DETERMINANTS OF NON-REVENUE WATER (NRW) ON TANZANIA WATER UTILITY: A CASE OF MBEYA WATER SUPPLY AND SANITATION AUTHORITY

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CERTIFICATION

The undersigned certified that he has read and hereby recommends for acceptance by the Open University of Tanzania as research titled: "***Determinants of Non-Revenue Water (NRW) on Tanzania Water Utility: A Case of Mbeya Water Supply and Sanitation Authority*****"** in partial fulfilment of the requirements for the Masters of Project Management (MPM) of the Open University of Tanzania.

……

Dr. Raphael Gwahula

(Supervisor)

……..……

Date

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DECLARATION

I, **Leonidas Deogratias Bernado,** do hereby declare that this dissertation is my own original work and that it has not been and will not be submitted to any other University for the similar or any other degree award.

…….

Signature

……

Date

DEDICATION

I dedicate this study to my mom and daddy who made sure I get education against all odds.

ACKNOWLEDGEMENT

I acknowledge my supervisor, Dr. Rafael Gwahula his guidance during the writing of this dissertation. If it was not for his guidance, this work could not have come to its fruition. To my lovely family I thank you for your tolerance on my absence during the period of study. I also acknowledge teachers and heads of studied of the Open University of Tanzania for participating in this study.

ABSTRACT

This study was conducted to examine determinants of Non-Revenue Water (NRW) in Mbeya water utilities. The study comprised three objectives; to assess the cut into which unbilled authorized consumption influence NRW in Mbeya water utilities; to evaluate the influence of billing system errors and technical errors on NRW in Mbeya water utilities; and to establish how social dynamics influences Non-Revenue in Mbeya water utilities. The study was guided by cross-sectional design to collect data from 137 respondents. Random sampling was adopted to select respondents and questionnaire was employed as a tool for data collection. Data analysis was performed in a quantitative and qualitative manner using descriptive statistics and thematic analysis respectively. Findings of the study revealed that, the influence of unbilled authorized consumption on NRW was high. Besides, linear relationship exists between metered, unmetered unbilled authorized consumption and level of NRW. Study findings also revealed that, billing system errors has high influence on NRW. Four technical errors influencing NRW were identified namely, age of infrastructure, leakages, bursts, and metering inaccuracy. Further, results indicated that, social dynamics factors, which influenced NRW, include water theft, corruption, high water tariffs, and intermittent water supply. Multiple linear regression analysis revealed that, unbilled authorized consumption, billing system and technical errors, and social dynamics factors have significant relationship with level of NRW. These determinants explain 19% increase of the level of NRW. The study recommends that, in order to reduce unbilled authorized consumption, installation of standard meter design should be conducted align with repair of meter registration inaccuracies. Also, regular maintenance should be carried out to ensure efficient working condition of water infrastructures.

Keywords: Non-Revenue Water, Authorized Consumption and Water Loss

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LIST OF ABBREVIATIONS AND ACRONYMS

AUWSA	Arusha Urban Water Supply and Sewerage Authority
EWURA	Energy and Water Regulatory Authority
FY	Financial Year
Mbeya WSSA	Mbeya Water Supply and Sanitation Authority
NRW	Non-Revenue Water
UWF	Unaccounted for Water loss

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

One of the major challenges faced by water utilities in the developing world is the considerable difference between the amount of water put into the distribution system and the amount of water billed to consumers (also called "non-revenue water" [NRW]) (Tabesh *et al*., 2020). Each year more than 32 billion m^3 of treated water does not reach subscribers due to numerous failures such as leaks, faulty connections or piping. The difference between water volume that enters the distribution system and the volume, which is charged to consumers, is usually referred to as non-revenue water (NRW) (Liemberger & Wyatt, 2019).

An audit report carried out on some 20 water companies in Africa by a mission of African experts reveals that unbilled water represents one third of the total volume of water produced. In some African low-income countries, losses account for 50-60% of the water supplied when the global average is 35%. This high rate of non-revenue water leads to significant reduction of water provision to the non-connected part of the population, and significantly impacts water utilities' financial sustainability due to losses in revenue and increased operating costs. NRW reduces the ability to fund service expansion, especially provision to the poor (Boztaş *et al*., 2019).

It has become increasingly important to better manage NRW and secure critical resources for water. Management of NRW helps utilities to extend and enhance operation, improve financial efficiency, improve urban attractiveness, increase climate

resiliency and decrease energy usage (Al-Washali *et al*., 2019). NRW management also provides superior cost efficiency in a water-constricting setting relative to supply augmentation. Meanwhile, saved water revenues boost the bottom line of a service provider while the lower water abstraction improves city resilience (Ananda, 2019). However, the advantages of reducing NRW are yet to be transforming powers in developed countries to tackle the endemic problem. While foreign and industrial organizations have given priority on decades of training and advocacy, NRW's reduction is still scarcely addressed by the utility organisations (Ociepa *et al*., 2019).

Non-revenue water (NRW) in the past years was termed as accounted for water loss (UFW) and had been widely used interchangeably (IWA 2000). Now NRW means unauthorized consumption and metering inaccuracies, which can cause leakages from transmission, distribution mains, storage tanks or/and through reticulation system up to the point of metering (IWA 2000).

Tanzania, like many other developing countries, has an intensive 33% of NRW in its water utilities. This percentage is higher than the standard amount (20%) as recommended by Energy and Water Regulatory Authority (EWURA) (Ingram & Memon, 2020). Presence of higher percentage of NRW does not only affecting financial performance of the utility, but also affects water quality produced and supplied to the consumers which in end might cause problem to human health (Josephat, 2015).

Various studies have been conducted to examine the determinants of NRW in Tanzania. For instance, Nzilano (2017) investigated factors influencing Mbeya WSSA

as one of the water utilities in Tanzania. Baasha (2013) investigated factors influencing NRW in Arusha water authority. Also, Celsus (2013) conducted a study on factors influencing water supplies in Webuye water supply scheme. However, very little is known regarding the influence of billing system error, technical error, and social dynamics on NRW. Present study therefore aims at filling this gap by assessing the aforementioned aspects, specifically in Mbeya water utility.

1.2 Statement of the Problem

A simple and clear definition of NRW is the difference between the amounts of water supplied/produced by an authority and amount of water billed to the intended consumers, this different termed as a loss to the authority. The amount (Magnitude) of the loss and causes differ from one water authority to another. One of the major challenges facing Tanzania water utilities is to attain service level benchmark for NRW 20% as directed by EWURA performance benchmarking report (2018). As per EWURA annual water regional report 2017/2018, there is slightly improvement of NRW reduction from 41.6% FY 2015/2016 to 40.5% FY 2017/2018 which is higher than the recommended standard (20%). This shows that the NRW value attained by most Tanzania water utility is still higher, extensive efforts are required to rescue the situation.

