**THE UNIVERSITY OF ZAMBIA**

# EFFECT OF NEW BOREHOLE PRICING REGIME IN THE WAKE OF GROUNDWATER REGULATIONS IN ZAMBIA

**BY**

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT FOR THE REQUIREMENTS FOR THE AWARD OF MASTER'S IN BUSINESS ADMINISTRATION**

## DECLARATION

I hereby declare that this research work represents my own work and that to the best of my knowledge, no other similar research work has been previously submitted for any award at the University of Zambia or from any other University. All that is borrowed from other scholars has been acknowledged and cited in my research work.

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## APPROVAL

This is to certify that this dissertation entitled, "**effect of new borehole pricing regime in wake of groundwater regulations in Zambia"** is submitted for examination under my supervision and approval.

**Name:** Dr. Aubrey Masumbu

**Signature: ……**

**Date: ..…… /……./……**

## DEDICATION

A special feeling of gratitude goes to my late father Mr. Mbolela Mkandawire, who ensured that l got educated to a level where l became independent. He was a strong believer in education as he knew that education is an equalizer and that it empowers women. My mother Estelle Zulu I am the woman l have become today because of your selflessness and tenacity to push me to greater heights so that I live a better life. I wish my father was here today to see what l have achieved thus far. It's very unfortunate that he is not here to celebrate with me yet another achievement in acquiring a Master's in Business Administration.

I further, dedicate this dissertation to my husband- Donald Chikule for being there for me and understanding my late nights of sleep. You supported me throughout my study period. To my children and wonderful sons Mapalo and Mbolela Chikule, I was not the best mom during this period of research as l was not always there to help you with the school-work because l had to pay more attention to my dissertation. Despite this situation, you remained understanding and supportive.

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## TABLE OF CONTENTS

**DECLARATION** ..... **i**
**APPROVAL** ..... **ii**
**DEDICATION** ..... **iii**
**ACKNOWLEDGEMENT** ..... **iv**
**LIST OF FIGURES** ..... **vii**
**LIST OF TABLES** ..... **viii**
**ACRONYMS AND ABBREVIATIONS** ..... **ix**
**ABSTRACT** ..... **x**
**1. CHAPTER ONE: INTRODUCTION AND BACKGROUND** ..... **1**
**1.1. Introduction** ..... **1**
**1.2. Background** ..... **1**
**1.3. Statement of the problem** ..... **3**
**1.4. Objectives of the study** ..... **3**
**1.4.1. General Objectives** ..... **3**
**1.4.2. Research Objectives** ..... **3**
**1.5. Research Questions** ..... **3**
**1.6. Significance of the study** ..... **4**
1.6 Scope of the study ..... 4
1.7 Limitations ..... 4
1.8 Structure of the dissertation ..... 5
**2. CHAPTER TWO: LITERATURE REVIEW** ..... **6**
**2.0 Introduction** ..... **6**
2.1 Empirical Review ..... 6
2.1.1 Groundwater Regulation in Zambia ..... 6
2.1.2 Groundwater Regulation in African Context ..... 9
2.1.3 Groundwater Regulation in Developed Countries ..... 13
2.1.4 Borehole Standardization and Design in African Context ..... **Error! Bookmark not defined.**
2.1.5 Borehole Pricing in African Context ..... **Error! Bookmark not defined.**
2.1.6 Borehole Pricing in Zambia ..... **Error! Bookmark not defined.**
2.1.7 Borehole Pricing in Developed Countries ..... **Error! Bookmark not defined.**
2.2 Theoretical Review ..... 17
2.2.1 Institutional theory ..... 17

2.1.2 Economic Theory ..... **Error! Bookmark not defined.**
2.1.3 Cost-Based Pricing ..... **Error! Bookmark not defined.**
**CHAPTER 3: RESEARCH METHODOLOGY ..... 18**
3.0 Introduction ..... 18
3.1 Research Design ..... 18
3.2 Research Approach ..... 19
3.3 Scope and Boundary ..... **Error! Bookmark not defined.**
3.4 Population and Sampling ..... 19
3.5 Study area, sample size ..... 20
3.6 Sampling Technique ..... 20
3.7 Trustworthiness and Credibility, ..... 21
3.8 Validity ..... 21
3.9 Reliability ..... 21
3.10 Data collection techniques ..... 22
3.10.1 Questionnaire ..... 22
3.10.2 Interviews ..... 22
3.11 Data Analysis ..... 22
3.12 Ethical Consideration ..... 23
**CHAPTER FOUR: DATA ANALYSIS AND PRESENTATION ..... 24**
4.0 Introduction ..... 24
4.1 Response rate ..... 24
4.1.1 Gender of the respondents ..... 24
4.1.2 Age of respondents ..... 25
4.1.3 Level of education ..... 26
4.1.4 Years in drilling business ..... 26
4.2 Borehole pricing among the players in the borehole drilling industry ..... 27
4.3 Borehole Standards ..... 28
4.5 Effects of ground water regulations ..... 29
4.6 Benefits of regulating the borehole drilling companies in the Zambia ..... 30
CHAPTER FIVE: DISCUSSION OF THE FINDINGS ..... 31
5.0 Introduction ..... 31
5.1 Discussion of the findings ..... 31
**CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS ..... 34**

6.0 Introduction ..... 34
6.1 Conclusion ..... 34
6.2 Recommendations ..... 35
**APPENDICES ..... 39**
Appendix I: Questionnaire ..... 39
Appendix II: Interview Guide ..... 42
Appendix III: Budget ..... 43
Appendix IV: Work Plan ..... 44

## LIST OF FIGURES

Figure 1: Response rate ..... **Error! Bookmark not defined.**
Figure 2: Percent Distribution of respondents by gender ..... **Error! Bookmark not defined.**
Figure 3: Years in drilling business ..... 26
Figure 4: Response on borehole standards ..... **Error! Bookmark not defined.**

## LIST OF TABLES

Table 1: Distribution of respondents by age group ..... 25
Table 2: Education level of the respondents ..... 26

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| **FAO** | Food Agriculture Organization |
| **NCC** | National Council for Construction |
| **WARMA** | Water Resources Management Authority |
| **WHO** | World Health Organization |
| **UNESCO** | United Nations Educational, Scientific and Cultural Organization |

## ABSTRACT

Water is life, essential for human existence, and its importance for individual health as well as the well-being of a nation and access to good quality water cannot be overemphasized. It is therefore believed that a borehole is a hydraulic structure which when properly designed and constructed, permits the economic withdrawal of water from an aquifer that can give fresh water to human beings, and other uses such agriculture, aquaculture, hydropower, industries and recreation. However, the fact that many boreholes fail, or perform poorly within a short time from construction is partly due, to a lack of professionalism in the drilling sector and the agencies and individuals that engage with it. Hence, the research objectives of the paper are generally focusing on how the regulation has impacted the pricing of a borehole in Zambia and provide the benefits that goes with regulating the borehole drilling and how the consumers stand to benefit from the groundwater regulation.

The study used a descriptive research design targeting a total of 65 respondents. The participants in the study, included WARMA (n=5), Drilling Companies and Clients/Customers (n=60). The non-probability sampling and purposive sampling to be specific was used for the targeted respondents as the study focused on Lusaka Province, Livingstone, Mongu, and Ndola, which are the locations of and bases of operations for most drilling companies. It employed both quantitative and qualitative approaches as it entailed the having gained an in-depth understanding of the phenomena under the study and help to understand the reality and how people interpret their different borehole drilling experiences.

The study discovered that drilling companies were registered companies, and that the majority of them were licensed with WARMA in class B which is mostly for the international companies and that after the introduction of drilling licenses by WARMA, the cost of drilling a borehole went higher than before such that both clients and drilling business companies were affected negatively hence the uproar.

It is evident that participants had strong opinion that drilling companies and their consumers suffer the impact when ground water and boreholes are regulated since they forced to pay more, and it takes a long time for drilling companies to obtain a license, without which it is impossible to drill a borehole. On the other hand, it was revealed that borehole regulations ensures that all people have equal access to water resources that are available in adequate quantities and of high enough

quality for a variety of purposes, such as commercial, the generation of hydropower, leisure, agriculture, mining, and navigation.

In conclusion, the development of management and monitoring of borehole standards strategies for borehole drilling is necessary since groundwater pollution is site specific and that to provide a good water supply service, every water borehole drilled, and every pump installed must be undertaken in a professional manner. Groundwater regulations have brought sanity in the industry thereby promoting sustainability of the ground water resources by inhibiting ramparted drilling of borehole which may lead to depletion of the resource. Further, the regulations provide for water quality standards that enforces assessments and treatment of polluted water which promotes the positive strides made by the government to increase the provision of safe and clean water. In addition to the enforcement of ground water regulations, it is imperative for the regulator to carry out sensitization programmes in communities and make sure that people understand why the regulation of drilling of boreholes was introduced in Zambia and its benefits to both the drilling business companies and the public at large.

# 1. CHAPTER ONE: INTRODUCTION AND BACKGROUND

## 1.1. Introduction

The research is focusing on how the regulation has impacted the pricing of a borehole in Zambia and provides benefits that goes with regulating the borehole drilling and how the consumers stand to benefit from the groundwater regulation. The study also provides the understanding on the effect that the groundwater regulations have had on the drilling business and how they can overcome the impeding potential problems in to sustain their businesses. This chapter presents the background of the study, objectives, research questions, problem statement, significance, and the scope of the study as well as the organization of the study.

