DETERMINANTS OF RESIDENTIAL WATER DEMAND IN NGAMILAND DISTRICT, BOTSWANA

BY
MANGA MOTHO
[Student number: 201705485]

A thesis submitted in fulfilment of Master of Philosophy (MPhil) in Natural Resources Management at the Okavango Research Institute, University of Botswana

SUPERVISORS:

PROF. O. D. KOLAWOLE

DR M. R. MOTSHOLAPHEKO

PROF P. K MOGOMOTSI

OCTOBER 2021

TABLE OF CONTENTS

LI ST OF TABLES

LIST OF FIGURES

DECLARATION

I declare that this thesis is my original work and it has not been submitted for any previous application for a degree or any academic award at any university. Except otherwise referenced or acknowledged, the work contained herein is entirely my work.

Signed: …….

Date: …….

DEDICATION

To my phenomenal mother Ms Grace Lumba Motho for her great love and ceaseless prayers.

ACKNOWLEDGMENTS

Almighty God, your love, mercy, and grace kept me going on throughout the journey of my studies. Let your name be praised and blessed forever. I would like to express my sincere gratitude to my supervisors, Professor O. D. Kolawole, Dr M. R. Motsholapheko and Professor P. K. Mogomotsi for the critical, insightful and constructive comments from the development of the proposal to the write-up of the thesis. Thank you for guiding and encouraging me to be professional and do the right thing. This project would have not been realised without your relentless help.

I would like to appreciate my sponsor, Carnegie-Regional Initiative in Science and Education (RISE) for funding my studies. RISE was supported by the Carnegie Corporation of New York, which was created by Andrew Carnegie in 1911 to promote "the advancement and diffusion of knowledge and understanding". My deepest gratitude to Professor Ketlhatlogile Mosepele for being the local coordinator of the scholarship. The University of Botswana, Office of Research and Development (ORD) is truly appreciated for funding the fieldwork, this project could not have reached its goal. I would like to recognise the invaluable assistance provided by the former Okavango Research Institute MPhil/PhD Graduate Program Coordinator, Professor Olekae Tsompi Thakadu. Thank you for being helpful in the success of the program. Your dedication, hard work and concern for the students was of great honour.

I would like to express my utmost appreciation to fellow students for endless emotional and academic support throughout my graduate study. You are amazing people, thank you for the support. Finally, I wish to acknowledge the support and great love from my family, especially, my mother, Ms Grace Motho, my sister, Ms Julia Ndozi Makanye and my husband, Mr

Goletetswemang Bofelwang for standing with me when the road was tough and for believing in me. They kept me going on and this research would have not been possible without their input. To my late father and grandparents, I know you would have been proud of me.

ACRONYMS

ANOVA	Analysis of Variance
BGCSE	Botswana General Certificate of Secondary Education
BNWMPR	Botswana National Water Master Plan Review
CLT	Central limit theorem
CSO	Central Statistics Office
DWA	Department of Water Affairs
FAO	Food and Agricultural Organisation
GWP	Global Water Partnership
ICWE	International Conference on Water and the Environment
IWRM	Integrated Water Resource Management
IWRM-WE	Integrated Water Resource Management and Water Efficiency
JC	Junior Certificate
MLMWSS	Ministry of Land Management, Water and Sanitation Services
MLR	Multiple Linear Regression
NDP 11	National Development Plan 11
ORD	Office of Research and Development
PED	Price elasticity of demand
SDG	Sustainable Development Goal

SPSS	Statistical Software Package for Social Sciences
SPT	Social Practice Theory
SSA	sub-Saharan Africa
SW	Shapiro-Wilk test
UN	United Nations
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	The United Nations Children's Fund
VDC	Village Development Committee
WDM	Water Demand Management
WHO	World Health Organization
WUC	Water Utilities Corporation
WWAP	World Water Assessment Programme
WWDR	World Water Development Report

ABSTRACT

Freshwater demand for direct human consumption is a significant concern globally. Water is increasingly becoming a scarce resource due to high demands intensified by rapid population growth, urbanisation, economic expansion, and climate change among other factors. Even though mitigating measures in the form of legislations have been implemented to lessen demand and confine it to levels that could be sustained through available supply, evidence shows that 2.4 billion people worldwide experience water shortages. Therefore, this empirical study is aimed at assessing the determinants of residential water demand in Ngamiland District, Botswana. The specific objectives were to (i) determine the demographic and socio-economic factors contributing to residential water demand; (ii) assess water supply and demand in Maun and Gumare; (iii) analyse the influence of psychological factors on residential water demand and (iv) determine household water use behaviour in relation to residential water demand in Ngamiland District.