Mbeya WSSA, like other water utilities in the country, has also been facing significant non-revenue water. The authority has managed to reduce NRW from 38% in 2012 to 30.1% in 2019, which is still higher than the recommended EWURA standard of 20%. This higher percentage of NRW does not only impact fulfilment of EWURA's standards but also affect internal financial performance of the authority (30% less

collection). It also affects water quality delivery to the consumers, which in end might cause health impacts through water borne diseases to the final water consumers. This study thus investigates the determinants of NRW in a selected water networks managed by Mbeya WSSA. Specific it looked onto influence of unbilled authorized consumption, billing system error, and social dynamics on NRW.

1.3 Research Objectives

1.3.1 General Research Objective

General objective of this study is to examine determinants of Non-Revenue Water (NRW) in Mbeya water utilities.

1.3.2 Specific Research Objectives

Hereunder are the specific objectives of this study:

(i) To assess the cut into which unbilled authorized consumption influence Non-Revenue Water in Mbeya water utilities.

(ii) To evaluate the influence of billing system errors and technical errors on Non-Revenue Water in Mbeya water utilities.

(iii) To establish how social dynamics influences Non-Revenue in Mbeya water utilities.

1.4 Research Questions

1.4.1 Specific Research Questions

(i) What is the influence of technical errors on NRW in Mbeya water utilities?

(ii) What is the influence of accounting /billing system errors on NRW in Mbeya water utilities?

(iii) What is the influence of social dynamics on NRW in Mbeya water utilities?

(iv) What is the influence of unbilled authorized consumption on NRW in Mbeya water utilities?

1.5 Relevance of the Study

Non-revenue water is an important topic for safe water supply utilities such as Mbeya WSSA, as it influences the financial sustainability, serviceability and the management of precious water resources to a large extend. According to the World Bank, in developing countries Tanzania being one of them, roughly 45 million cubic meters of water are lost daily with an economic value of over US$3 billion per year.

Hence this study aims to help the water supply utility overcome such challenge in which the report of this study comes up with practical mitigation measures toward reduction of Non-Revenue Water to water networks managed and operated by Mbeya WSSA.

The Implementation of recommendations of this study will fulfil authority objectives stipulated in Mbeya WSSA business plan of 2018/2021, especially increasing collection and help other authorities to overcome the challenge and ensuring Clean water for all (SDG number 6).

1.6 Organization of the Report

This report was organized in six main chapters. Chapter one was the Introduction chapter followed by chapter two of Literature review of the proposed topic, such as introduction, meaning of NRW and theoretical literature were discussed in this chapter.

Chapter three discussed research methodology, which included research design, source of data, data collection instruments to be used in this study as well as data analysis and technique.

Chapter four provided data presentation and analysis of the findings. Determinants that contribute to non-revenue water, observed and obtained from this study were analysed and presented in this chapter.

Chapter five included discussion of the findings while chapter six provides conclusion and recommendations of the research findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Chapter Overview

This chapter offers a review of works carried out by other scholars and researchers relevant to the problem of the study both globally and regionally. The chapter consists conceptual definitions, theoretical framework, empirical literature, research gap, and conceptual framework.

2.2 Conceptual Definitions

2.2.1 Non-Revenue Water (NRW)

NRW is equal to the total amount of water flowing into the water supply network from a water treatment plant, borehole system or imported bulk water supply (System Input Volume) minus the total amount of water that consumers (domestic, commercial, industrial and institutions) are authorised to use and are billed for (Billed Authorized Consumption) (Tabesh *et al*., 2018).

2.2.2 Authorized Consumption

Refers to the annual volume of metered and non-metered water taken by registered customers, the water supplier, and others who are implicitly or explicitly authorised to do so (e.g. water used in government offices or fire hydrants). It includes exported water and the leaks and overflows after the point of customer metering (Jang & Choi, 2018).

2.2.3 Water Loss

This is the difference between system input volume and authorised consumption. It consists of commercial losses and physical losses (See & Ma, 2018).

2.2.4 Commercial Losses

Sometimes referred to as apparent losses, consist of unauthorized Consumption and all types of metering inaccuracies (Murrar, 2017).

2.2.5 Physical Losses

Sometimes referred to as real losses, are the annual volumes lost through all types of leaks, bursts and overflows on mains, service reservoirs and service connections, up to the point of customer metering (Appiah *et al*., 2017).

2.3 Theories of the Study

2.3.1 The Game Theory

This theory provides a structural analysis of logical strategic relations of human beings. Game theory has become a philosophy of mathematics that focuses on formulating the best approach in order to effectively tackle the problem facing the dynamic problem (Szep & Forgo, 2012). Theory of game is based on the idea that, one player can 'win' in any situation or in any 'game' through a strategy. Any firm can be regarded as a competitive game or even a consumer game. This is an instrument that has widely been used by researchers to examine factors and behaviour influencing decision-making in the resolution of water resources conflicts and management (McKinsey, 2003).

This theory can also be interpreted from an analysis of the eventual outcomes of a competitive scenario, from interacting with the units (so-called 'players' or 'agents') based on the players' priorities and wishes and the approach each player uses. In this

theory, an agent has a predetermined "play path" to decide what to do when other players (i.e. gaming players) respond to previous acts and plans (Forgo *et al*., 1999).

Adoption of this theory was based on the fact that; game theory conceptualises the role of various stakeholders in mitigating challenges regarding management of water utilities and NRW. The theory provides a theoretical insight on how water utilities and water consumers as "*game players*" can manage water resources and reduce non-revenue water.

2.3.2 The Theory of Planned Behaviour (TPB)

The TPB predecessor was the Theory of Reasoned Action (TRA), the first model that was used to predict and describe behaviours of human. Fishbein and Ajzen presented it in 1975. As a model of socio-psychology, TRA argues that the real (voluntary) action of an individual is driven directly by its behavioural intentions. In comparison to the TRA, the TPB acknowledges that, there are human behaviours, which are involuntary oriented (Hung and Chang, 2005).

Kaiser (2006) also argued that, the more external circumstances affect the actions of an individual, the less they can deliberately maintain their voluntary behaviours. The TPB is founded on the notion that, three antecedents are behavioural intentions: behavioural attitudes, social norms and perceived control of behaviour (Ajzen & Fishbein, 1970).

This theory is especially significant in studying an individual behaviour when people need skills and resources as well as willingness to act towards NRW.

2.4 Empirical Literature Review

2.4.1 Influence of Unbilled Authorized Consumption on Non-Revenue Water

Kiptala *et al*. (2019) examined the impact of financial performance on the unbilled authorized consumption in Kenyan water utilities. This study carried out a descriptive research design to address 50 respondents. Their findings showed that, the relationship between unbilled authorized consumption and financial performance was positive and statistically significant.

Shilehwa (2013) assessed the factors, which influence non-revenue water supply in Kenya. Hypothesis tests showed that, a significant positive correlation exists in the Webuye water supply system between meter registration inaccuracy and non-revenue water. Also, significant positive relationship for the water supply scheme between unmetered use and non-revenue water. It was also found a positive correlation in illegal consumption with non-revenue water. However, water tariff and water non-revenue system did not have a major correlation.

Gungor-Demirci *et al*., (2018) established NRW's determinants for a water utility in California by using a panel regression analysis with uncertainty for fixed effects. The NRW was found to have a negative correlation between the network length, link density as well as the net operating revenue per cm of water sold. For the 5 districts in California, a positive relationship was found between the number of leaks and NRW.