## 1.2. Background

Groundwater comprises ninety-seven (97%) percent of the world's readily accessible freshwater and provides the rural, urban, industrial and irrigation water supply needs of 2 billion people around the world. As the more easily accessed surface water resources are already being used, pressure on groundwater is growing. In the last few decades, this pressure has been evident through rapidly increasing pumping of groundwater, accelerated by the availability of cheap drilling and pumping technologies and, in some countries, energy subsidies that distort decisions about exploiting groundwater World Health Organization report (WHO, 2015).

The groundwater abstraction future rates of global groundwater depletion will depend on the economic and environmental viability of extracting water from increasingly stressed aquifers. The analysis of global groundwater depletion is based explicitly on Global gridded groundwater availability and extraction cost data are aggregated to produce non-renewable resource supply curves for 235 major river basins and geopolitical regions. These resources are then exposed to dynamically generated demands for water in a fully coupled, multi-sectoral, global simulation. As groundwater head levels drop, imposing greater capital and operating costs to bring water to the surface, modeled water use sectors are able to deploy a range of supply and demand-driven adaptive responses (Van der Gun, 2012).

It is common for an enterprise to quote the cost of drilling a meter of hard rock based entirely on what others in the market quote, with the hope that at the end of the day, some profit will be made.

A water borehole is not just a hole in the ground. It has to be properly designed, professionally constructed and carefully drilled. Boreholes for extracting water consist essentially of a vertically drilled hole (inclined and horizontal boreholes are rare and will not be discussed here), a strong lining to prevent collapse of the walls, which includes a means of allowing clean water to enter the borehole space (screen), surface protection, and a means of extracting water. Drilling by machine is an expensive process, and boreholes require professional expertise for both their design and their construction (Danert, 2008).

Over 62 years Zambia had been operating on the premises of the old Water Act of 1948 until recently in 2011 when a revision of the Act was done and bared a new Water Act number 21 of 2011. The previous Water Act of 1948 the regulation of ground water was not prescribed hence the extensive drilling of boreholes was more pronounced leading to depletion of ground water in some part of the country more especially in the Lusaka's Chalala area. (WARMA Groundwater Assessment Report, 2015)

In the absence of the ground water regulations, the country saw rapid growth in the borehole drilling industry, which led to reduced borehole pricing and brought about competition among the players in the industry. The drilling companies had to in some cases compromised on the quality of boreholes which led to contamination of water and collapsing of boreholes. Refer to figure 1 .

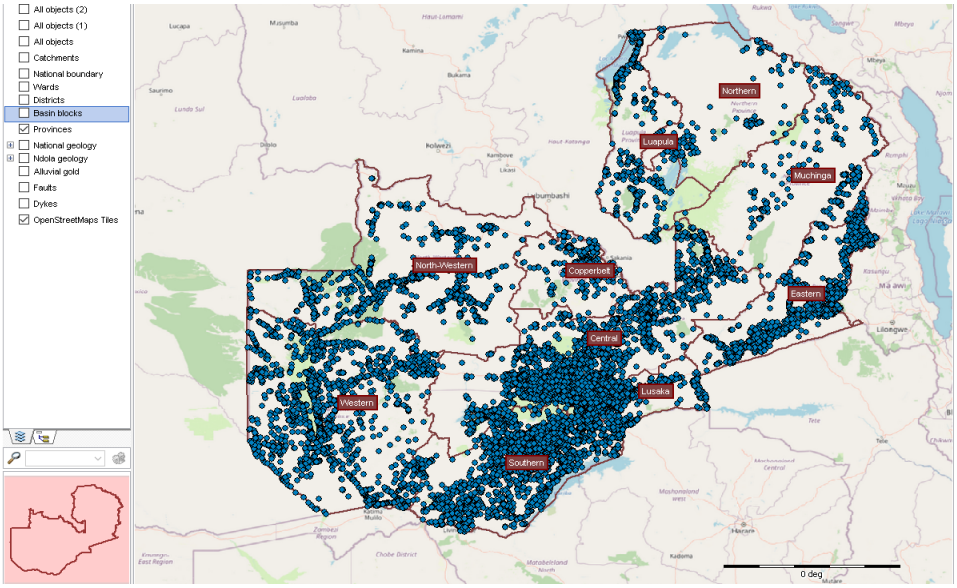



*Figure 1: Map shows boreholes drilled in Zambia (2022) - courtesy of WARMA*

The government of Zambia realized that water is a finite resource if not regulated it can deplete with time owing to the climate change scenarios. It was at this point that the government enacted a Water Resources Management Act number 21 of 2011 which prescribe the ground water regulations and borehole works. The law bared statutory instruments 18, 19 and 20 of 2018 which now defines in detail on how boreholes are to be drilled. With the climate change at the top of the agenda of every country in the world, the introduction of the groundwater regulation has come at a right time. The study of effect of borehole pricing regime in the wake of groundwater regulation is timely as it will provide the information on the importance of regulation of the borehole drilling and its benefit to the resource as well as the consumers and the public.

## 1.3. Statement of the problem

Government and donors were major players in the drilling of boreholes and relied on good management practices before groundwater regulations were introduced. Industrial boom of drilling machines created competition for customers resulting in price depression which further resulted in poorly constructed boreholes. It is yet to be known what has caused the sudden increase in the cost of drilling of a borehole in Zambia.

## 1.4. Objectives of the study

### 1.4.1. General Objectives

- To examine how the implementation of groundwater regulations and a new pricing regime for borehole drilling has affected the accessibility and affordability of groundwater resources in Zambia.

### 1.4.2. Research Objectives

a) To explore the different borehole pricing among the players in the borehole drilling industry.
b) To investigate the effect of ground regulation on the borehole drilling business and to the consumer
c) To assess the benefits of regulating the borehole drilling companies in Zambia

## 1.5. Research Questions

a) What are the different borehole pricing among the players in the borehole drilling industry?

b) What are the effects of ground water regulation on the borehole drilling business and to the consumer?

c) What are the benefits of regulating the borehole drilling companies in the Zambia?

### 1.6. Significance of the study

The importance of investigating the effect of new borehole pricing regime in the wake of ground water regulation in Zambia lies in its direct impact on water accessibility and quality. Unreliable or substandard boreholes jeopardize the well-being of the communities, potentially leading to waterborne diseases and long term degradation. Addressing the issue is essential for ensuring the effectiveness of water resource management policies and interventions, safeguarding public health, and promoting sustainable development in the region.

In addition, this study will reveal why the drastic change in pricing after the introduction of ground water regulations. Additionally, the findings of the study could be used as a basis for future studies by other researchers who wish to take similar study and may focus on why implementation of new regulations fails. Lastly, the study may be used as basis to carry out scientific evidence to the depletion of groundwater in some parts of Lusaka.

### 1.6 Scope of the study

The research focuses specially on understanding the recent price trends in borehole drilling in Zambia, more so drilling companies that are in Lusaka, Ndola and Livingstone. The choice of study area was based on capturing a variation of the scenarios and the extent of the clientele which are mostly found in the major towns. In addition, it was costly to target all drilling companies in the country because the research had a limited budget to work with. Equally time and human resources was not enough to cover the whole country.

### 1.7 Limitations

While the study aimed at identifying factors that contributed to current price increase, the study acknowledges potential limitations, such as limited access to proprietary industrial data and dynamic nature of market force. The other limitation of the study was access to limited sample size that affected the generalizability of the findings, as well as deepen the understanding the effect

of new borehole pricing regime in wake of groundwater regulations in Zambia, since not all towns are represented but boreholes are drilled countrywide.

### 1.8 Structure of the dissertation

The research is organized in six chapters and has been designed to follow the following structure of chapters:

**Chapter One:** This chapter covered the background of the study, the statement of the problem, the purpose of the study, the research objective, the research questions, the specific objectives, significance, and the scope of the study.

**Chapter two**: This chapter was a discussion of previous research studies related to the groundwater regulations and borehole pricing, benefits and effect to both the drilling companies and the consumers. The review was based on the country text and countries in the region that implemented similar regulations. The chapter highlighted the importance of regulating the drilling companies as well as consumer's rights.

**Chapter three:** The chapter was an elaboration of the research methodology adopted for the research and the aspects of the research that cover such as the design, approach, population sample and size.

**Chapter four:** The chapter presented the presentation and interpretation of the research findings, data analysis adopted from the research methodology.

**Chapter five**: This chapter presented in-depth discussion of the findings.

**Chapter six**: Conclusions and recommendations were drawn from the critical literature review and presented in light of the theoretical literature review. It out outlined the outcomes of the critical analysis tool used in research and the results obtained from the data collection and analysis

# 2. CHAPTER TWO: LITERATURE REVIEW

## 2.0 Introduction

To support the research on the works that has already been done and benefit from such works, a number of studies have been reviewed. The literature review includes both the empirical and theoretical review of the research study. The reviewed studies mainly focused on the groundwater regulations, standardization and pricing of boreholes in Zambia, Africa and Global perspective. The literature follows the order as outlined above:

## 2.1 Empirical Review

### 2.1.1 Zambia

Danert (2022), conducted a research on the achievement and lesson learned in the implementation of Groundwater Regulations in Zambia. It was found that developing the regulations illustrates the importance of partnership and wide consultation. The author indicated that since the promulgation of the three Statutory Instrument (IS) in March 2018, a considerable amount of data on boreholes drilled was collected by Water Resources Management Authority alongside the generation of substantial revenue. Further the study indicated that they were valuable learnt legal pitfalls alongside the practicalities of groundwater regulations. Among all the stakeholders interviewed for the study, there was an appreciation of the importance of and need to regulate groundwater, alongside a recognition that, particularly given the size of the country, that it was a huge undertaking for Water Resources Management Authority. The study further revealed that, the regulations were politicized, and even labelled “the borehole tax”, which could affect implementation going forward.