The supply and demand theory in combination with the social practice theory were employed to analyse the determinants of residential water demand in Ngamiland. The data were collected from a random sample of 497 households in Maun and Gumare villages using an interview schedule and key informant interview guide. While descriptive statistics were used to summarise data, non-parametric (such as Spearman's correlation analysis, Chi-Square, Mann-Whitney U, Kruskal-Wallis) and parametric (such as Analysis of variance and independent T-test) tests were employed to make inferences. The results revealed that variables such as gender, household income and household size had positive associations with monthly water demand. Household size was found to be the most influential variable at a significant moderate positive correlation with monthly water demand, $r_s = 0.422$ and $\rho < 0.05$. This result implied that households with a greater number of people were likely to demand more water.

The study demonstrated that water demand exceeded supply due to population growth, diminishing of both ground and surface water sources, institutional management, and poor management of infrastructures, among other factors. Water plant infrastructures were of limited capacity and not performing well to meet the demand of the entire population. There was a significant association between household's monthly water demand and awareness on water conservation, χ^2 (1) = 5.7, ρ = < 0.05. The study also revealed that people are more likely to become committed to water conservation when they are aware of the importance and scarcity of water resources.

There was a significant very weak positive correlation between household's monthly water demand and water use activities, r_s = 0.068 and ρ = < 0.05. The results also highlighted the importance of both technological and behavioural approaches to demand management. Variables such as small household size, lower education and income levels, result in less water demand. Households need to adopt practices that conserve water and avoid water-use behaviors such as the utilisation of facilities that are associated with inefficient water use. It is imperative for the Botswana government to work hand in hand with all relevant stakeholders most especially communities in devising pragmatic strategies for enhancing water demand management.

Keywords: Determinants, residential, social practice theory, supply and demand, water demand management

CHAPTER 1

INTRODUCTION

1.1. Background of the study

The earth's surface is made of about 71% of water and the remaining 29% consist of continents and islands (Kerr, Waldteufel, Wigneron, Delwart, Cabot, Boutin & Juglea, 2010; Shiklomanov, 1993). The total volume of the water on earth is about 1.5 billion cubic kilometres (km^3) and it is estimated that about 97.3% and 2.7% of the available water constitutes saline and freshwater, respectively (Shiklomanov, 1993, United Nations [UN], 2002). Of the 2.7% of freshwater, 77.2% is frozen in the ice caps and glaciers in Antarctica, the Arctic Circle and Greenland (Gleick, 1993; UN, 2014). As for the remaining 22.8% of freshwater, 22.4% is in deep underground aquifers implying that only 0.4% of freshwater is available for human use in lakes and rivers (Alley & Konikow, 2015; Gleick, 1993). Freshwater resources are very limited, and the global demand is increasing (Gleick, 1993; UN, 2014). Therefore, the world at large needs to conserve the little that is available in order to keep up with the global water demand which is increasing annually. In regions like Asia and Pacific, Europe and central Asia, Latin America and Caribbean, North America and western Asia the overall consumption increased six-fold between 1990 and 1995 (United Nations Development Program [UNDP], 2000).

Globally, water management has gained more attention as factors such as rapid population growth, pollution emerging from human activities, urbanisation and climate change continue to engender increasing water demand (Kusangaya *et al.*, 2014; Kenway *et al*., 2015). Consequently, available water resources are unable to meet the growing demand for various water uses (Gichana, 2014; UN, 2014). In the quest to reduce water demand, management goals have been formulated and implemented to ensure efficient water provision across the globe

(Global Water Partnership [GWP], 2012; Kenway *et al*., 2015). To eliminate poverty and achieve global sustainable development and ensure that no one is left behind, the Sustainable Development Goals [SDGs] for 2030, which apply to all UN member states, were adopted by the United Nations Sustainable Development Summit in September 2015 (UNDP, 2018). The agenda, which comprises 17 SDGs and 169 targets, was formulated to build on the Millennium Development Goals [MDGs] which was implemented from 2000-2015 to combat poverty in developing countries. SDG 6, which aims to "ensure availability and sustainable management of water and sanitation for all", calls for clean water and sanitation for all people (UN-Water, 2018). For the SDGs to be fully effective, there is a need for the implementation and monitoring of programmes in local government authorities and communities (UN-Water, 2018). Increasing water efficiency and management are crucial in balancing the competing and ever-increasing water demands from various sectors and users (UN-Water, 2018).

There has been progress in meeting the demand for water even though available evidence shows that 2.4 billion people still lack access to safe water (Connor, 2015). It is projected that the world population will grow from its current estimate of 7.6 billion to 9.1 billion by 2050, with 2.4 billion people living in sub-Saharan Africa which is the most affected by water resource scarcity (Connor, 2015). The global demand for freshwater is likely to increase hence this will lead to an increment in water prices resulting in a negative impact on households (Schleich & Hillenbrand, 2009).