Jang and Choi (2018) used multiple regression analysis and artificial neural network (ANN) to evaluate the NRW ratio in order to enhance estimation accuracy and propose an effective method of defining associated NRW ratio parameters in Korea. Findings indicated that, the accuracy of the calculation was higher than the accuracy

of the conventional statistical approaches when used for the optimum number of neurons.

Yi *et al*. (2017) addressed the problem of non - revenue water (NRW) and the understanding of stakeholders as regards management to design steps for remediation of controls for lost water and sustainable supply in Thailand. Findings indicated that, about 50% of water staff is unaware of the concept of NRW. In addition, more than 90% of water users are unable to take part in water conservation. The key causes of water loss in the city of Mandalay are: a very low-pressure system; poor maintenance; inadequate knowledge of water operations; insufficient understanding of the NRW concept; relationship among customers was poor; and lack of preparation for the use of water in management of water loss.

2.4.2 Influence of Billing System Errors and Technical Errors on Non-Revenue Water

Chabe (2018) analysed the amounts and determinants of non-revenue water in Zambia water utilities. The results demonstrated that, the NRW was 45%, with physical loss, commercial loss and unbilled authorized consumption as the key determinants, each of which constitute 45%, 38% and 17% respectively. The physical loss was primarily due to the weak infrastructural condition that led to high leakage levels and plummeting of the tubes. The key source of commercial losses includes error metering and water robberies, while fire hydrants for fire fighting, new connections and reconnections not provided for operation were main sources of unbilled authorized consumption due to lack of meters or incompetence on the part of the water utilities' employees.

Ronoh (2019) conducted a study to assess the impact of GIS application on non-revenue water level in Kenya. It was revealed that, the effect of the introduction of the GIS showed a high technology impact as there was large standard deviation in the NRW level. The NRW decreased to an appropriate amount from 56% in 2013 to 25% in 2018. The same applies to all NRW management operations, which showed a positive deviation of NRW standards. It was also attested that; GIS technology has had a huge effect on the NRW management and made NRW management simple and inexpensive so that most things could be achieved in offices by everybody without attending into the industry.

Rajasekhar *et al*. (2018) conducted an urban water supply non-revenue water evaluation. Results showed that, intended metering by local residents and collusion of utilities with residents in order to plan bills is more a source of illegal consumption. Currently, meters have only been set for such connections and the remaining liaisons are paid fixed amounts. These charges are disproportionate to the residence 's occupancy and use of water, since the utility lacks significant revenues.

2.4.3 Influence of Social Dynamics on Non-Revenue Water

Perera *et al*. (2018) proposed a cost-effective method of management in the Sri Lankan water distribution system for non-revenue water. The inquiry followed a quantitative approach. The data gathered were analysed in order to identify the causes of non-revenue water production in distribution systems under four principal groups: leaks in distribution lines, administrative errors, unauthorized use of water and free water supply. It was found that, the technique to avoid various forms of water loss has been built in a cost-effectiveness management model. In the water distribution system,

cost efficiency of investing in non-commercial water decreases was calculated with regard to the archives.

Murrar (2017) examined non-revenue water determinants in the Balkans. Results indicate that the connecting density network, the percentage labour costs at operating costs, number of connections, quantity of output per link, amount of consumption per person daily, the ratio of metering, and unit cost are significant for non-revenue water. An analysis of the correlation suggests that, more the ratio of metering and the percentage of labour costs to the operating expense, less the percentage of non-revenue water. On the other hand, the higher the consumption per person, connecting production, population number, density of connecting networks, cost per cubic meter sold and number of links, the greater the percentage of non-revenue water.

Mukundi (2014) assessed the determinants of NRW in Kenya. It was found that, the number of bursts and leakages in the water utility 's total level of non-revenue water was average. The analysis also showed that, the gross non-revenue water level in the company was determined moderately through accounting errors. Blasts and leaks played a major role in non-revenue water overall. The age of the water pipes and fittings infrastructure and quality.

Kingdom *et al*. (2006) conducted a study on the challenges facing reduction of NRW in developing countries, Tanzania included. They aimed at determining how the public-private partnership (PPP) can help in reducing and controlling NRW in the developing countries. Nzilano (2017) also found that, human resource competences in waste water management, civil engineering, distribution of water resources, other

industrial services and agricultural water management contributes to a small extent to organisation efficiency of the utility. Shortage of funds, lack of priorities in government budget and low rate of return on investment contributes less to organisation efficiency of the utility. The author recommended to Mbeya UWSA to take deliberate efforts to improve the attributes of human resource competences, financial resources and physical resources that have bearing effect on the organization efficiency of the utility in delivering services to customers.

Baasha (2013) assessed the factors influencing NRW in Arusha water utilities. His findings showed that, The NRW increases due to many factors, including ineffective infrastructure, inadequate water meters, an improper water collection system, customer robbery, and out-dated pipes across all facilities, poor technology in billing program.

2.5 Research Gap

The reviewed literature indicates general concerns on this subject matter under study. In light of this, there is extensive empirical literature, which indicates that there is a wide Non-Revenue of Water. For instance, Nzilano (2017) investigated factors influencing Mbeya WSSA as one of the water utilities in Tanzania. Baasha (2013) investigated factors influencing NRW in Arusha water authority. Also, Celsus (2013) conducted a study on factors influencing water supplies in Webuye water supply scheme. However, very little is known regarding the influence of billing system error, technical error, and social dynamics on NRW. Present study therefore aims at filling this gap by assessing the aforementioned aspects, specifically in Mbeya water utility.

2.6 Conceptual Framework

Conceptual framework of this study is informed from the variables' relationship as regards to determinants of NRW. The framework consists of three independent variables and one dependent variable. Unbilled authorised consumption, billing system errors, and social dynamic were conceptualised as independent variables whereas level of NRW acts as dependent variable of the study as depicted on Figure 2.1.

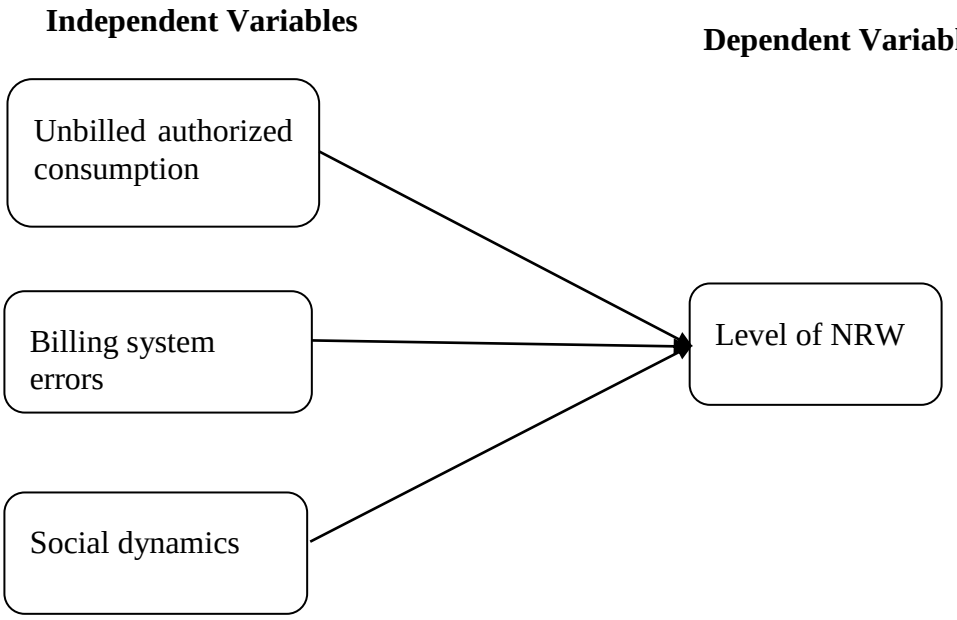

Figure 2.1: Conceptual Framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Chapter Overview

The methodology used in this study is presented in this chapter. It specifically following hereby sections: study design research philosophy, area of the study, survey population, sampling design and procedures, data collection techniques and data analysis methods.