However, the study did not clearly indicate if the implementation of groundwater regulation affected the cost of drilling a borehole instead the report focused on the consultation and engagement of stakeholders and their response to the implementation of the groundwater regulations.

The finding of the study revealed that developing groundwater regulations takes time, they need to be government-led and requires the consultation of diverse stakeholders. Further, the study indicated that regulations must fall within the planning process and the regulator should envisage what happens after promulgation of the regulations. Communication about regulations and

stakeholder engagement is an ongoing task and must be priorities to ensure that there is a buy in from the public inclusive of the drilling companies.

According to WARMA (2021), In Zambia, water is recognized, by law, as having as an economic value, and the cost of facilitating its use is recognized as having a significant administrative cost. It was essential that the associated permit, license and use charges were widely understood, particularly by water users. It is believed that there was widespread awareness of the new regulatory requirements, this was due to initial communication efforts by WARMA, but concerns exist that more is needed to communicate with water users who may not yet be aware of the regulations, including those who do not read newspapers, hear the radio or watch television, or who may have otherwise missed the initial campaign.

The reports allude to the fact that the tremendous importance of water for the social and economic development of the country and the need for regulation, communication between WARMA and water users should actually be continuous. Collaboration between WARMA and organizations that represent different stakeholder groups provides one way of improving communication with water users, alongside use of mass media and other channels that enable face-to-face dialogue. The report indicated that there was generally goodwill towards the groundwater regulations, alongside concerns that while these regulations were generating revenue for WARMA, the process of translating the Water Resources Management Act, 2011 into regulations was not yet fully complete, and important gaps remain, with respect to groundwater depletion, borehole standardization and pricing, pollution and protection, as well as local governance of water resources and allocations at catchment and sub-catchment levels.

The report recommended that WARMA, national stakeholders and partners accelerate efforts to ensure that all subsidiary legislation are developed for all aspects of the WRM Act, 2011, with process planning efforts that extend beyond their promulgation. WARMA invests more in regular communication with those who are being regulated, including listening to, and documenting their concerns and ideas. As part of improved communication and implementation of groundwater regulations.

In another study conducted by Smith et al. (2018) examined the effectiveness of groundwater governance mechanisms in ensuring sustainable groundwater use and preventing overexploitation.

Their findings highlighted the importance of robust monitoring systems and regulatory enforcement to address groundwater management challenges.

It is clear that the report focused on communicating regulations to stakeholder, less was discussed regarding the standards introduced by the regulations and the effect of the same regulation on the business of drilling companies, and this posed a huge gap thereby affecting the borehole drilling cost.

WARMA (2022) the report focuses on the increase of drilling companies in Zambia, the report states that in 2005 India experienced industrial boom in the mass production of drilling rigs. The business model on production of drilling rigs was that they were loaned OUT TO Indian nationals who were in a race to repay the loans and quickly make a kill from the emerging borehole market in Zambia.

Further the report indicates that this led to the flooding of the market with many drilling rigs, many of which were provided as a loan. Due to the increased supply, with a somewhat constant demand, there was pressure on the supply side for the drillers. They needed to do some things that attracted customers to one and not the other. This biggest incentive was on the pricing.

So most drillers reduced the borehole drilling prices. In the absence of regulations, the casualty fell on the standard of drilling and materials to be used. Most drillers used the pretext or a trick that the rock beneath the surface was hard rock or competent rock which did not collapse if left uncased. This act dropped the market price of drilling from K25, 000 to a minimum of K6, 000. The resultant effect was the drilling of substandard boreholes which did not stand the test of time as most of them collapsed within a year.

The report further states that with these tendencies of substandard boreholes, it resulted in an unfriendly business environment as drillers and customers kept tripping to the Consumer and Competition Commission seeking compensation for substandard works. The Commission was approached due to absence in regulations from the Water Act of 2011. Even this intervention was not enough without express regulations dictating the construction standards of boreholes. However, it is unclear why the prices went up after the enactment of the Water Act of 2011. This study will therefore, reveal factors that influenced the prices in the drilling industry.

WARMA (2022) the report further reveals that gaps were created by lack of regulations and consumers exposed to unfair drilling practices such as installation of only 12m casing pipes, leaving the rest of the boreholes uncased. This resulted in poor constructed boreholes which would collapse within a short period of time. The consumers would then have to spend more trying to address the self-supply issue. It is for this reason that regulations on the construction of standard boreholes was done in 2018

The report documented that regulations provide for installation of full casing. Critical analysis of a borehole cost depicts casing pipes as costing one third of the borehole drilling cost. Drillers who want to cut prices will exploit this regulation in order to circumvent the provision or provide poor quality casing pipes. The effect would be that prices of certain boreholes would be uncharacteristically lower than the market prices. This has lead to increased number of poorly constructed boreholes leading to borehole failure (WARMA, 2022).

Another study by Johnson and Mwape (2019) investigated the impact of the new borehole pricing regime on the affordability of groundwater for rural communities. The research revealed the need for pricing mechanisms that balance affordability for users while ensuring sustainable funding for groundwater management.

### 2.1.2 African Context

According to (Ron 2010), a research was undertaken with regards to Assessment of Groundwater Investigation and Borehole Drilling Capacity in Uganda, in the research, the author emphasizes the need for government to regulate and support the water sector more vigorously, as follows; license drilling companies and groundwater professionals, design standard technical protocols for drilling projects and hydrogeological investigations, set up a performance monitoring system for contractors and consultants including regular field audits of work done by drillers and consultants, Improve compliance and enforcement of water laws, permits and licensing conditions for the various stakeholders (drillers, groundwater professionals, districts and NGOs) like closer monitoring of drilling companies and enforce implementation procedures according to standard documents Assessment of Groundwater. As the Author outlined above, these were measures to ensure that groundwater regulation were implemented in Uganda and that they were effective. This study was initiated with the overall aim to investigate the reported reduction in drilling capacity, analyze the factors that may play a role, and come up with suggested mitigation measures. In this

research, it is learned that in order for groundwater regulations to be implemented effectively, a number of measures must be put in place as to ensure compliance to the groundwater regulations.

In another study carried out by Alley in 2017, on High and dry: meeting the challenges of the world's growing dependence on groundwater. The study was as a result of the increase of groundwater dependence and the slowly depletion of groundwater in the New Haven. The research also emphasizes on ensuring that registering and/or licensing of groundwater abstraction must be held as a "best practice" in the control of groundwater use and a necessary step toward volumetric management of water resources. Yet, groundwater licensing and legalization processes in areas with many scattered (often agricultural) users tend to face severe difficulties and are rarely successful. Based on a survey on groundwater governance, this article revisits the reasons for the users' lack of interest, the failure of most legalization/licensing processes, and the frequent lack of both capacity and the political will of government agencies in conducting such processes. It identifies a groundwater licensing dilemma that explains why governments deploy too little effort too late.

In this report the author focused on the measures to be undertaken to ensure compliance on the registering and licensing of groundwater users which includes borehole drilling professions however, the report does not clearly indicate whether the licensing of these borehole drilling companies could potentially increase the borehole price thereby creating an uproar among water users.

Boreholes should be designed so that they are fit for their intended purpose (Carter et al, 2006). The author emphasizes that the diameter, depth, lining and backfill materials, screen open area and other design features should be well-matched to need (expressed as water demand, longevity, hydraulic efficiency and cost). Differentiating between different magnitudes of abstraction requirements is particularly important. Unfortunately, this is not always the case, because most drilling companies try by all means to abate the standards to reduce the cost of drilling a borehole.

Doyen (2003) points out that often, wells drilled for rural hand pump are being constructed to give high yields, and are forced to conform to higher standards necessary. Well yields of 0.25l/s are adequate for hand pump wells. Hand pump boreholes diameter requirements and the small

diameter submersible pumps that are now on the market mean that 4" (102mm) internal diameter boreholes are usually sufficient. However, diameter requirements vary considerably between countries: • Tanzania - the internal diameter for deep and shallow wells are specified at 150mm and 117mm respectively.

• Mozambique - 4" casing is installed, but there are no official standards (We Consult, 2006). • In Uganda 4-5" casing is specified (MWE, 2007a). • Six inch casing is used in Ethiopia and Zambia, although drilling diameters are often 10" or 12" (Carter, 2006). • Malawi specifies the installation of 110 mm casing (Mthunzi, 2004). • In Burkina Faso and Senegal, final drilling diameters are 8" and 12" respectively (ANTEA, 2007). • In Nigeria, there are five different borehole designs depending on the geology and aquifer depth in different parts of the country (Adekile and Olabode, 2008b). • In Kenya, well diameters for boreholes with hand pumps are 152mm (Doyen, 2003). In countries where boreholes are drilled into stable basement formation, it is possible to make savings by casing the collapsing formation only, grouting at the joint to the hard formation only and not casing the hole drilled into the basement, as is the standard in Uganda (MWE, 2007a). In Tanzania, all boreholes are fully cased and gravel packed, although Baumann et al (2005) state that the specifications are not very precise. In Nigeria, boreholes are lined to the full depth. Concerns about silting of partially cased boreholes have been raised.