The African continent is faced with water challenges due to climate variability and low adaptive capacity among other factors (Kusangaya *et al*., 2014). As a response to these challenges, the African Water Vision for 2025, which was adopted in 2000, has been formulated to ensure "equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation and the environment" (UN Water/Africa, 2003, 2). Countries such as Ethiopia are faced with water crises because water

demand in the nation exceeds supply (Dagnew, 2012; Legamo, 2014). Similarly, a study by Gichana et al. (2014) shows that Kenya has water challenges due to a high annual population growth rate of 7 percent and other factors such as an increase in demand for food, rapid economic expansion, and climate variability.

Equally, water demand has been a concern in the southern African region due to rapid population growth and unfavourable climatic conditions engendering severe droughts which have weakened government efforts in a bid to meet water demand in the region (Global Water Partnership [GWP], 2012; Guest, 2015). Except for Angola which has abundant water resources, southern Africa has very limited water resources which are unevenly distributed, resulting in water scarcity (Ragab & Prudhomme, 2002). For example, South Africa has 10% of the water resources in the region but uses about 80% of regional water resources (Kusangaya *et al*., 2014; Mukheibir, 2008).

Botswana like many other developing countries is faced with severe water challenges. Botswana's population has increased from 650 832 people in 1968 to 2.2 million in 2011, resulting in a high increase in water demand (Mogomotsi, Mogomotsi & Matlhola, 2018; Statistics Botswana, 2014). In addition to population growth, the country's mining, agricultural and tourism sectors contribute to high water demand (Botswana National Water Master Plan Review [BNWMPR], 2006). Among various sectors, household water demand poses a serious challenge in Botswana (Hambira *et al*., 2011; Kujinga *et al*., 2014). There is a lack of understanding of the determinants of residential water demand. Hence there is a need for a careful analysis on the issue.

As water is an important natural resource, the Government of Botswana has prioritised it in the National Development Plan 11 (April 2017-March 2023). The plan emphasises integrated water

resource management (IWRM) and water demand management. It highlights the implementation of programmes such as the Botswana IWRM and Water Efficiency (IWRM-WE) plan of 2013, National Water Policy of 2012 and the BNWMPR of 2006 which provides a guide on national water demand, use and development strategies (National Development Plan [NDP] 11, 2016). Besides, the water accounting section of the natural capital accounting aims at providing information on water supply, use, costs and revenues for the improvement of the management of the resource (NDP 11, 2016). Botswana Vision 2036 also emphasises sustainable utilisation of natural resources (NDP 11, 2016).

Botswana Vision 2036 aims at ensuring a water efficiency and water-secure nation through the promotion of integrated resource management strategies, policy instruments and public education that inspire water efficiency and conservation efforts (Musekiwa & Mandiyanike, 2017; NDP, 2016). Moreover, as an attempt to meet SDGs, Botswana's Vision 2036 and NDP 11 priorities are set out in a way that delivers the targets under each SDG (NDP, 2016).

1.1.1. Problem statement

Water plays a significant role in sustainable development as it is essential for socio-economic development, health, ecosystem services and human survival. Despite its role in improving the quality of life, water demand is still one of the world's main challenges (Gleick, 1998; Postel, 2014; Sharma & Vairavamoorthy, 2009; Vörösmarty *et al*., 2000). There is increasing evidence that human activities are placing unsustainable demands on freshwater (Fielding *et al*., 2012; Gichana *et al*., 2014; Gondo & Kolawole, 2016; Madigele, 2016; Postel, 2000). Surface and groundwater supplies are being over-extracted in many regions of the world (Postel, 2000; Vorosmarty, *et al*., 2000). This ultimately poses challenges on policymakers and water authorities to meet increasing human water demand as well as protect ecosystems (Legamo,

2014). Thus, there is lack of understanding on the influence of household factors on water demand. Knowledge on this subject matter would enable policymakers to integrate relevant policies in equalising both supply and demand. Water demand is a one of the crucial issues affecting livelihoods, therefore, this study has been carried out in Ngamiland District because it is one of the areas experiencing high water demand in Botswana.