3.2 Research Philosophy

Research philosophy concerns the development of knowledge through the compilation, analysis and use of data. There is a broad variety of fields of research philosophy. There are four principal philosophies of science, namely pragmatism, positivism, realism and interpretivism (Moon *et al*., 2019). The philosophy of positivism was used for the purpose of this study. Positivist philosophy typically seeks to test theory and most frequently is associated with the quantitative techniques used for data collecting and analysis (Scotland, 2012). Highly organized, large samples, calculation, and quantitative measures are standard methods in positivism philosophy (Johnson & Onwuegbuzie, 2004; Creswell, 2014).

The rationale of this choice is that the purpose of the present analysis is the creation by documentation and questionnaire of concepts, which examine determinants of NRW, and involve participation of individuals in the subject matter. The results of the study include the creation of concepts based on fields of data.

3.3 Research Design

The design of the study is a particular study plan or procedure that helps the researcher to convert the conceptual hypothesis into a practical study (Spector, 2019). This study used cross-sectional design in which the survey was performed for the entire study only once. Cross-sectional studies are carried out at one time or for a short time. They are normally done to estimate the prevalence of information outcomes in a particular population.

Therefore, the design offers a 'snapshot' at a particular time of the findings and related characteristics (Levin, 2006). Cross-sectional design is reasonably inexpensive and take a short time to perform. As a data collection tool, questionnaire was used to acquire primary data during the survey.

3.4 Area of the Study

This study was conducted at Mbeya Urban Water Supply and Sanitation Authority (Mbeya WWSA). Mbeya WWSA is based in Mbeya region, Tanzania and is part of the government Industry. The company comprise 208 workers at all of its sites. Mbeya WWSA is responsible for providing water supply and sanitation services across the urban area of Mbeya city. It was officially introduced in 1998. This study area was chosen as regards to its significance in service delivery in Mbeya region. Findings obtained in this area is essential in reflecting other scenarios concerning the determinants of NRW in the entire region.

3.5 Survey Population

This study targeted a population of all the registered water consumer connections and staffs of Mbeya WSSA. The staffs are the ones involved in the daily running of the

water supply system and as such they are conversant with the subject matter of the study. The study population was 208 employees.

3.6 Sample Size and Sampling Techniques

3.6.1 Sample Size

For obtaining sample size of study, the mathematical formula was used. In order to calculate the required sample size, Yamane (1967) proposes a simplified formula for calculating sample size of the study;

$$n = \frac{N}{1 + N(e)^2}$$

Where;

n: is the sample size

N: is the population size,

e: is the level of precision, sometimes called sampling error or margin of error.

So far, if N = 208, and e = 0.05.

Then, calculated sample size was

$208/1+208(0.05)^2 = 136.8421$

Hence, number of respondents was 137

3.6.2 Sampling Technique

The selection of study participants was achieved via a random sampling method. The technique proclaims that, all respondents are equally likely to be chosen for a sample in the population (Adam & Kamuzora, 2008). During the survey, 137 individuals from a population of 208 were chosen using a random sampling technique. Microsoft excel was used to develop a random participatory code, thereafter, the code was distributed

to the study population. Employees who chose a participation code were asked to take part in the survey.

3.7 Methods of Data Collection

3.7.1 Questionnaire

Questionnaire can be defined as a data compilation tool consisting of a question type for the study respondents (Brace, 2018). Kothari (2004) argues that, the questionnaire has many merits, including, cost effectiveness regardless of the geographical area. The tool is also bias-free because its own terms are based on the participants' words. The surveyor included a questionnaire as a method for data collection in this particular study. A logical sequence of questions, allowing a smooth transition from subject to subject, is the main requirement for questionnaire formats (Hickson, 2010). Closed questions were utilized for this study, although they are hard to formulate, but easy to analyse.

3.7.2 Interview

Interviews were scheduled to be held to provide respondents their thoughts on the issue under investigation. The purpose was to supplement the questionnaire data collection method, in order to capture qualitative data that cannot be obtained via questionnaires. There were interviews with the 5 head of departments. The interview took less than 30 minutes. For easy transcription, interview data were collected on a digital recorder.

3.8 Data Analysis Techniques

In order to ensure that correlating data is sorted together to promote the analysis, the data collected from the primary sources was purged, organized and coded. In Chapter

4 of the study, descriptive statistics measured were provided and summarized by graphic representations and the estimation of the descriptive. The first, second and third objectives were analysed using descriptive statistics while the relationships between dependent and independent variables was analysed using multiple regression. Statistically, the data were analysed through the 24rd version of SPSS.

3.8.1 Multiple Linear Regression

Multiple linear regression is a modelling method for evaluating the concurrent relationship between multiple independent variables and one continuous variable (Eberly, 2007). The value of the Y result variable is estimated, given a set of independent variables (i.e. x1, x2...) (Tranmer & Elliot, 2008). Before the analysis was performed, some regression assumptions were tested. These were; linearity, normality, autocorrelations, and multicollinearity. Regressions model was developed from general equation; $Y = \alpha + x_1\beta_1 + x_2\beta_2 + .. x_n\beta_n + \varepsilon$

3.9 Reliability and Validity of Data

3.9.1 Reliability Test

Reliability refers to the ability of an instrument to produce consistent results (Creswell *et al*., 2003). The instrument is considered reliable if it produces the same or consistent results whenever it is repeated (Best & Khan, 2006). Reliability test was measured using Cronbach's Alpha. Result indicated that, all variables obtained Cronbach's Alpha coefficient above 0.7 as demonstrated on Table 3.1. This ensures that, variables data were statistically reliable as recommended by a Cronbach Alpha's rule of thumb.

Table 3.1: Cronbach's Alpha Coefficient Showing Reliability Analysis

Variable	Sample size	Cronbach's Alpha	Number of items
Unbilled authorized consumption	137	0.811	5
Billing system errors	137	0.895	5
Technical errors	137	0.803	
Social dynamics	137	0.913	5
Level of NRW	137	0.894	5

3.9.2 Validity Test

Validity analysis aims at testing the truthfulness or correctness at which research tool examines field data. Validity in this study was measured using test-retest method, which is usually conducted by pilot study. The study questionnaire was self-administered to 10 respondents and collected. After three days, the same questionnaire was then administered to the same respondents. It was found that, responses filled in the research tool from the two pilot studies were similar ensuring the tool is valid.