A study in Malawi (Mthunzi, 2004) of 60 partially cased and 23 fully cased boreholes found that 73% of the partially cased boreholes had no depth reduction over 4-6 years and that 5% of boreholes showed an increase exceeding 5% of datum depth. Borehole yields were comparable for both types. In Kenya, drillers lobbied government for six years to relax the drilling specifications and thus drilling and rig costs but did not succeed. Part of the rational for this are plans to upgrade these sources to motorized pumps with small piped distribution systems at a later stage. Higher levels of abstraction also raise questions with respect to water resources. Drilling beyond the optimum yield depth is common, with examples documented in Ethiopia (Carter et al, 2006), Kenya (Doyen, 2003) and Nigeria (Adekile and Olabode, 2008b). Doyen (2003) estimates that cost savings of 25% could be made in Kenya if drilling was not beyond the optimum yield depth. In the basement complex, a geophysical survey can provide a good indication of depth requirements and for sedimentary formation; existing drilling records can be used to determine realistic drilling depths. There is need for close on-site supervision, with the supervisor having

the confidence and authority to decide when depth is sufficient. It is envisaged that the increased cost of better supervision would ultimately be offset by reduced drilling costs and improved construction quality. It is learned that they are several factors that increase the cost of drilling a borehole. Standardization and good designs of boreholes have huge impact on the drilling business. It is still unclear whether the standards introduced by the ground regulations have an impact or there are other factors influencing the increase in the borehole pricing.

Danert (2009), conducted a research on the Cost-Effective Boreholes in Sub-Saharan Africa which was aimed at understanding the borehole drilling cost based on standards in the Sub-Saharan region. The study consisted of over 10 countries in the region. The author stated that although drilling costs in Sub-Saharan Africa are generally higher than in India, there are valid reasons for this.

However, changes to borehole designs, procurement and contract management practices, well clustering for economies of scale, siting and supervision practices as well as support to and professionalization of the private sector can all serve to bring drilling costs down, and improve construction quality.

Further, the study pulls together the key issues that affect drilling costs and prices into a conceptual framework. The framework is subsequently used to compare policies and practices for the countries where information regarding borehole drilling cost was readily available

In addition, the study was intended to raise awareness and improve the analytical capacity of implementers and decision-makers regarding measures that could be adopted to improve the cost-effectiveness of borehole drilling in their particular context. It is therefore learned that the cost of borehole is different from pricing and that they are many factors that determine the price of the borehole. In the study of new borehole pricing in wake of groundwater regulation in Zambia it will reveal what constitute the pricing of the borehole in Zambia.

In another study, Doyen (2003), raised concerns regarding the disparity between the relatively low costs of hand pumps and the high costs of drilled wells at the UNDP-World Bank International Hand pump Workshop in 1992 (Cost savings on conventional drilling of as little as 10% would have a significant impact on extending access to improved water supplies). Use of manual drilling where feasible could also extend access at very low cost. However, it is essential that cost-savings

do not adversely jeopardize quality and that water borehole infrastructure can be sustained over the long term. Further, in order to attract private investment, borehole drilling must be a viable business venture. In order to improve the health of the borehole drilling sector, decision-makers and implementers should be able to easily identify issues that reduce efficiency and compromise quality.

It is essential to distinguish between borehole 'price' and borehole 'cost'. 'Price' refers to the amount paid by the Government or a particular project for a successfully completed borehole, whereas 'cost' is borne by the drilling companies. The difference between the two is the sum of overheads, taxes, profit and a margin for risk (e.g. dry holes, payment delays, insecurity and breakdown). Accurate information on drilling prices or costs in sub-Saharan Africa is not easy to access (ANTEA, 2007). Systematic analysis is a challenge because there is poor, fragmented and non-standardized record keeping of water supply projects and programmes in sub-Saharan Africa as well as lack of transparency.

**2.1.6 Global Perspective**

Sophocleous (2009), conducted a research on groundwater management, practices, challenges and innovation in High Plain Aquifers in the US. The aim of the study was to understand different approaches to the development and management of the groundwater based on each state's body of water laws that abide by different legal principles. The study indicates that the US High Plains groundwater is believed to be one of the largest freshwater groundwater systems in the world, continues to decline, threatening the long-term viability of the region's irrigation-based economy. The eight High Plains States take different approaches to the development and management of the groundwater based on each state's body of water laws that abide by different legal doctrines, on which Federal laws are superposed, thus creating difficulties in integrated regional water-management efforts.

The author further states that although accumulating hydrologic stresses and competing demands on groundwater resources are making groundwater management increasingly complex, they are also leading to innovative management approaches, which are a good examples for emulation in managing and regulating groundwater resources in Zambia. It is concluded that the fragmented and piecemeal institutional arrangements for managing the supplies and quality of water are inadequate to meet the water challenges of the future which includes the rampant borehole drilling.

Similarly in another study, The National Research Council (2001, 2004) indicated that the existing institutions are inadequate for managing water as a common pool resource or as a public good. The fragmented and piecemeal institutional arrangements for managing the supplies and quality of water are unlikely to be sufficient to meet the water challenges of the future (NRC 2001, 2004). Yet, the NRC (2001, 2004) also concluded that knowledge about how such institutions might be modified and improved is scarce, and research on institutions occupies only "a very small portion of the current water research agenda."

It is apparent that dealing with groundwater regulations and depletion issues forces politically difficult choices. Aiken (1984) pointed out that the most difficult choice was whether existing groundwater users would be forced to share groundwater deficit through reduced withdrawals, or whether that cost will be borne primarily by those denied groundwater access through development restrictions or prohibitions. Most western states, including the High Plains States, have exempted existing users from restrictions on groundwater use and are restricting only future groundwater development. This is probably the most important shortcoming of western groundwater depletion policies (Aiken 1984).

It is clear that the failure to regulate existing groundwater users reflects not only the strong opposition of existing groundwater users who have lobbied accordingly but also an apparent limitation inherent in appropriation law—that the quantity of an appropriative water right is not subject to reduction so long as the water is used beneficially. As pointed out by Aiken (1984), this fixed-quantity principle, followed in the High Plains States of Colorado, Kansas, and New Mexico, should yield logically to the physical reality of permanent supply reduction from groundwater depletion, such that withdrawal limitations should be legally tolerated to extend the life of the aquifer. Because the states of Texas, New Mexico, Kansas, Colorado, and Nebraska have critical area legislation and groundwater development may be restricted or prohibited in those areas. The economic impact of reduced irrigation is probably the biggest challenge in achieving reductions in water use when saving for tomorrow at the cost of today. The more the economy can be shifted away from irrigation and diversified, the easier it will be to implement and improve voluntary programs and regulations to conserve the water resource far into the future.

In the article Economic, social and resource management factors influencing groundwater trade: Evidence from Victoria, Australia the authors state that groundwater resources globally are under

increasing pressure due to factors such as historical unfettered development and increasing pressure for agricultural production and urban water demands (Qureshi et al.,2012; Gao et al., 2013; Palazzo and Brozovic 2014). The author further emphasized that once surface and groundwater systems become fully exploited, variability in seasonal rainfall and climate trends can restrict supply, cause supply reliability problems, increase competition among users and cause decline in groundwater levels. In most cases, this often comes at the expense of water-dependent ecological assets. Study state that groundwater use was regulated through provisions in the Victorian Water Act (1989) that require implementation of resource management plans in defined groundwater supply areas.

Further economic development is fundamentally constrained once the natural water resource limits have been reached, unless transfer of water holdings from low value use to higher value occurs. As with many other comparable economies and countries, agriculture is the main user of groundwater in the state of Victoria, Australia. Thus importance of groundwater regulations cannot be overemphasized.

It is apparent that from all these studies, the regulation of groundwater is mainly focused on the communication of groundwater regulations, institutions and stakeholders who are mandated to ensure compliance to the acceptable groundwater use. However, a huge gap still exists on how regulations affects the cost of doing borehole drilling business and changes in the borehole pricing regimes.

Zhussupbekov, Sarsembayeva & Kaliakin (2023) in the article Application of standardized subsurface conditions based on preprocessing of borehole data in Seoul, South Korea state that a bottom cap ensures that once a borehole is drilled and fully cased, there are no debris or mad that enters the borehole from below causing reduced overall depth of the borehole. The installation of this bottom plug requires a certain level of technical skill and competence. This attracts a premium on the management of drilling crew. Drillers who want to keep their costs low will circumvent this condition by omitting to install the cap to avoid costs or because they have not engaged the requisite skills. Further, explains that Gravel pack are crushed stones that are put between a borehole casing and the circular wall of the rock which has been bored. The space is called the annulus. This gravel pack is meant to be placed from about 1.5m below the ground to the bottom of the well. These crushed stones cost dearly. Drillers who want to reduce costs may only put very

little and only provide a superficial cover on top. The cost of the borehole may be below market price but the quality of the borehole poor.

This is the seal that is placed on the base of the borehole to about 1.5m below the ground. This is composed of a special material called bentonite or grout. It is a costly material. Drillers who want to undercut on pricing may not use this but natural soil. This is also a serious gap as material type is not specified in the law

The lack of specifying materials has the potential for circumvention which can lead to price depression and at the same time deliver poor quality boreholes.

The lessons from this report is that the materials used in drilling of a borehole has a serious cost implication on the costing and pricing of a borehole. In addition, the professional who are engaged in the drilling borehole such Hydrogeologist also contribute to the cost of the borehole since there services are a requirement for a drilling company to ensure a standard and quality borehole.

The study is therefore necessary to the proceeding study which will reveal the effect of new borehole pricing regime in the wake of groundwater regulation in Zambia as well as avail information relating to the extent drilling companies went in increasing the borehole prices as well as give more insight as how the regulator or enforcers can improve on information dissemination regarding groundwater regulation.

Having reviewed the literature on groundwater regulation, borehole standards and pricing in Zambia, Africa and Developed countries, it has been observed that groundwater regulations are everywhere and in most cases introduces standards that influence change in pricing of the borehole owing to other factors that may contribute in price increase such as high demand in the commodity and availability of materials used in the construction of a borehole.