Water demand management is considered an essential element of future water security (Arbues *et al*., 2003; Brooks, 2006). About 11% of the world population or 783 million people do not have access to water (American Water Works Association, 1999). Global water demand is projected to increase significantly in future, with the agricultural sector being the main user of water at about 70% of worldwide water use (World Water Assessment Program, 2017). Other factors that contribute to water demand are urbanisation and tourism which pressurise the available water resources (Rohrdrommel, 2017). Many developed and developing countries worldwide face significant water demand problems (Chukwuka & Olubayo, 2019; Mogomotsi *et al*., 2018; Mulwafu *et al.*, 2020). The demand problems are expected to continue in the future due to the rapid population growth and impacts of climate change (Dharmaratna & Harris, 2012). Additionally, it is estimated that 663 million people still use water from unimproved sources such as wells, springs, and surface water (UNDP, 2015). It is also estimated that half of the affected people live in sub-Saharan Africa (UNDP, 2015).

Climate change has an impact on water resources (Arnel, 1999; Vorosmarty *et al*., 2000). It is an essential driver of the water cycle, and it determines the volumes of water available (supply), and water required (demand) (van Schaik & Bakker, 2008). Globally, freshwater resources are diminishing due to climate change (van Schaik & Bakker, 2008; Serur & Sarma, 2018). This is reflected in increased incidents of droughts (Misra, 2014). Climate change is likely to increase the demand for water while decreasing water supplies (Arnell, 1999).

Safe drinking water is important in various ways and has a vital role in poverty alleviation (Ahmad, 2003). However, this basic resource is gradually declining in most areas in Botswana, including Ngamiland District. For example, in 2017, internal renewable water resources per capita for Botswana was 1,088.4 cubic meters. Between 1972 and 2017, internal renewable water resources decrease at a moderate rate from 3,231 cubic meters in 1972 to 1,088.4 cubic meters in 2017 (World Data Atlas, 2017). This suggests a decline of water resources which is anticipated to worsen. The Government of Botswana estimated that water demand will increase from 193 million cubic metres (Mm^3) /year in 2000 to 335.2 Mm^3 by 2020 (BNWMP, 2006). These figures show an increase in water demand by 73.7% implying a high demand for water in the country. Botswana is prone to water scarcity due to limited water resources (Kujinga *et al*., 2014), it is estimated that almost half of the available water is wasted through leakages, lack of effective water demand management programs and inefficient management practices (BNWMP, 2006).

Water demand continues to be problematic even though Botswana's access to drinking water in 2001 reached 99.5% and 83.5% in urban areas and rural areas, respectively (Central Statistics of Botswana [CSO], 2011; Kujinga *et al*., 2014). The problem of water supply challenges is experienced across the country (Mogomotsi *et al.*, 2018). Lack of effective and efficient water supply and management institutions and water infrastructures are also contributing factors (Mogomotsi *et al.*, 2018). Some communities, especially in rural areas, could go without access to water for long periods (Kujinga *et al*., 2014). In the Ngamiland District, water resources are limited as the region is semi-arid and receives an annual rainfall ranging from 450mm to 600 mm (Oageng & Mmopelwa, 2014). Additionally, the population of Ngamiland District is growing rapidly due to the immigration of people, especially to the main village of Maun, which offers employment opportunities in the growing tourism industry and other sectors. The increasing population consequently increases residential water demand.

Several studies on water resources management have been conducted in Ngamiland District and surrounding areas (Bonyongo *et al*., 2012; Gondo, Kolawole & Mbaiwa, 2019; Masamba & Mazvimavi, 2008; Mogomotsi, Mogomotsi & Mosepele, 2020; Murray-Hudson, Wolski & Ringrose, 2006; Setlhogile & Harvey, 2015; Swatuk & Motsholapheko, 2008). However, there is a dearth of research on residential water demand and household water use behaviour. Therefore, a better understanding of residential water demand in Ngamiland District is necessary for effective management and improvement of the level of water service. A clear understanding of the determinants of residential water demand is vital for enabling managers and other stakeholders such as Water Utilities Corporation, the government and policymakers to formulate effective demand management policies. This study aims at analysing the determinants of residential water demand in Ngamiland District, north-western Botswana. The following questions are, therefore, addressed.

1.1.2. Research questions

The general question of the study is: what the factors are influencing residential water demand in Ngamiland District, Botswana

The specific questions are:

(i) What are the demographic and socio-economic factors influencing residential water demand in Ngamiland District?

(ii) What is the water supply and demand situation in the study area?

(iii) What influence do psychological factors have on residential water demand in the study area?

(iv) How does household water use behaviour influence water demand in the study area?

1.1.3. Research objectives

The general objective of the study is to analyse the factors influencing residential water demand in Ngamiland District, Botswana.

The specific objectives of the study are to:

(i) Determine the demographic and socio-economic factors influencing residential water demand in Ngamiland District.

(ii) Assess water supply and demand in the study area.

(iii) Analyse the influence of psychological factors on residential water demand in the study area.

(iv) Determine the relationship between household water use behaviour and residential water demand in the study area.