CHAPTER FOUR

PRESENTATION OF FINDINGS

4.1 Chapter Overview

This chapter provides analysis of the findings in regards to the specific objectives of the study. The chapter also covers socio-demographic characteristics.

4.2 Socio-demographic Characteristics of the Respondents

The study sought to summarise social features of the respondents in the study area. Age, gender, educational level, and working experience were the main characteristics considered as shown on Table 4.1.

Table 4.1: Descriptive Statistics Showing Demographic Characteristics

Variable	Category	Frequency	Percent
Gender			
	Male	65	47.4
	Female	72	52.6
Age			
	18-30	54	39.4
	31-45	41	29.9
	46-60	42	30.7
Education Level			
	Secondary education	21	15.3
	College education	53	38.7
	Undergraduate	41	29.9
	Postgraduate	22	16.1
Experience			
	1-5	49	35.8
	6-10	55	40.1
	11-15	19	13.9
	Above 15	14	10.2

4.2.1 Gender of the Respondents

As obtained on Table 4.1, female respondents were 72(52.6%) whereas male respondents occupied 65(47.4%) out of 137(100%). It shows that, majority of the participants were female workers.

4.2.2 Age of the Respondents

Results on Table 4.1 indicate that, 54(39.4%) of the respondents were youth aged between 18 and 30 years old, 41(29.9%) were adult aged between 31 and 45, while 42(30.7%) were respondents aged above 45 years old.

4.2.3 Education Level of the Respondents

Table 4.1 obtained that, majority of respondents had college education level accounting for 53 (38.7%), followed by 41(29.9%) of respondents with undergraduate degree, 22(16.1%) with postgraduate degree, and only 21(15.3%) out of 137(100%) had secondary education.

4.2.4 Working Experience of the Respondents

Findings revealed that, the study involved 55(40.1%) of the respondents with working experience between 6 and 10 years, 49(35.5%) of respondents with 1-5 years, 19(13.9%) with 11-15 years, and 14(10.2%) out of 137(100%) had above 15 years of working experience.

4.3 The Influence of Unbilled Authorised Consumption on Non-Revenue Water in Mbeya Water Utilities

The study examined the rating of respondent's views on unbilled authorized consumption in NRW. Results indicate that, 95(69.3%) of the respondents rated the

influence of unbilled authorized on NRW as high. On the other hand, 15(10.9%) rated it as moderate while 27(19.7%) rated the influence of unbilled authorised consumption on NRW as low. Findings are depicted on Table 4.2.

Table 4.2: Descriptive Statistics Showing Rating of Unbilled Authorised Consumption

Variable	Frequency	Percent
Very high	45	32.8
High	50	36.5
Moderate	15	10.9
Low	13	9.5
Very low	14	10.2
Total	**137**	**100.0**

4.3.1 Correlation Between Metered and Unmetered Unbilled Authorised Consumption

The study sought to establish linear relationship between metered and unmetered authorized consumption on NRW. It was found that, significant (p <. 05) linear relationship exists between metered, unmetered and NRW. However, unmetered unbilled authorised consumption had weak positive relationship, r (137) =. 45 compared to metered unbilled authorized consumption which showed strong positive relationship, r (137) =.88, on NRW among Mbeya water utilities as illustrated on Table 4.3.

Table 4.3: Correlation Test Demonstrating Relationship between Metered, Unmetered Unbilled Authorised Consumption on NRW

Variable	Metered	Unmetered	NRW
	1		
Metered			
	137		
	.193*	1	
Unmetered	.024		
	137	137	
	.876	**.451**	1
NRW	**.013**	**.005**	
	137	137	137

*. Correlation is significant at the 0.05 level (2-tailed).

In line with statistical findings, interview session among respondents also affirmed that, unbilled authorised consumption has strong influence on NRW. For instance, some employees claimed that, pre-paid meters in some areas were installed with billing errors resulting to unbilled consumption.

One respondent quoted that;

> "*Most of the prepaid meters installed in public and private institutions have billing problem/errors. This scenario has caused wrong estimation of water bills compared to the actual water consumptions in a particular institution*" – Respondent 1.

4.4 Influence of Billing System and Technical Errors on Non-Revenue Water in Mbeya Water Utilities

4.4.1 Billing System Errors

Descriptive statistics were employed to assess the extent at which billing system errors influences NRW based on respondents rating. Findings show that, 70(50.8%) of

the respondents rated the influence of billing system errors as high, whereas, 24(17.4%) rated them as moderate, and 43(31.2%) of the respondents rated the influence of the errors as low. Table 4.4 illustrate the findings.

Table 4.4: Descriptive Statistics Showing Rating of Billing System Errors on NRW

Variable	Frequency	Percent
Very high	55	39.9
High	15	10.9
Moderate	24	17.4
Low	27	19.6
Very low	16	11.6
Total	**137**	**100.0**

4.4.2 Technical Errors

The study also sought to identify the most likely technical error, which influence NRW in Mbeya water utilities. Four technical errors were identified namely, age of infrastructure, leakages, bursts, and metering inaccuracy. Findings indicate that, age of infrastructure had the highest mean score (*M*=3.2, *SD*= 1.5), followed by leakages (*M*=3.1, *SD*=1.4), bursts (*M*=3.0, *SD*= 1.5). Whilst, metering inaccuracy attained lowest mean score (*M*=2.9, *SD*=1.4) compared to other technical errors as shown on Table 4.5.

Table 4.5: Descriptive Statistics Showing Mean Score of Technical Errors on NRW

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Age of infrastructure	138	1.00	5.00	3.2391	1.46270
Leakages	138	1.00	5.00	3.0942	1.37170
Bursts	138	1.00	5.00	3.0072	1.47236
Metering inaccuracy	138	1.00	5.00	2.9565	1.44924

In the same vein, interview session supported the fact that, billing and technical errors catalyses high NRW in Mbeya water utilities. For example, most of the water infrastructure was faced by underground leakage, which in some point is difficult to detect due to nature of soil in the region.

One of the respondents quoted that;

> "*Nature of Soil in Mbeya region is porous characterised by high infiltration rate. When underground leakage happens, it takes time to detect. In this case, substantial amount of water is lost leading to high NRW*". -Respondent 2

Interview respondents also claimed that, floating ball valves in some water storage tanks lacked repair and regular maintenance. It is thus creating risk for water overflow.

One respondent noted that;

> "*Most of the storage tanks are equipped with none or old floating ball valves which have a less working capability. Such old valves have been causing frequent overflow of water which in turn influences high NRW*." – Respondent 3.

In regards to age of the infrastructure, respondents claimed that, most of the water meters in Mbeya water utilities were aged above the recommended age suffice to water meter life span.

One of the respondents stated that;

> "*Normally life span of water meter is 10 years. However, 60-70% of existing water meters are over 10 years which raise a concern for inaccurate estimate in water bills.*" - Respondent 4.