However, pricing of boreholes differ from country to country, sub-sahara Africa and developed countries having the high cost of drilling boreholes. In addition, the lessons drawn from studies reviewed were that standards and quality of a borehole, material used and availability of drilling rigs can be used to determine the costing and pricing of the borehole. None availability of serviced water has a huge influence on the demand for boreholes. A huge gap still remains on how groundwater regulations affect the pricing of the boreholes.

## 2.2 Theoretical Review

### 2.2.1 Institutional theory

Institutional theory suggests that institutions, which can include organizations, laws, regulations, and cultural beliefs, play a crucial role in shaping human behavior by providing stability, guidance, and legitimacy. These institutions create expectations and norms that individuals and organizations adhere to in order to gain social acceptance and legitimacy.

The theory emphasizes that individuals and organizations are not only driven by economic incentives but also by social and cultural pressures to conform to institutional expectations. Compliance with institutional rules and norms is seen to gain legitimacy, reduce uncertainty, and ensure social approval (Scott, 2008).

Institutional theory also recognizes the influence of isomorphism, which refers to the tendency of organizations to become similar or mimic other organizations within the same institutional field. Isomorphism can occur through coercive pressures (such as legal requirements), normative pressures (social expectations and professional standards), and mimetic pressures (imitation of successful practices), (Scott, 2008).

Overall, institutional theory helps explain how institutions shape the behavior, decision-making, and organizational structures of individuals and organizations (Scott, 2008). It provides insights into how institutions influence processes such as organizational change, decision-making, and the adoption of new practices or innovations. Institutional theory was used to understand the challenges of implementing the new borehole pricing regime in Zambia. Institutional theory also provided insights into the factors that influence the adoption and diffusion of new policies and regulations.

# CHAPTER 3: RESEARCH METHODOLOGY

## 3.0 Introduction

The present chapter elucidated the procedure of formulating the research methodologies requisite for the successful execution of the ongoing investigation. The chapter provided a comprehensive examination of the different phases involved in the development of the methodology, encompassing a thorough analysis of the philosophical underpinnings of the selected research approach. Furthermore, the chapter provided a comprehensive overview of the data collection strategy, which encompassed the meticulous selection of research instrumentation and the implementation of a rigorous sampling methodology. The chapter concluded with a comprehensive examination of the analytical methodologies employed for data analysis.

## 3.1 General philosophical perspective

The philosophical perspective that was applied to the study on the effect of the new borehole pricing regime in the wake of groundwater regulations in Zambia was Constructivism. Constructivism is a learning theory that emphasizes the active role of learners in building their own understanding. According to constructivism, knowledge is not passively received but actively constructed by individuals based on their previous knowledge, experiences, beliefs, and insights (Tam, 2000). Applying a constructivist perspective to the study involved considering how individuals in Zambia, such as borehole users, construct their understanding of the new pricing regime and regulations. It explored how their previous knowledge and experiences shaped their interpretation and response to these changes. This perspective also considered the social and cultural context in which individuals operate and how it influences their understanding and actions.

By adopting a constructivist perspective, the thesis delved into the ways in which individuals in Zambia actively engage with and make sense of the new borehole pricing regime and groundwater regulations. It further explored the role of individual interpretations, knowledge construction, and the influence of social and cultural factors on the implementation and impact of these policies.

## 3.2 Research Design

The concept of research design can be defined as a comprehensive framework that delineates the specific procedures and methodologies employed in the execution of a research study (Yin, 2013). This encompasses the methodology for data collection, the selection and utilization of instruments, the procedures employed in instrument usage, and the methods for data analysis. The present study

employed a descriptive research design to investigate the effects of groundwater regulation on the pricing of boreholes in Zambia. The research employed a descriptive study methodology to assess the influence of groundwater regulation on borehole pricing. The study specifically examined drilling companies operating in Lusaka, as well as a sample from other towns such as Ndola, Livingstone, and Mongu.

## 3.3 Research Approach

The study employed a mixed research method informed by the philosophical notion of pragmatism. Pragmatism provides a valuable opportunity for researchers to employ a combination of quantitative and qualitative methodologies in their research endeavors. According to Hall and Greene (2010), pragmatism is a comprehensive approach that is tailored to the specific problem at hand and employs a combination of methodologies to gain understanding and knowledge about the problem. Therefore, it is crucial to employ a mixed methods approach as it is inadequate to solely rely on quantitative or qualitative methods as unbiased approaches in order to gain a comprehensive understanding of research problems. The triangulation of research approaches provides the most comprehensive understanding (Creswell, 2014). Consequently, this research employed a combination of qualitative and quantitative methodologies in order to obtain a comprehensive comprehension of the phenomena being investigated and to elucidate the nature of reality and individuals' interpretations of their experiences.

## 3.4 Population and Sampling

Sampling was a fundamental procedure in this research that involves the deliberate selection of units from a specific population of interest. This process is crucial as it enabled researcher to draw valid and reliable conclusions from the sample, which can then be generalized to the larger population. The subset of individuals under investigation was referred to as a sample population. A sample in this case were elements that were obtained through a systematic process from a predetermined population. Hence, this research has recruited prospective participants from drilling companies, regulatory bodies, and consumer groups. The focus of this study encompassed solely on the drilling companies, consumers, and the regulatory body. During the initial stage of data collection, drilling companies were selected for sampling based on their classification using a method known as disproportionate sampling. In the second phase, the research employed maximum variation sampling to select drilling companies and consumers for in-depth interviews.

This sampling technique aimed to ensure that the selected participants would possess characteristics that aligned with their responses to the survey questionnaire.

## 3.5 Study area, sample size

The study was carried out in the cities of Lusaka, Livingstone, Mongu, and Ndola. The following municipalities exhibit the highest concentration of registered drilling enterprises. The primary study region encompasses an area of approximately 21,896 square kilometers. Additional sites have been incorporated based on the spatial distribution of drilling companies and their relevance to the study. A comprehensive survey was conducted, consisting of interviews with a total of 60 drilling companies.

A sample size of 70 participants was included in the study, comprising 10 individuals from the Water Resources Management Authority (WARMA) and 60 consumers/clients who had boreholes drilled in the current year. The participants were selected through purposive sampling and subsequently interviewed.

The subsequent section presents the formula and calculation utilized to determine the sample size for drilling companies.

**The variable "n" is used to represent an unknown or unspecified value in mathematical equations or**

In this context, the variables are defined as follows: n represents the desired sample size, N denotes the target population size, and e signifies the level of precision, also known as the margin of error. When the data, consisting of 70 targeted drilling companies, is inputted into the formula with a 95 percent confidence level and a 0.05 level of precision, the resulting sample size is as follows:

Therefore, a sample size of 60 potential respondents was selected from a population of 70 licensed bore drilling companies.

### 3.6 Sampling Technique

The research employed a non-probability sampling method, specifically the purposive sampling technique. In this methodology, it is imperative to possess a comprehensive understanding of the subject matter, and subsequently, carefully choose sample elements that exhibit a higher degree of representativeness to the overall population. Purposive sampling is employed when an expert in a

particular field selects a sample that is more representative and likely to yield more accurate results compared to other probability sampling techniques. The procedure entails the deliberate selection of individuals from the population, solely on the basis of their affiliation with registered drilling companies under the authority's purview.

### 3.7Trustworthiness and Credibility,

To ensure the reliability and validity of the study, the research employed the strategy of utilizing multiple sources of data and employing triangulation techniques. Data was gathered through the utilization of interviews and questionnaires, which encompassed a wide range of participants, such as regulators, borehole drilling companies, and water consumers. This approach aimed to encompass diverse viewpoints and ensure a comprehensive understanding of the subject matter. Furthermore, the study furnished an elaborated exposition of the study's design and methodology, which consisted of the sampling technique and procedures for data analysis. The research additionally ensured that ethical considerations are duly acknowledged, encompassed the acquisition of informed consent from participants, upholding confidentiality, and guaranteeing accurate analysis and presentation of data.

### 3.8 Validity

In order to establish the credibility of the study, the research took measures to ensure that the research questions are unambiguously formulated and closely aligned with the study's objectives. The research additionally ensured that the inquiries in the questionnaire were pertinent and suitable for the target population, and that they accurately assessed the intended constructs. The research i employed well-established instruments and methodologies, including the preliminary testing of the questionnaire with a limited number of participants, in order to ascertain the clarity and lack of ambiguity in the questions.

### 3.9 Reliability

To enhance the dependability of the study, the research used standardized methodologies and protocols for both the collection and analysis of data. The research implemented measures to ensure the questionnaire was designed with consistency and administered uniformly to all participants. Furthermore, the study employed statistical methodologies to evaluate the dependability of the gathered data, encompassed internal consistency and test-retest reliability.

### 3.10 Data collection techniques

#### 3.10.1 Questionnaire

A questionnaire is a research tool comprising a sequence of inquiries and supplementary prompts strategically formulated to extract information from individuals participating in the study. The standardized data collection tool mentioned is employed to systematically and structurally collect data from a substantial sample size of individuals (Krosnick, 2018). The utilization of the questionnaire method proved advantageous in situations where the research aimed to gather data from a substantial number of participants. This study employed questionnaires as a data collection method to evaluate the effects of the recently implemented borehole pricing system on the accessibility of clean water, affordability of borehole drilling services, and overall satisfaction among a representative sample of water consumers. The questionnaires served as a foundation for examining the various factors that impact the demand and supply of borehole drilling services. The questionnaires were administered with the authorization of the University and the Water Resources Management Authority (WARMA), in addition to obtaining consent from the participants. During the study, participants provided responses without experiencing any apprehension, as the research ensured the maintenance of privacy and confidentiality.