1.1.4. Hypothesis

The hypotheses for this study are as follows:

(i) H1: Demographic and socio-economic factors influence residential water demand in Ngamiland District.

(ii) H1: Psychological factors have an influence on residential water demand in the study area.

(iii) H1: Household water use behaviour has a significant relationship with water demand in the study area.

1.1.5. Justification and Significance of the study

Globally, a common resolution by water suppliers has been to expand water supply to meet the growing demand regardless of the costs incurred. A lot of effort has been made to maintain water consumption, yet the demand for water is rising due to factors such as increasing population and economic expansion. For this reason, a different approach to water shortage will be the implementation and establishment of policies to promote water demand management. In Botswana, there is little or no knowledge about households' behaviour regarding factors contributing to their water use. As a result, policy decisions are often not very well informed as it is assumed that residential water demand in developing countries reflects those of developed countries. Henceforth, more detailed knowledge on the residential water demand is essential as it can help better understand household water use behaviour and help in reducing high water demands. It is also essential to estimate the change in residential water demand for a policy that will result in some alteration in tariffs or household income as under-pricing of water may lead Water Utilities to increase tariffs as a way of maintaining supply costs to ensure sustainable provision. This thesis is, therefore, important as it will identify variables influencing of residential water consumption which will inform policymakers.

The thesis will contribute to the literature and fill the research gap of knowledge in enhancing the understanding of factors affecting residential water demand in developing countries. Similarly, it will provide valuable information for policymakers, water utility planners, academics, researchers, students, the community and other stakeholders on issues of freshwater demand management. A water demand analysis is crucial as policymakers and planners need a

better understanding of the determinants of residential water demand. This will enable them to determine the type, size, and location of areas that need to be improved and developed, as well as formulating effective water management strategies to sustain the scarce resource. Thus, the thesis will assist in providing information that would be helpful in the implementation of policies that support Vision 2036, NDP 11 and SDG number 6 (2030). With the assistance of this thesis the Botswana Water Utilities Corporation (WUC) and Department of Water Affairs (DWA) would be able to work towards the development of residential water demand and supply through identification and enforcement of policy actions that promote water conservation both at a national and local level. The thesis will also have a significant contribution to the body of knowledge in the subject matter.

1.1.6. The operational definition of concepts

The following definitions will be used in this thesis:

Determinants: These are factors that affect the outcome of something (Oxford Learner's Dictionaries, 2018). In this study, determinants refer to factors influencing household water demand. Examples of these factors include age, gender, education level, household size, household income, household composition, dwelling type and ownership, price of water, attitudes and knowledge, etc. (Ballings *et al*., 2008; Jones, 2008; Lux, 2008).

Household: It is a social unit consisting of one or more people living together under the same roof (Oxford Learner's Dictionaries, 2018). It can either be made of a combination of adults and kids, couples with kids, one adult with kids, people sharing a house or a single person.

Residential: It is an area gazetted for housing people and it contains amenities such as water and electricity (Oxford Learner's Dictionaries, 2018). In this study, it refers to single-family housing or multi-family housing. Residential areas are divided into sections called wards.

Water demand: This is the quantity of water that needs to be produced to meet all water needs in the community (Billings & Jones, 2008). It is water required for different purposes such as domestic, industrial, commercial and agriculture (Sabbaghi *et al*., 1994). This study deals with domestic water demand.

Residential water demand: This is the water required per unit time by households for indoor and outdoor activities (Wentz & Gober, 2006; Yan, 2015). Indoor water uses activities include personal hygiene such as (showering, bathing, washing of hands), cooking, laundry, etc. Outdoor use includes gardening, car-washing, and swimming pools.

Water demand management: Any activity that promotes water use efficiency or reduces the amount of water used (Brooks, 2006; Nyambe *et al*., 2002). It connotes the adaptation and implementation of approaches by water institutions or consumers to influence water demand and consumption to achieve economic efficiency, social development, environmental protection, and sustainable water supply. Water pricing can be used to manage water use (Soto *et al*., 2018)**.**

Water use: It is the water extracted from the environment and used for various purposes such as agriculture, industry, energy production, households and other uses (Corbella & Pujol, 2009; Inman & Jeffrey, 2006; Kohli *et al*., 2010).

1.1.7. Limitations of the study

The following are some of the limitations of the study:

(i) The study was conducted in Ngamiland District, particularly Maun and Gumare villages, therefore it may not be truly representative of water demand issues in Botswana. The sample size is a limiting factor because it is too small and does not reflect the actual population of the study sites. The study needs to be carried out in other parts of the country to validate the research results.

(ii) The study used cross-sectional design, yet water demand needs to be studied over time. A longitudinal study needs to be conducted since it can show changes in water demand over a period of time.