4.5 Influence of Social Dynamics on Non-Revenue Water

The study sought to assess respondents' views on key social dynamics, which influence NRW in Mbeya water utilities. Factors, which were examined include water theft, corruption, high water tariffs, and intermittent water supply.

Table 4.6: Descriptive Statistics Showing Rating of Unbilled Authorised Consumption

Variable	Frequency	Percent
Water theft	70	51.1
High water tariff	26	19.0
Corruption	21	15.3
Intermittent water supply	20	14.6
Total	**137**	**100.0**

4.5.1 Water Theft

Water theft refers to dishonest behaviour of tapping water illegally from the supply system. Findings on Table 4.6 indicate that, 70(51.1%) of the respondents regards this as the most factor influencing NRW.

4.5.2 High Water Tariff

Water tariff is an expense at which a water utility assigns to a customer through a piped network. As indicated on Table 4.6, 26(19%) of the respondents claimed that, high water tariffs influenced NRW.

4.5.3 Corruption

As indicated on Table 4.6, 21(15.3%) of the respondents suggested that, corruption is one of the most social dynamic factors influencing NRW in Mbeya utility.

4.5.4 Intermittent Water Supply

It was revealed that, 20(14.6%) of the respondents regarded intermittent water supply as the one of the most social dynamic factors influencing NRW. Based on the interview findings, respondents claimed that, another social dynamic influencing NRW was a smaller number of meter readers in relation to given targets. Majority of meter readers fails to report appropriate bills as provided by a particular meter in their respective area.

One respondent quoted that;

> "*Majority of meter readers do not physically visit every client meters. They do record some water bills based on their experience or trend of previous bills. Generally, Meter readers are given 800-1300 houses to record in 10 days which is quite high target to reach in the specified period.*" - Respondent 5

4.6 Effect of NRW Determinants on the Level of NRW

The effect of determinants of NRW on the level of NRW was measured using multiple linear regression. Prior to the analysis, assumptions of multiple regression were tested which included, linearity, normality, homoscedasticity, autocorrelations, and collinearity.

4.6.1 Assumptions of Multiple Regression

4.6.1.1 Linearity Assumption

Results indicate that, there is significant (p <.05) linear relationship between NRW and its determinants. However, NRW had weak positive relationship with billing system errors, r (137) =.36, unbilled authorized consumption, r (137) =.24, and social dynamics, r (137) =.28 as shown on Table 4.7.

Table 4.7: Descriptive Statistics Showing Rating of Unbilled Authorised Consumption

		Billing System Errors	Unbilled authorized consumption	Social Dynamics	NRW
Billing System Errors		1			
		137			
Unbilled authorized consumption		.193*	1		
		.024			
		137	137		
Social Dynamics		.263**	.109	1	
		.002	.206		
		137	137	137	
NRW		**.362****	**.237****	**.283****	1
		.000	**.005**	**.001**	
	N	137	137	137	137

**. Correlation is significant at the 0.01 level (2-tailed).

4.6.1.2 Normality Assumption

Table 4.8 demonstrates that, all values in the independent variables were normally distributed. Normal distribution is statistically detected when variable values ranges at ±2.58.

Table 4.8: Descriptive Statistics Showing Rating of Unbilled Authorised Consumption

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Billing System Errors	137	**.896**	.207	**-.298**	.411
Unbilled authorized consumption	137	**.880**	.207	**-.191**	.411
Social Dynamics	137	**.873**	.207	**.019**	.411

4.6.1.3 Homoscedasticity Assumption

As shown on Figure 4.1, variance errors were scattered evenly around the horizontal line. This portrays that, homoscedasticity assumption was affirmed.

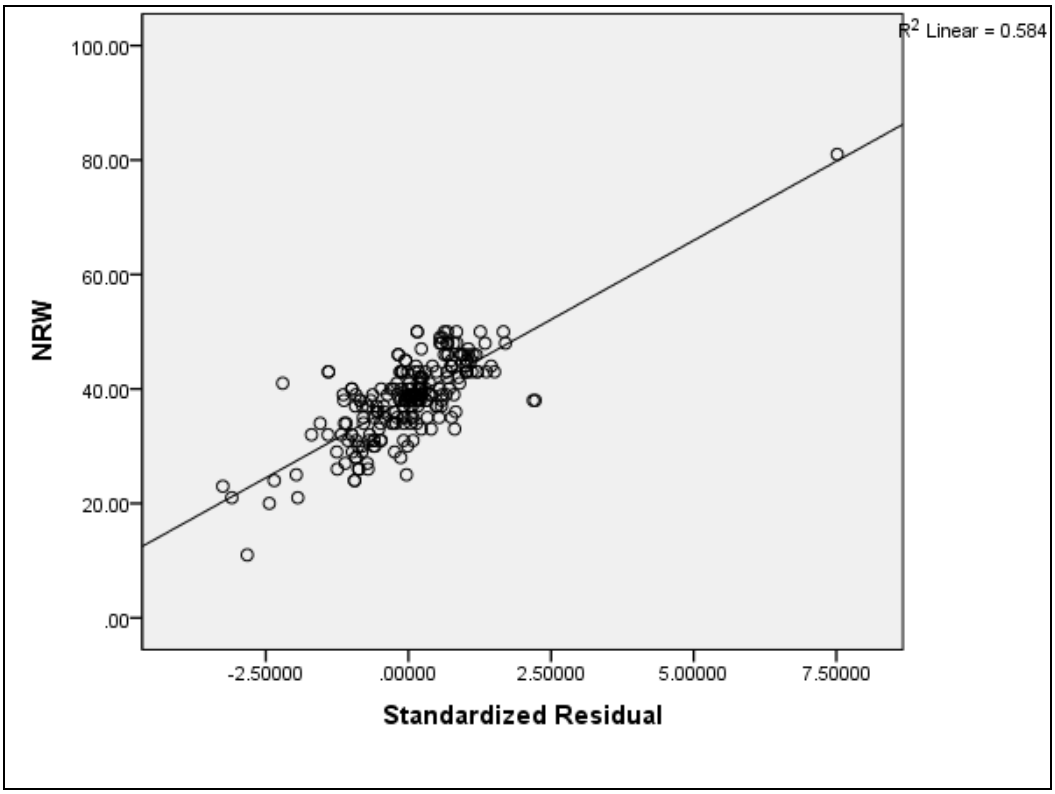

Figure 4.1: Scatterplot Showing Homoscedasticity Test

4.6.1.4 Autocorrelation Assumption

Autocorrelations test was conducted using Durbin-Watson. Results revealed that, variables had very low autocorrelations as regards to Durbin-Watson coefficient (*DW*=1.2). It is recommended that, Durbin-Watson should range between 1.5 and 2.5, for a low autocorrelation. Table 4.9 demonstrate the findings.

Table 4.9: Autocorrelations assumption

Model	R	R Square	Adjusted R Square	Std. Error	Durbin-Watson
1	.441	.194	.176	1.33502	1.202

4.6.1.5 Multicollinearity Assumption

Table 4.10 demonstrate that, tolerance was above 0.8 while Variance Inflation Factor (VIF) was not larger than 1.0 in independent variables. Results indicate that, multicollinearity was very low among the variables since the values of VIF were low and those of tolerance were large. The coefficients of VIF and tolerance are measured in a range of 1-10 and 0-1 respectively.