#### 3.10.2 Interviews

The interview method proved to be advantageous in situations where the research had seek to acquire a more profound comprehension of the viewpoints and encounters of the participants. This study involved conducting interviews with key stakeholders such as WARMA and water consumers to gather their perspectives on the efficacy of the recently implemented borehole pricing regime in facilitating sustainable groundwater management and enhancing the availability of safe drinking water. The conducted interviews yielded valuable insights regarding the challenges and opportunities that are linked to the implementation of the new regime.

### 3.11 Data Analysis

The qualitative data was gathered and examined thematically, while the quantitative data was entered and coded using Microsoft Excel 2016. The collected quantitative data was summarized and analyzed using Statistical Package for Social Sciences (SPSS) version 22.

The research identified pertinent segments of data and assigned codes to them. The process entailed assigning concise descriptive phrases or words to the segments of data in order to represent their content. Various codes were allocated to distinct components of the data, including sentences, paragraphs, or sections of text. Additionally, the research discerned patterns or recurring ideas within the coded data. The process entailed categorizing codes into thematic clusters according to shared characteristics in their content. The themes were formulated in accordance with the research questions and objectives of the study.

In general, the utilization of thematic analysis facilitated the research in the identification and examination of recurring patterns and themes present in the data obtained from interviews and questionnaires. The themes were formulated in accordance with the research questions and objectives, and subsequently modified and improved as deemed necessary. The analysis yielded valuable insights regarding the effects of the recently implemented borehole pricing system in Zambia, following the introduction of groundwater regulations. These insights were obtained by considering the viewpoints of the participants involved.

### 3.12 Ethical Consideration

Ethical considerations encompass a set of moral principles that guide the conduct of research, with the aim of generating systematic and verifiable knowledge (Wehmeier, 2011). The study has taken into account ethical concerns, particularly in relation to the preservation of anonymity. These concerns encompass the principles of confidentiality and the protection of respondents' right to privacy. Participants are an essential component of any research endeavor. Consequently, it is crucial to prioritize the treatment of participants throughout the research process. This involves addressing ethical considerations, such as obtaining participants' informed consent, ensuring anonymity, maintaining confidentiality, and respecting their privacy.

The involvement of the individuals in the study was completely based on their own volition. The decision to participate or abstain from participation lies within the discretion of the individual participant. The decision of individuals to abstain from participation will have no impact on the borehole drilling industry or any related matters. The duration of the interviews and questionnaires is estimated to be approximately 10 to 15 minutes per session.

## CHAPTER FOUR: DATA ANALYSIS AND PRESENTATION

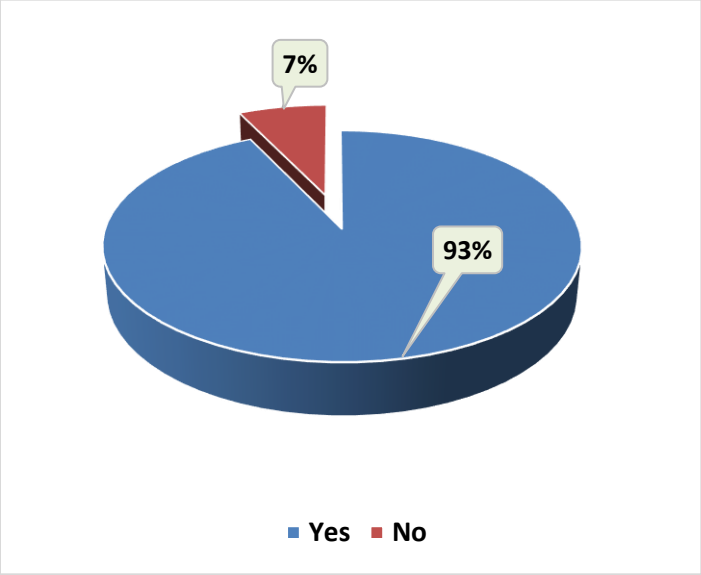
### 4.0 Introduction

This chapter focuses on the presentation and interpretation of data regarding the effects of groundwater regulations on borehole pricing and how the regulations have affected consumers and borehole drilling.

### 4.1 Response rate

The study achieved a response rate of 93% (n=65). This indicates that 65 out of the intended 70 participants actively engaged in the study, and subsequently, the collected data was subjected to analysis. The participants in this study were selected from the Water Resources Management Authority (WARMA) and individuals who had boreholes drilled between the years 2020 and 2022.

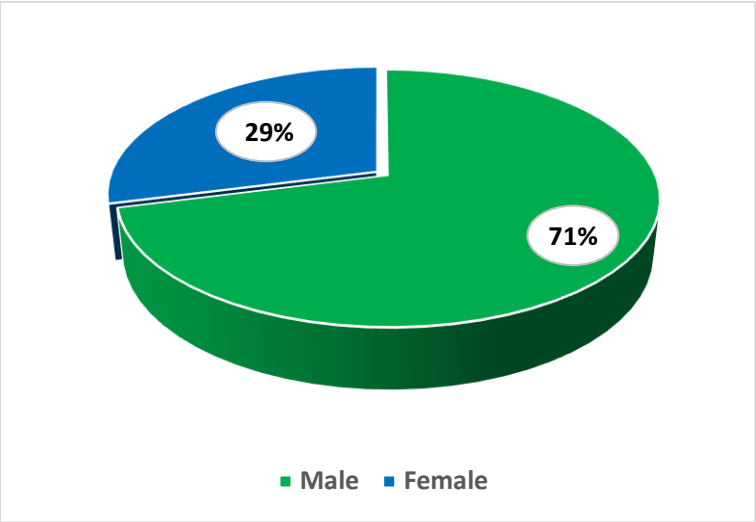
**Figure 1: Response rate**




### 4.1.1 Gender of the respondents

The gender of the participants is depicted in the findings presented in Figure 2 below. A total of 46 respondents, constituting 71% of the sample, identified as males, while 19 respondents, accounting for 29% of the sample, identified as females. This finding indicates that the study predominantly consisted of male participants.

**Figure 2: Percent Distribution of respondents by gender**




### 4.1.2 Age of respondents

Table 1 presents the distribution of ages among the respondents. The results indicate that a significant proportion of the participants, specifically 46% (n=30), fell within the age range of 31-40 years. Additionally, 31% (n=20) of the respondents belonged to the age group of 41-50 years, while 15% (n=10) of the participants were aged between 20-30 years. Furthermore, a total of 5 respondents, accounting for 8% of the sample, fell within the age category of 50 years and older. This finding indicates that a significant proportion of the participants in the study fell within the age range of 31 to 40 years.

***Table 1: Distribution of respondents by age group***

| Age (Years) | Frequency | Percent |
|---|---|---|
| 20-30 | 10 | 15 |
| 31-40 | 30 | 46 |
| 41-50 | 20 | 31 |
| 50 and above | 5 | 8 |
| **Total** | **65** | **100** |

### 4.1.3 Level of education

The findings of the study indicate that a significant proportion of the participants (55%, n=36) had received a tertiary education. This was followed by participants who had attained a secondary level of education, accounting for 30% (n=19) of the sample. A smaller percentage, specifically 15% (n=10), had completed only primary education. This suggests that all the participants who were surveyed possessed a certain level of educational attainment

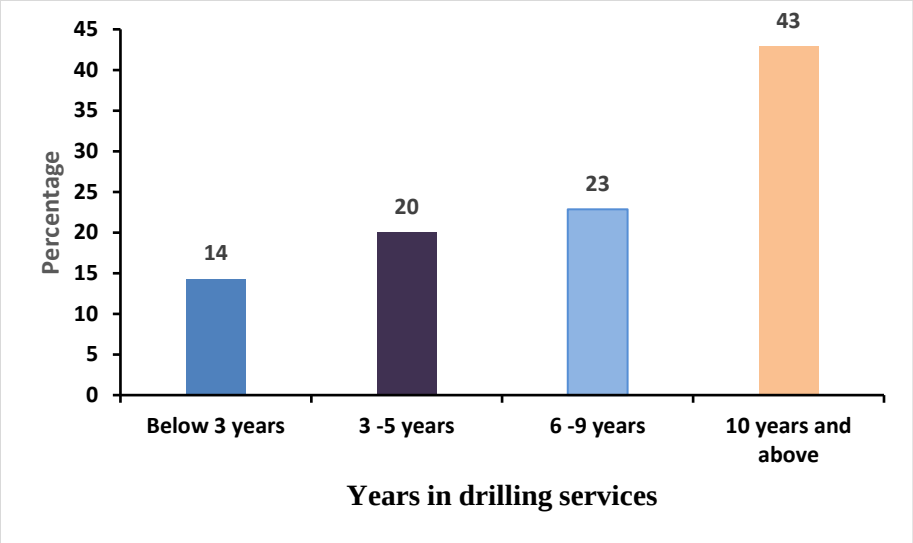
***Table 2: Education level of the respondents***

| Education level | Frequency | Percent |
|---|---|---|
| Primary | 10 | 15 |
| Secondary | 19 | 30 |
| Tertiary Educationl | 36 | 55 |
| **Total** | **65** | **100** |

### 4.1.4 Years in drilling business

The majority of the participants had been involved in the drilling industry for a period exceeding 10 years (43%, n=15). This was followed by individuals who had been in the industry for a duration ranging from 6 to 9 years (23%, n=8). Additionally, 20% (n=7) of the respondents reported having been engaged in the same business for a period between 3 and 9 years, while the smallest proportion consisted of newcomers to the industry, with less than 3 years of experience (14%, n=5). This suggests that a significant proportion of the 35 drilling companies included in the study had been operating for a period exceeding 10 years.