1.1.8. Structure of the thesis

This thesis is structured into five chapters. Chapter One introduces the study. It presents the background information/introduction of the thesis (problem statement, research questions and objectives, hypothesis), justification, significance, limitations of the study and the operational definitions of the thesis.

Chapter Two reviews the literature covering water demand and its related topics. The concept of water, social significance of water, global and regional water demand are discussed first. Followed by the water sector in Botswana. Water demand management is elaborated including its approaches. The conceptual framework of the study is discussed, highlighting the factors under investigation. Household water use behaviour is also discussed. After that, the theories

related to water demand are discussed and some empirical studies from different parts of the world.

Chapter three provides a detailed description of the methods and study design applied in this research. Firstly, brief descriptions of the study areas, namely Maun and Gumare villages, are presented. The research design is then elaborated, followed by the discussion of the sampling procedure, instrumentation and measurements of variables. Research issues concerned with validity and reliability of the instruments are discussed. Then data collection and analysis procedures of the study are then described in detail. Ethical considerations are also outlined.

Chapter four present the results, analysis and discussion of the study. The chapter is divided into four sections. The first section (4.2) illustrates results and analysis of the first objective which is on the demographic and socio-economic factors influencing residential water demand. The section 4.3 presents research results regarding the second objective on water demand and supply in Ngamiland District. Section 4.4 which covers the third objective on the influence of psychological factors on residential water demand. Section 4.5 presents the fourth objective which assess the relationship between household water use behaviour and residential water demand in Ngamiland District.

Chapter five concludes the research by providing a synthesis. A summary of the findings is presented based on the research questions outlined in Section 1.1.2 above. It also examines the reflection of research findings on the conceptual framework developed in Section 2.6 of the thesis. After that, contribution of the research to knowledge, suggestions and implications for policy based on the findings of the study are presented. It also outlines future research and the limitations of the study. The references of the study are found after the fifth chapter of the thesis followed by the appendices.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

Water is one of the most essential natural resources on earth. It is the core for sustainable development, and it is vital for socio-economic development, environmental sustainability and for human survival (Li & Wu, 2019; Yildiz, 2017). This chapter reviews literature on water demand. It discusses the concept of water, global and regional water demand, water sector in Botswana, meaning of water to different people, global and regional water demand, water demand management, household water use behaviour, conceptual framework (determinants of residential water demand) of the study.

2.2.The concept of water

Water is a basic need and a fundamental resource to all living things although it is limited and used inefficiently, worldwide (Mutembwa, 1998, Onyango, Okoth & Kunyanga, 2018). Water is needed for human survival, and it is essential for food and energy production, transportation, waste disposal, for a healthy environment and many more benefits (Shiklomanov, 1993). There are various forms of water such as blue, green, grey and virtual water (Allan, 2003; Hoekstra, 2003; Zaag *et al*., 2002). Bluewater is the renewable water that occurs in rivers and aquifers (Zaag *et al.*, 2002). Falkenmark (1998) describes blue water as the measurement of water inflow that is abstracted from the surface and ground.

Green water is a water resource that is held in the soil as a result of precipitation and available to plants (Ringersma *et al*., 2003). It is the result of precipitation. Grey water includes all

wastewater generated in households or office buildings (such as showers, baths, basins, washing machines, etc.) without faecal contamination (Ringersma *et al*., 2003). Virtual water is defined as water embodied in a product (Allan, 2003). It is the water used in the manufacturing process of agricultural or industrial products (Hoekstra, 2003). Virtual water is used in terms of importing or exporting products (Hoekstra, 2003).

Water resources are classified into two categories namely, ground and surface water. Groundwater is found below the earth's surface while surface water is found on the surface of the earth such as water in rivers or lakes (Calow *et al*., 2010). Groundwater is normally used for household uses whereas surface water may also be used for household purposes and has many other uses such as agricultural production and generation of electricity (Calow *et al*., 2010). Groundwater is the largest source of freshwater, yet it is scarce with higher demand (Calow *et al*., 2010). In Africa, for example, at least 320 million people lack access to fresh and reliable water (Calow *et al*., 2010). In Ethiopia, only 11% of the population are estimated to have access to water (WHO/UNICEF, 2015). Most African countries depend on groundwater because it is normally cheaper to develop than surface water (Burke *et al*., 1999; Carlow *et al*., 2010). Robbins et al. (2006) argue that groundwater is the only practical method for ensuring enough water supply in the arid and semi-arid countries such as Botswana, Zambia, Zimbabwe, Namibia, and others.