Table 4.10: Multicollinearity Test

Model	Collinearity Statistics	
	Tolerance	**VIF**
Billing System Errors	.927	1.078
Unbilled authorized consumption	.904	1.107
Social Dynamics	.959	1.043

4.6.2 Multiple Regression Analysis

Multiple regression analysis was carried out prior to the completion of its assumptions. It was found that, the regression model was statistically significant ($p<.000$). Besides, 19.4% of the mode variations was explained by independent variables as depicted on Table 4.11.

Table 4.11: Model Summary Showing Multiple Regressions Analysis

Model	R	R Square	Adjusted R Square	Std. Error	Sig.
1	.441	.194	.176	1.33502	.000

Results of the regression coefficients indicated that, all independent variables were significant ($p<.0.5$) and positive predictors of NRW. It was also revealed that, 1 unit increase of billing system errors influenced 0.2 unit increase of NRW. Whereas, 1-unit

increase of unbilled authorized consumption and social dynamics accounts for 0.3 and 0.2 increase of NRW units as illustrated on Table 4.12.

Table 4.12: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	.562	.372		1.513	.133
Billing System Errors	.218	.092	.192	2.377	.019
Unbilled authorized consumption	.359	.105	.280	3.421	.001
Social Dynamics	.212	.104	.162	2.041	.043

The following regression equation was developed as regards to the coefficient's findings;

From $\boldsymbol{y = \alpha + x_1\beta_1 + x_2\beta_2 + \dots\dots x_n\beta_n + \varepsilon}$

Then,

$$\boldsymbol{y = \alpha + (BSE)\beta_1 + (UAC)\beta_2 + (SD)\beta_3 + \varepsilon}$$

Hence,

$$\boldsymbol{y = 0.6 + 0.2BSE + 0.4UAC + 0.2SD}$$

Where,

Y =Level of NRW

α = Constant

BSE = Billing System Errors

UAC = Unbilled authorized consumption

SD = Social Dynamics

CHAPTER FIVE

DISCUSSION OF FINDINGS

5.1 The Unfluence of Unbilled Authorised Consumption on Non-Revenue Water in Mbeya Water Utilities

Based on the findings, unbilled authorized consumption was regarded to have high influence on NRW. For instance, 69% of the respondents rated its influence as high. This provides an implication that, poor management of unbilled authorised consumption leads to increase of level of NRW. Findings also suggest that, metered and unmetered unbilled authorized consumption have significant correlation ($p<.05$) with level of NRW. This implies that, there is no variation between metered and unmetered consumption when it comes to unbilled authorized consumption. When water is supplied without authorized billing system directly influence high NRW.

Current findings were in harmony with several empirical studies. For example, Gungor-Demirci *et al*. (2018) noted that, there is direct link between uncertainties, unbilled authorized consumption and high NRW. Perera *et al*. (2018) developed a cost-effective model as long-term plan for controlling unbilled authorized consumption, illegal usage of water, and free water supply in order to decrease NRW in water distribution system. Kiptala *et al*. (2019) also revealed that, activities associated with unbilled authorized consumption such as meter bypassing, illegal water connection, and improper billing system not only influenced high NRW but also affected financial performance of water utilities.

5.2 Influence of Billing System and Technical Errors on Non-Revenue Water in Mbeya Water Utilities

In regards to the findings, billing system errors and technical errors had high influence on NRW. It was revealed that, approximately 51% of the respondents rated the influence of billing system errors as high. This implies that, inaccurate billing systems attribute to insufficient collection of water revenue, which results to high NRW. Results also revealed that, among the technical errors affecting NRW, age of water infrastructure had the highest mean score. This implies that, aged water infrastructures influence increase of NRW as they are more likely susceptible to leakage and bursts. However, metering inaccuracy was considered as the least technical error, which influences high level of NRW in Mbeya water utilities.

Findings of this study were consistent with Yi *et al*. (2017) on the notion that, technical errors, which significantly influence high NRW include, inadequate repair of infrastructure, irregular maintenance, and poor pressure of water supply system. Similarly, Murrar (2017) indicated that, water utilities are mostly suffering from commercial losses due to enormous number of physical leakage and high NRW. Mukundi (2014) also revealed that, level of NRW is highly affected by physical leakages and bursts. Old infrastructure age and poor pipes quality are crucial indicators leading to causes of high NRW.

5.3 Influence of Social Dynamics on Non-Revenue Water

Social dynamics were found to have a significant influence on NRW as regards to the study findings. Four aspects of social dynamics were assessed including water theft,

high water tariff, corruption, and intermittent water supply. Findings suggest that, 51% of the employees consider water theft as one of the most social dynamics influencing NRW. This implies that, loss of water revenue is usually contributed by illegal consumption of water in water utilities. It was also found that, 19% of the employees outlined high water tariff as another important social dynamics influencing NRW. This means that, the available water tariffs do not comply with some customers consumptions. Thus, this situation may lead to illegal water consumption as a result of failure to pay bills according to water tariffs. Furthermore, 15% of employees suggested corruption as amongst crucial social dynamics influencing NRW. This gives a notion that, corruption in water utilities negatively affects effective water supply and management of water resources.

These findings align with Mosha (2018) on the notion that, corruption and bribery among meter readers are crucial causes of NRW in water utilities and they cut off return on investment and utility profitability. Findings were also in consistent with Jabari (2017) on the fact that, implementation of ineffective strategies in reducing NRW is rooted under corruption and bribery. Also, rate of NRW increase is mostly influenced by insufficient water infrastructure maintenance and theft.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Chapter Overview

This chapter provides conclusions of the study. The conclusions were drawn in a basis of specific objectives of the study. The chapter comprises of summary, conclusions, and recommendations of the study.

6.2 Summary of the Findings

This study aimed at assessing the determinants of NRW in Mbeya water utilities. The objectives of the study were threefold; to assess the cut into which unbilled authorized consumption influence Non-Revenue Water in Mbeya water utilities; to evaluate the influence of billing system errors and technical errors on Non-Revenue Water in Mbeya water utilities; and to establish how social dynamics influences Non-Revenue in Mbeya water utilities.

First objective results showed that, 95(69.3%) of the respondents rated the influence of unbilled authorized on NRW was high. 15(10.9%) rated it as moderate while 27(19.7%) rated the influence of unbilled authorised consumption on NRW as low. It was also found that, significant (p <. 05) linear relationship exists between metered, unmetered and NRW. However, unmetered unbilled authorised consumption had weak positive relationship, r (137) =. 45 compared to metered unbilled authorized consumption which showed strong positive relationship, r (137) =.88, on NRW.