***Figure 1: Years in drilling business***




### 4.2 Borehole pricing among the players in the borehole drilling industry

Due to the pressures of commercial competition, drilling contractors frequently exhibited hesitancy in disclosing price quotations unless accompanied by precise information regarding geological conditions and projected depths of potential boreholes at respective sites. One possible action that they might take is to make a request for a hydrogeological site survey to be conducted prior to proceeding. On the contrary, it is worth noting that the majority of drilling companies identified were duly registered entities specializing in drilling operations, possessing a valid class B license issued by the Water Resources Management Authority (WARMA).

Based on the interviews conducted with the companies, it was found that prior to the implementation of licensing by the Water Resources Management Authority (WARMA), the prices of boreholes ranged from ZMK 6,000.00 to 8,000.00. However, following the introduction of the licensing system, it was reported that the charges increased significantly, ranging from ZMK 13,000.00 to 14,000.00.

When queried about the reasons behind the significant fluctuations in borehole prices, the respondents provided the following responses:

*Regrettably, Zambia has witnessed a significant number of instances wherein drilling enterprises have faced insolvency or struggled to maintain competitiveness. One of the challenges encountered pertains to the absence of realistic cost estimation and pricing strategies for their endeavors.*

*Consequently, the implementation of standards by the Water Resources Management Authority (WARMA) has had a significant impact on our business, resulting in price increases.*

**Respondents 1, 3, 5,13**

*The escalating expenses associated with fuel, particularly diesel, have a significant impact on the transportation of goods via trucks, trains, and ships. In order to maintain sustainability, we are compelled to raise prices.*

***Respondent 1, 24,30***

*The cost has increased because we are casing the borehole from top to bottom.*

***Respondents 2,3***

*Since the introduction of borehole standards has raised the cost of doing business, it has also been necessary to raise prices because we must pay for licenses each year and obtain permission to drill boreholes. However, if we are licensed with WARMA, there is a proper system.*

***All respondents***

### 4.3 Borehole Standards

Borehole standards refer to a set of guidance notes that outline the contractual arrangements and specifications for casing a borehole from top to bottom and capping it. These standards are applicable to the construction and installation of water supply boreholes. The execution of all tasks must adhere to the most recent Health and Safety regulations, with the shared responsibility for ensuring compliance falling upon the client, consultant, and drilling contractor.

The participants were requested to provide their perspective on the relevance of obtaining a licence from the Water Resources Management Authority (WARMA). Although a significant proportion of participants (53%, n=16) concurred that borehole standards were pertinent, the majority of respondents expressed a preference for such standards. A total of 27% (n=8) of participants expressed disagreement, whereas the lowest percentage of respondents, 20% (n=6), indicated ambivalence towards the same question.

### 4.5 Effects of ground water regulations

The Lusaka West Groundwater Assessment Report (WARMA, 2022) highlights a decline in the operations of borehole drilling companies due to their role in the contamination of groundwater. This is the rationale behind the government's desire to implement regulations on borehole drilling companies, with the aim of mitigating the consumption of contaminated water and the depletion of this valuable resource.

The participants were requested to provide an elucidation regarding the impacts of ground water regulation on both the borehole drilling industry and consumers. The participants provided the following responses:

*The increased costs have an impact on both clients and drilling companies, as they are required to allocate additional funds.*

***All Respondents***

*Obtaining a license is a time-consuming process, and without this license, it is not possible to proceed with the drilling of a borehole.*

***The individuals identified as the number of respondents was 12, 23 and 17.***

*At times, adhering to the prescribed standards for placing casings from top to bottom can pose challenges, thereby rendering compliance with this regulation arduous. Additionally, the associated costs of materials further compound the difficulty in adhering to said regulation.*

***The number of respondents was five.***

*Indeed, the clients and drillers are producing commendable tools that have garnered recognition from the WARMA department. This recognition is based on the adherence to the specific requirements set forth by the drillers. Consequently, the drillers' requirements serve as a pivotal factor in determining the efficacy and satisfaction derived from these tools.*

***Respondents 12***

*The regulation, management, protection, and conservation of Zambia's water resources contribute to the achievement of sustainable development within the country. Furthermore, it will ensure*

*equitable availability of water resources that are sufficient in both quantity and quality to cater to a diverse array of purposes, encompassing commercial activities, hydropower generation, agricultural practices, mining operations, navigation requirements, and recreational pursuits.*

***The personnel at WARMA***

*The ineffectiveness of licensing systems for drilling, specifically aimed at regulating groundwater withdrawal, can be attributed to several factors. These include challenges related to tax enforcement, resistance from pumpers to comply with regulations, a lack of well-defined criteria for granting or denying licenses, and inadequate enforcement mechanisms.*

***The individuals identified as respondents 3, 5, 8, and 11.***

**4.6 Benefits of regulating the borehole drilling companies in the Zambia**

*The expansion of borehole drilling enterprises has experienced a setback due to their role in facilitating the contamination of groundwater. In order to mitigate the consumption of contaminated water, the government endeavors to regulate companies engaged in borehole drilling.*

***The personnel of the Water Resources Management Authority (WARMA).***

Water from boreholes can become unsuitable for domestic use due to contamination, making it unfit for consumption. Therefore, effective water quality management is crucial in order to mitigate the health risks associated with its use.

***The participants identified as Respondent 1, Respondent 3, and Respondent 5.***

By implementing regulations on borehole drilling companies, clients are provided with a sense of safety, and the likelihood of borehole collapse in our communities is reduced.

## CHAPTER FIVE: DISCUSSION OF THE FINDINGS

### 5.0 Introduction

This chapter provides an overview and analysis of the study. The present discourse centers on the examination of the consequences of groundwater regulations on the pricing of boreholes, as well as the subsequent effects on borehole drilling and consumers in Zambia.

### 5.1 Discussion of the findings

Groundwater holds paramount significance within the hydrological cycle, serving as a crucial reservoir of potable water in Africa and accounting for approximately two-thirds of the global freshwater resources, as reported by the Food Agriculture Organization (FAO Aquastats, 2000).

The study achieved a response rate of 93% (n=65). It should be noted that, in this study, the total number of participants fell short of the intended target of 70, with only 65 individuals ultimately taking part. The subsequent analysis of the collected data revealed that males constituted the majority of respondents, accounting for 71% (n=46) of the total sample. Out of the participants, 50% (n=25) belonged to the age group of 31-40 years, while the age group of 50 and above had the lowest representation. Furthermore, a significant proportion of the participants exhibited a level of educational attainment, with the majority possessing experience in the drilling industry for a duration exceeding 10 years (43%, n=15).

The findings of the study suggest that the drilling companies examined were officially registered entities, with a significant proportion of them possessing Class B licenses granted by WARMA. Furthermore, it was observed that a considerable number of these drilling companies were of international origin. The study also unveiled that before the introduction of licensing by the Water Resources Management Authority (WARMA), the cost of borehole drilling varied between ZMK 6,000.00 and ZMK 8,000.00. Subsequently, following the implementation of drilling licenses and permits, there was a notable surge in charges, with rates ranging from ZMK 13,000.00 to ZMK 14,000.00. The aforementioned findings align with the conclusions derived from Michaela Draganska's research conducted in the domain of Marketing Science in the year 2006. Draganska's research findings have illustrated that the pricing dynamics of a particular product, regardless of its nature as a tangible good or an intangible service, are subject to the complex interaction between

the forces of supply and demand. Furthermore, it can be argued that according to the theory of price, the optimal market price for a particular good or service is determined by the intersection of the benefits perceived by buyers and the marginal costs incurred by sellers (Draganska, 2006).

The findings of the study indicate that the implementation of groundwater regulations can result in elevated expenses for both clients and drilling companies. It can be inferred that adherence to the regulations may necessitate supplementary investments in equipment, materials, and processes, potentially leading to elevated service fees for clientele. However, it is important to consider that drilling companies could encounter elevated operational expenses as they strive to adhere to regulatory mandates, which could potentially have an adverse effect on their profitability. Moreover, the research highlighted that the acquisition of the requisite permits for drilling boreholes can be a laborious and time-intensive procedure. The potential for delays in the acquisition of licenses may impede the prompt implementation of borehole projects, thereby impacting both drilling companies and clients seeking access to groundwater resources. This matter underscores the significance of optimizing the licensing procedure and establishing concise and effective protocols for acquiring permits. The results of this study align with those of Majuru et al. (2017), which demonstrated that the regulation of groundwater has a notable adverse impact on businesses engaged in borehole drilling. This is primarily due to the increased costs associated with complying with regulatory obligations. On the contrary, Nkhuwa et al. (2014) found that establishing trust with consumers and stakeholders can be achieved by demonstrating a dedication to quality, safety, and ethical standards through regulatory compliance. This trust-building process has the potential to enhance customer satisfaction and facilitate business expansion.

Furthermore, the study also revealed that the regulation of water resources in Zambia contributes to the achievement of sustainable development within the country. This regulation ensures equitable access to water resources that are sufficient in quantity and quality for various purposes, such as hydropower generation, agricultural activities, mining operations, industrial processes, navigation, and recreational activities.

Additionally, the research revealed that enterprises engaged in borehole drilling may encounter limitations on their water extraction capacity due to regulatory measures. This phenomenon can potentially constrain their capacity to fulfill consumer expectations and impact the financial viability of the enterprise. In contrast to the aforementioned findings, Homes (2007) discovered

that borehole water became unsuitable for domestic use due to contamination, rendering it unfit for consumption. Consequently, the regulation of borehole drilling is necessary, without necessarily compromising the proficiency of drillers in meeting customer demands. The findings of Udom et al. (2002) are incongruent with the present study, as they indicate that the primary objective of water quality management is typically to mitigate the health hazards associated with both direct and indirect water usage. Furthermore, their research suggests that the implementation of regulatory measures for water quality leads to a reduction in the likelihood of water contamination.