Water plays an important role (social, ecological and economic value) in communities. As a social good, it is used in large amounts daily as it serves various purposes such as health care, hygiene, drinking, cleaning, showering, cooking, irrigation, transportation of people and goods, and many other purposes (Arbues *et al*., 2003). Ecologically, water plays a crucial function in the ecosystem, habitat creation, hydrological cycle and climate adaptability (Webster *et al*., 2001). Since the 1992 Dublin conference on Water and Environment (International Conference

on Water and the Environment [ICWE, 1992], water resource managers worldwide have viewed water as an economic good (see Table 1). The Dublin principles were aimed to emphasise sustainable use and development of water resources (Solanes & Gonzalez-Villarreal, 1999).

Table 1: The Four Dublin principles

1.Water is a finite, vulnerable and essential resource which should be managed in an integrated manner.
2. Water resource development and management should be based on participatory approach, involving all relevant stakeholders.
3. Women play a central role in the provision, management and safeguarding of water.
4. Water has an economic value and should be recognised as an economic good, considering affordability and equity criteria.

(Source: ICWE, 1992)

Additionally, the principles stressed the importance of water resources for environmental protection and human development. The GWP summarises these principles this way:

> Integrated water resources management is based on the equitable and efficient management and sustainable use of water and recognises that water is an integral part of the ecosystem, a natural resource, and a social and economic good, whose quantity and quality determine the nature of its utilisation (GWP, 1996).

Water as an economic good is vital and it should be used efficiently (Rogers *et al*., 2002; Savenije & Van der Zaag, 2002; Van der Zaag & Savenije, 2006). Water is used efficiently when wastewater is being reduced. Thus, water efficiency is the reduction of water wastage through measuring the amount of water required for a specific use and the amount of water used (Amy, 2002). Residential water use efficiency can be achieved by fixing leaking taps, taking

showers instead of baths, using dishwashers and washing machines with full loads, etc. (Carragher *et al*., 2012; Lee *et al*., 2011; Willis *et al*., 2011). If water is not treated as an economic good, there is a possibility of overuse and inefficient use, resulting in water shortages (Madigele, 2016; Van der Zaag & Savenije, 2006). In the era of water scarcity, depletion and high demands for quality water, the challenges would be resolved if water resources were appropriately treated economically (Postel, 2014). Postel (2014) states three points on which decisions can be made about efficient water resource use thus:

> 'The first point is the user level, where price and technology play a vital role. Local water use efficiency can be improved by marginal cost pricing and by encouraging households to adopt water-saving technologies. The second point is water allocation efficiency, whereby appropriate decisions must be made on the use and sharing of available water resources among different sectors. The third point is the global water use efficiency, globally some regions are water-scarce, and others have abundant water. Similarly, some regions have a low demand for water and others have a high demand for water (p. 140).'

Residential water is a private good in the sense that it must be bought and consumed by one individual or household and another person should not consume it unless there is an agreement. Economists refer to it as rivalrous and excludable. The need to conserve water arises from three different understandings of "water scarcity," namely economic, biophysical and social water scarcity. Water is not a purely economic good in the sense that it is not priced against its actual value although it is a scarce resource. The government subsidises residential water to cater for everyone including the underprivileged. As a social good water should be available to all although residential water is scarce and cannot meet the demands for a population. Therefore, water is a special good with a large number of characteristics that differentiates it from other

goods. It cannot be substituted with any other good. Without it there is no life, economic production nor the existence of nature.

2.3. Social significance of water

Globally water is tremendously valuable to both indigenous and non-indigenous people as it is used for many different purposes (Strang, 2005). For example, indigenous Australians consider water as a spiritual, natural resource and a commodity that is not only essential to livelihoods but has significant economic value (Altman & Jackson, 2008). However, Indigenous groups in many ecologically rich and often remote environments consider water sources such as the inland waters, rivers, wetlands, sea, islands, reefs, sandbars and seagrass beds as an inseparable part of their lands (Altman & Jackson, 2008). Water is crucial to culture as well as sustaining social and economic well-being (Altman & Jackson, 2008). It is believed that water holds the "image" or "spirit" of people (Strang, 2005).

Water is regarded as a "social and economic good" with a significant role in the gratification of basic human needs food security, poverty alleviation and the protection of ecosystems (UN, 1998). Numerous researchers and economists view water differently. For example, Savenije (2002) argues that water is not a normal good (a good whose demand increases as people's income rises) because it has characteristics that distinguish it from other goods and hence it is a special economic good. On contrary, Meijerink and Ruigs (2003) state that some authors reason that water is not an economic good due to its specific characteristics whereas economic theory states that water should be considered as a normal economic good. Therefore, the fact that water is a "scarce", it is considered an "economic good."