Second objective findings revealed that, 70(50.8%) of the respondents rated the influence of billing system errors as high, 24(17.4%) rated them as moderate, and

43(31.2%) of the respondents rated the influence of the errors as low. Four technical errors were identified namely, age of infrastructure, leakages, bursts, and metering inaccuracy. Findings indicate that, age of infrastructure had the highest mean score (*M*=3.2, *SD*= 1.5), followed by leakages (*M*=3.1, *SD*=1.4), bursts (*M*=3.0, *SD*= 1.5). Whilst, metering inaccuracy attained lowest mean score (*M*=2.9, *SD*=1.4) compared to other technical errors.

Third objective results indicated that, social dynamics factors, which were examined include water theft, corruption, high water tariffs, and intermittent water supply. 70(51.1%) of the respondents regards this as the most factor influencing NRW. 26(19%) of the respondents claimed that, high water tariffs influenced NRW. 21(15.3%) of the respondents suggested that, corruption is one of the most social dynamic factors influencing NRW. 20(14.6%) of the respondents regarded intermittent water supply as the one of the most social dynamic factors influencing NRW.

6.3 Conclusions of the Study

Findings of this study provides an evidence that, level of NRW in water utilities is significantly influenced by unbilled authorized consumption, billing system errors and technical errors, and social dynamics. These factors have shown a reasonable connection with an extent at which NRW increase or decrease by 19%. However, there is variation on the significance effect exerted by each NRW determinant towards the level of NRW. For instance, unbilled authorised consumption tends to affect twice more NRW than billing system errors and social dynamics. This affirms that, high NRW in Mbeya utilities is more likely influenced by illegal water consumption, meter

bypassing and the likelihoods as far as unbilled authorized consumption is concerned. The study findings also attest that, there is no significant difference between metered and unmetered unbilled authorized consumption. The correlation effect attributed by either metered or unmetered connection attribute to high NRW as the matter of unbilled authorization.

The study confirms that, age of infrastructure; leakages, bursts, and metering inaccuracy are the major technical errors influencing NRW. Whereas, aged infrastructures demonstrate higher severe effect than the rest. This calls for an attention on effective maintenance and repair of Mbeya water utilities infrastructures.

Furthermore, high NRW in Mbeya water utilities is undoubtedly affected by social facets particularly water theft, corruption, high water tariffs, and intermittent water supply. The study suggests that, water theft and bribery from meter readers strongly influence loss of revenues of water. Water utilities loose return on investment and profitability from incidents related with theft and corruption.

6.5 Recommendations of the Study

Based on the findings, the study recommends the following;

(i) In order to reduce unbilled authorized consumption, installation of standard meter design should be conducted align with repair of meter registration inaccuracies. Also, regular maintenance should be carried out to ensure efficient working condition of meters.

(ii) The study recommends that, Mbeya WWSA should upgrade aged infrastructure in its utilities for enhancing sufficient water supply and reduce risks associated with leakages and bursts.

(iii) Training and capacity building should be conducted to customers and staffs regarding the importance of reserving and managing water resources in order to streamline management of NRW fatalities.

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APPENDICES

Appendix I: Questionnaires

Particular information

1. Gender:

☐ Female ☐ Male

2. Age:

☐ 18-30 ☐ 31-45 ☐ 46-60

3. Education Level

☐ Secondary Education ☐ College Education ☐ Undegraduate

☐ Postgraduate

4. Experience

☐ 1-5 ☐ 6 years - 10 years ☐ 11 years - 15 years

☐ Above 15 years

1. Influence of unbilled authorised consumption on Non-Revenue Water

Please indicate your opinion on each of the item with a tick "√" based on scale 1-5: 1=Very high, 2=High, 3=Moderate, 4 =Low, 5=Very low.

s/n	Variable	Response				
		5	4	3	2	1
1	Unbilled authorised consumption influences NRW					
2	Metered Unbilled authorised consumption influences NRW					
3	Unmetered Unbilled authorised consumption influences NRW					

2. Influence of billing system errors on NRW

Please indicate your opinion on each of the item with a tick "√" based on scale 1-5:

1=Very high, 2=High, 3=Moderate, 4 =Low, 5=Very low.

s/n	Variable	Response				
		5	**4**	**3**	**2**	**1**
1	Billing system errors influence NRW					

3. Influence of technical errors on NRW

Please indicate your opinion on each of the item with a tick "√" based on scale 1-5: 1=Very high, 2=High, 3=Moderate, 4 =Low, 5=Very low.

s/n	Variable	Response				
		5	**4**	**3**	**2**	**1**
1	Age of infrastructure					
2	Leakages					
3	Bursts					
4	Metering inaccuracy					

4. Influence of social dynamics on Non-Revenue Water

Please indicate your opinion on each of the item with a tick "√" based on scale 1-5:

1=strongly disagree, 2=disagree, 3=neutral, 4 =agree, 5=strongly agree.

s/n	Variable	Response				
		5	**4**	**3**	**2**	**1**
1	Water theft					
2	High water tariff					
3	Corruption					
4	Intermittent water supply					

Appendix 2: Research Clearance Letter

THE OPEN UNIVERSITY OF TANZANIA

DIRECTORATE OF POSTGRADUATE STUDIES

P.O. Box 23409
Dar es Salaam, Tanzania
http://www.openuniversity.ac.tz

Tel: 255-22-2668992/2668445
ext.2101
Fax: 255-22-2668759
E-mail: dpgs@out.ac.tz

Our Ref: PG201801450

6th November 2020

Managing Director,
Mbeya Water Supply and Sanitation Authority,
P.O.Box 2932,
MBEYA.

RE: RESEARCH CLEARANCE

The Open University of Tanzania was established by an Act of Parliament No. 17 of 1992, which became operational on the 1st March 1993 by public notice No.55 in the official Gazette. The Act was however replaced by the Open University of Tanzania Charter of 2005, which became operational on 1st January 2007.In line with the Charter, the Open University of Tanzania mission is to generate and apply knowledge through research.

To facilitate and to simplify research process therefore, the act empowers the Vice Chancellor of the Open University of Tanzania to issue research clearance, on behalf of the Government of Tanzania and Tanzania Commission for Science and Technology, to both its staff and students who are doing research in Tanzania. With this brief background, the purpose of this letter is to introduce to you Mr. Leonidas Deogratias Bernado Reg No: PG201801657 pursuing Master of Project Management. We here by grant this clearance to conduct a research titled **"Determinants of Non-Revenue Water on Tanzania Water Utility: A Case of Mbeya Water Supply and Sanitation"**. He will collect his data in your office from 9th – 23th November 2020.

In case you need any further information, kindly do not hesitate to contact the Deputy Vice Chancellor (Academic) of the Open University of Tanzania, P.O.Box 23409, Dar es Salaam.Tel: 022-2-2668820.We lastly thank you in advance for your assumed cooperation and facilitation of this research academic activity.

Yours,

THE OPEN UNIVERSITY OF TANZANIA

Prof. Magreth Bushesha

DIRECTOR OF POSTGRADUATE STUDIES.

Appendix 3: Plagiarism Report

DETERMINANTS OF NON-REVENUE WATER (NRW) ON TANZANIA WATER UTILITY: A CASE OF MBEYA WATER SUPPLY AND SANITATION AUTHORITY

ORIGINALITY REPORT

25%	22%	12%	16%
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