The present study elucidated several prospective advantages associated with the regulation of borehole drilling enterprises. By implementing regulatory oversight and ensuring adherence to established guidelines, clients can have confidence in the safety of these companies. This aspect holds significant importance due to the heightened probability of borehole collapse and subsequent endangerment of communities reliant on these water sources when the drilling and maintenance procedures are inadequately executed. Furthermore, the government's motivation for regulating borehole drilling companies primarily stems from its concern for the management of water quality. The implementation of suitable regulations enables the mitigation of risks related to groundwater contamination. The implementation of appropriate protocols and effective supervision can contribute to the responsible execution of borehole drilling activities, thereby mitigating the risk of groundwater contamination.

# CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

## 6.0 Introduction

The chapter presents the study's findings and offers suggestions for future actions. The conclusions and recommendations in this study were derived solely from the findings and recommendations provided by the respondents.

## 6.1 Conclusion

In summary, this study has elucidated the ramifications of groundwater regulations on the pricing of boreholes and the subsequent effects on borehole drilling and consumers in Zambia. The study aimed to examine the variations in borehole pricing within the borehole drilling industry, analyze the impacts of groundwater regulations on both the borehole drilling business and consumers. The present study conducted a comprehensive evaluation of the advantages associated with the regulation of borehole drilling companies in Zambia. Additionally, the research sought to investigate the categorization of drilling companies by the regulatory body.

The study revealed that the drilling companies identified were registered entities, with a significant proportion of them holding licenses from WARMA classified as Class B. This classification predominantly applied to international drilling companies.

The study posited that the implementation of effective regulatory measures for borehole drilling can yield substantial advantages, such as enhanced safety measures, diminished likelihood of groundwater contamination, and the promotion of responsible drilling methodologies. Through strict adherence to established guidelines and robust oversight mechanisms, companies engaged in borehole drilling have the potential to make significant contributions towards the protection of the environment and the provision of dependable access to clean water resources for local communities. Nevertheless, there exists a divergence of opinions regarding the ramifications of regulatory measures on enterprises engaged in borehole drilling. Certain research endeavors have demonstrated adverse consequences on operational expenses, while others have underscored the favorable influence on the management of water quality and mitigation of contamination hazards.

In general, the research emphasized the significance of achieving a harmonious equilibrium between regulatory measures and commercial concerns in order to establish a sustainable approach to groundwater management and ensure fair distribution of water resources. Additionally, the

study advocated for the adoption of responsible drilling techniques, with the aim of benefiting all parties involved.

### 6.2 Recommendations

The study findings suggest the following recommendations:

- It is recommended that local communities, in collaboration with borehole management committees and the Water Resources Management Authority (WARMA), assume responsibility for monitoring anthropogenic activities in the vicinity of boreholes. Additionally, conducting regular sanitary inspections is crucial to ensure the maintenance of proper hygiene and sanitation standards surrounding these vital water resources. The consideration of a safe distance between the borehole and potential sources of groundwater pollution is imperative.
- It is imperative to establish management and monitoring strategies for individual boreholes due to the site-specific nature of groundwater pollution. Regular assessments of water quality and subsequent treatment of contaminated water should be carried out as part of these strategies.
- To safeguard the progress achieved by the government in expanding access to safe and clean water, it is imperative to implement community sensitization programs. These initiatives aim to enhance public awareness and comprehension regarding the introduction of the borehole permit in Zambia, as well as its advantages for both drilling companies and their clientele.
- The implementation of licensing systems aimed at regulating groundwater withdrawal for drilling purposes should prioritize both practical effectiveness and stringent enforcement measures, as deemed necessary by the government.
- The Water Resources Management Authority (WARMA) should establish effective mechanisms for expediting the processing of licenses to prevent any delays in the issuance of drilling licenses, as such delays can have a significant impact on the operations of drilling businesses.

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# APPENDICES

## Appendix I: Questionnaire

Dear respondent,

My names are Violet Mkandawire I am pursuing post graduate studies at Institute of Distance Education-University of Zambia and Open University of Zimbabwe. I am inviting you to participate in study titled: Impact of new borehole pricing regime in wake of groundwater regulations in Zambia

This is a kind request to you to accept to complete this research questionnaire. The aim of filling this questionnaire is to enable the study to assess the impact of ground water regulation on the borehole pricing. This information will be useful in making constructive recommendations on how the regulator must ensure that groundwater regulation does not affect the cost of doing business and avoid the consumer exploitation. Your views and responses will be highly appreciated and held in confidence to be used for academic purposes only.

**Instructions**

You are requested to fill in this questionnaire by giving your opinion. Do not indicate your name on the questionnaire booklet. Kindly please mark (√) in the box that matches your answer to the questions. This is a questionnaire for the respondents who are the drilling companies and client who have drilled boreholes after 2018 in Lusaka, Livingstone, and Mongu.

**SECTION A: Company Information**

1. What is your gender? Male [ ] b. Female [ ]
2. What is your age group?

a. Below 25 years [ ] b. 25-30 years [ ] c. 31-40 years [ ]
d. 41-50 years [ ] e. Above 50 years [ ]

3. What is the highest level of education obtained?

a) Secondary [ ] b. Diploma [ ] c. Bachelor's degree [ ]

d. Masters [ ] e. PhD [ ] Any Other _____

3. Are you a registered drilling company? ……
4. Have you been licensed with Water Resources Management Authority (WARMA)?
   Yes [ ] No [ ]
5. In what class or license category have you registered your company in
   Class

| A | B | C | D |
|---|---|---|---|

(Please "tick" the relevant box)
Please give a reason?.....

6. How long have been doing your drilling of borehole business? (Please "tick" the relevant box or mark with "x")
   a. Below 3 years [ ] b. 3 -5 years [ ]
   c. 6 -9 years [ ] d. 10 years and above [ ]

7. Are you aware of the ground water regulations on licensing of drillers and constructors?
   Yes [ ] No [ ]
   (Please "tick" the relevant box or mark with "x")

| | Statutory Instrument Number | Tick (√) |
|---|---|---|
| 1 | Sl No. 18 of 2018? | ☐ |
| 2 | Sl No. 19 of 2018? | ☐ |
| 3 | Sl No. 20 of 2018? | ☐ |

8. What are the benefits of licensing your company with WARMA?
   ……
   ……
   ……....
9. What was the price of the borehole before the introduction of licensing with WARMA? ZMK_____
10. What is the current price of a borehole? ZMK_____
11. Why has the price of a borehole changed drastically compared to the price before the introduction of the statutory instrument on licensing of drilling companies and constructors?

……

……

……

**SECTION B: INTRODUCTION BOREHOLE STANDARDS**

12. ) Has introduction of borehole standards affected the cost of doing your business?

Yes [ ] No [ ]

If the answer to question 10 (a) is YES, Please, explain how?

……

……..

13. What has necessitated the increase in the pricing of the borehole? Standards Or the licensing of drilling companies?.....

14. If given an option would you follow the borehole standard? Yes [ ] No [ ]

Please explain your answer ……

……

……..…..

15. a.) In your opinion do you think its relevant to be licensed with WARMA?

Yes [ ] No [ ]

b.) If yes, why do you think its relevant? ……

……

……..

c.) Do you have problems with applying for your drilling licenses? Yes [ ] No [ ]

d) How does it affect your business?.....

……

e) What are the effects of ground water regulation on the borehole drilling to the drilling companies?

……

……

f) What should WARMA do to improve its licensing speed?.....

……

……..……..

**THANK YOU FOR YOUR PARTICIPATION!**

**Appendix II: Interview Guide**

1. What is your gender?
2. What is your age group?
3. What is the highest level of education obtained?
4. When did you drill your borehole?
5. Are you happy with the borehole standards?
6. How much did the drilling of the borehole cost?
7. How much do you think your borehole should have costed you and why? Explain
8. Are you aware of borehole standards?
9. If yes, have you benefited from the borehole standard introduced by the Statutory Instruments on borehole drilling?
10. Have you experienced conflicts with the drilling company?
11. If yes, was the conflict resolved by a regulator (WARMA)?
12. Where are you satisfied with the outcome of the conflict resolution?
13. What are the benefits of regulating the borehole drilling companies in Zambia?
14. What are the effects of ground water regulation to consumer?

END

**Appendix III: Budget**

Budget Table: Below is an estimated budget for the study.

| **Item** | **Quantity** | **Unit Price (ZMK)** | **Sub Total (ZMK)** |
|---|---|---|---|
| Rims of paper | 2 | 80 | 160 |
| Printing of the thesis | 5 | 110 | 550 |
| Printing of the proposal | 3 | 100 | 300 |
| Bond Paper | 10 | 30 | 300 |
| Pens | 5 | 2 | 10 |
| Pencils | 1 | 10 | 10 |
| Binding of the thesis | 5 | 200 | 1,000 |
| Notebooks | 4 | 10 | 40 |
| Flush disk | 1 | 65 | 65 |
| Transportation costs | 6 | 2,000 | 12,000 |
| **TOTAL** | | | **14,435.00** |

**Appendix IV: Work Plan**

| Activities | Timelines | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | December, 2021 | January, 2022 | February, 2022 | March, 2022 | April, 2022 | May, 2022 | June-November, 2020 | December, 2022 |
| Contact with supervisors | | | | | | | | |
| Agreement on topics | | | | | | | | |
| Proposal development | | | | | | | | |
| Proposal Submission | | | | | | | | |
| Field Work (Data Collection and Analysis) | | | | | | | | |
| Compilation of reports | | | | | | | | |
| Submission | | | | | | | | |