02	0.02	
						0.79	1	79%
Institutional								
staff per 1000 connections	3	0.2	5	12	0.92	0.18	0.2	
Adoption of IWRM	1	0.4	100	90	0.9	0.36	0.4	
Corresponding education leve	2	0.3	100	100	1	0.30	0.3	
spares availability	4	0.1	100	80	0.8	0.08	0.1	
						0.92	1	92%
Political								
Measure of corruption	3	0.17	100	70	0.7	0.12	0.17	
Defined roles and responsibilit	1	0.5	100	100	1	0.50	0.5	
Compliance with policy	2	0.33	100	90	0.9	0.30	0.33	
						0.92	1	92%
						overall sustainability		84%

Table 10: Results for the sustainability calculations for the year 2010

Socio-	Ranking	Wt	Rec	result	normalized	Score	Total	PERCENTAGE
Coverage	1	0.5	100	75	0.75	0.38	0.5	
Continuity of water supply	2	0.33	24	17	0.708333	0.23	0.33	
Complaints redressal efficiency	3	0.17	100	51	0.51	0.09	0.17	
						0.70	1	70%
environment								
water quality	1	0.5	100	100	1	0.50	0.5	
conservation measures	3	0.17	100	50	0.5	0.09	0.17	
per capita supply of water	2	0.33	150	90	0.6	0.20	0.33	
						0.78	1	78%
Economic								
Cost recovery	2	0.16	100	98	0.98	0.16	0.16	
Collection efficiency	6	0.09	100	100	1.00	0.09	0.09	
collection days	3	0.15	90	228	0.39	0.06	0.15	
Extent of metering	4	0.13	100	100	1.00	0.13	0.13	
Extent of NRW	1	0.18	23	47	0.52	0.09	0.18	
affordability	5	0.11	100	61.64	0.62	0.07	0.11	
willingness to pay	7	0.07	100	73	0.73	0.05	0.07	
Sources of investment	8	0.05	100	70	0.70	0.04	0.05	
income levels	9	0.04	100	70	0.70	0.03	0.04	
% of people with secondary education	10	0.02	100	80	0.80	0.02	0.02	
						0.73	1	73%
Institutional								
staff per 1000 connections	3	0.2	5	16	0.88	0.18	0.2	
Adoption of IWRM	1	0.4	100	90	0.9	0.36	0.4	
Corresponding education level	2	0.3	100	100	1	0.30	0.3	
spares availability	4	0.1	100	80	0.8	0.08	0.1	
						0.92	1	92%
Political								
Measure of corruption	3	0.17	100	70	0.7	0.12	0.17	
Defined roles and responsibilities	1	0.5	100	100	1	0.50	0.5	
Compliance with policy	2	0.33	100	90	0.9	0.30	0.33	
						0.92	1	92%

Appendix D: Photos



Figure 1: New clear water pumps at Walkers Ferry

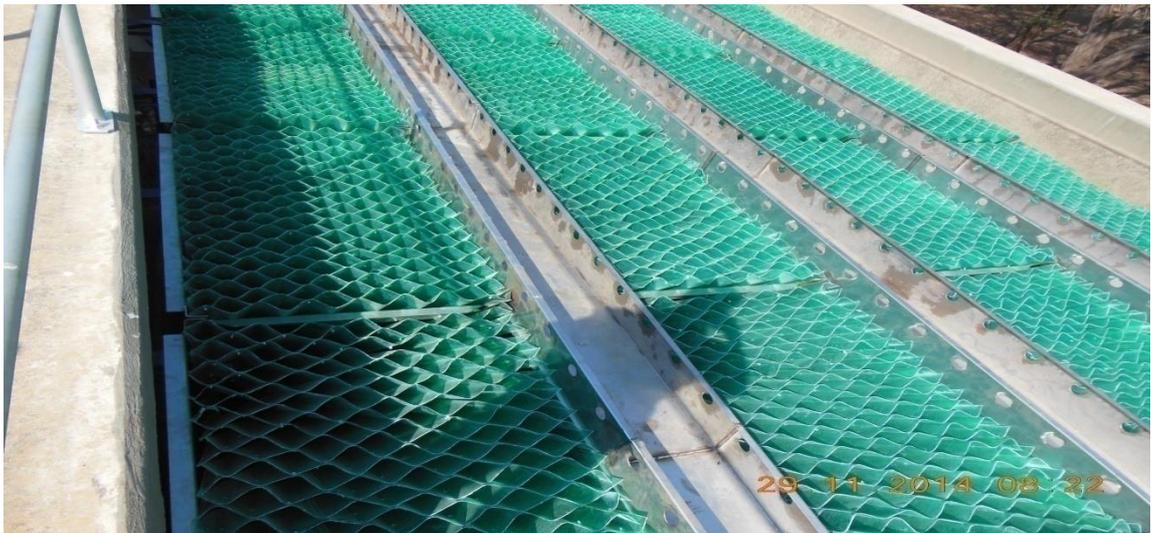


Figure 2: Lamella Tubes Installed in the Pre-settling Tanks at Walkers Ferry Treatment Plant



Figure 3: Pressure logger installed on customer meter to measure pressure for 7 days.