Water as an economic good can be characterised as both a private and public good. In terms of water as a private good, it means water is like any other good, that its production allocation should be determined by the value of customer control (by the amount people are willing and afford to pay for it) (Rogers, Bhatia & Huber, 1998). The criterion of customer control disregards the distribution of income in the community. Moreover, if the poor cannot afford to pay as much for a unit of water as the rich, they should get less water (Rogers *et al.*, Huber, 1998). On the contrary, advocates of water as a public good argue that water is a basic need that should be accessible at reasonable levels to every person (Rogers *et al*., 1998; Winpenny, 2005). In economics, a public good is defined as a good that is both non-excludable and non-rival, thus people cannot be excluded from using it and its use by a person does not reduce its availability to others (Cornes & Sandler, 1996; Mas-Colell *et al.*, 1995; Zai, 2014). Water as a natural resource has also been recognised as a public good (Sorinel, 2011). Thus, people cannot be denied from using water and it can be used simultaneously by more people (Sorinel, 2011). Water has been declared a "human right" by the UN Committee on Economic, Social, and Cultural Rights, thus it is often provided at subsidised prices or for free to the poor communities (Gleick, 1998; UN, 2002). The human right to water allows all people to have access to sufficient, safe, physically accessible and affordable water for personal and domestic uses (UN, 2003). Water resources are also vital for ecological, environmental and aesthetic benefits; therefore, it should not be allocated to other uses merely on grounds of willingness to pay (Briscoe, 1998; Rogers *et al*., 1998). Water is a social good in the sense that its availability to humanity and various purposes below market prices would serve the greater benefit to communities.

2.4. Global and regional water demand

Water demand refers to the total volume of water needed to supply customers within a certain period (Billings & Jones, 2008). It can also be defined as the amount of water required for a given purpose in litres per person per day. Water demand comprises different kinds of use such as residential, agricultural and commercial uses (Sabbaghi *et al*., 1994). Residential water demand entails the use of water by households for both indoor and outdoor activities (Sabbaghi *et al*., 1994). The volume of water use differs according to the nature of residence, family composition, occupation of the residents, price of water, use of water meter and other factors (Andre, 2013).

Globally, water is a scarce resource, as a result, this has led to increasing problems such as high demands for water, increased deaths due to unclean water, economic downfalls, etc. (Rohrdrommel, 2017). The global demand for water continues to increase at a rate of about 1% over the past decades as a result of population growth, economic development, variation in consumption patterns, among other factors (World Water Development Report [WWDR], 2017. It is expected that industrial and domestic water demand will increase rapidly compared with agricultural demand, although agriculture remains the largest user (WWAP, 2017). Currently, there is an increasing demand for water worldwide. There is a need for more reliable and strong water supplies to meet the demands. With regards to the progress of SDG 6, despite a lot of work to ensure water supply to all, many people across the globe still lack access to safe water and sanitation facilities. For example, it has been reported that "in 22 countries, mostly in the Northern Africa, Western Asia region and in the Central Southern Asia region, the water stress is above 70%, indicating the strong probability of future water scarcity" (WWAP, 2018). The SDG 6 Synthesis Report of June 2018 provides a summary of progress on each of the 8 targets and concludes that "the world is not on track to achieve SDG 6 by 2030". This indicates

that there is a need for participation by all in programmes aimed towards the achievement of the set goal.

Countries such as Italy, Spain, and Malta are already using almost 20% of their long-term water resources to meet current water demand (Manchin & Ali, 2011). According to the UN, human beings need 50 litres per day for personal health and hygiene (UNDP, 2015). Water consumption in various regions differs from each other. In Germany, for example, the water consumption per person amounts to 121 litres per day (Institute for Water Africa, 2008). In the African region, agriculture is the main water user and the sector accounts for about 85% of water use, followed by households at 10% and only 5% to industry (Institute for Water Africa, 2018).

Sub-Saharan Africa (SSA) is estimated to have the highest population of people in Africa (World Health Organisation/United Nations Children's Fund, [WHO/UNICEF], 2015). Despite the efforts in some SSA countries to expand basic services and improve urban housing conditions, meeting increasing demands is still a challenge. Moreover, the southern African region is characterised by low levels of precipitation, extensive arid areas, variable development of infrastructure, limited and unevenly distributed water resources, socio-economic issues, etc. (Goldblatt *et al*., 1999). Therefore, it is difficult to meet the water demanded by various sectors due to growing populations, hence it is estimated that 190 million people in southern Africa lack access to freshwater and sanitation services (Rothert & Macy, 2001). For example, South Africa is semi-arid and has limited water resources to meet the needs of various sectors (Johnson *et al*., 2002). Namibia is also faced by water challenges, the demand is higher than supply due to factors such as variable rainfall, frequent drought and growing population (Schachtschneider & Nishipili, 2002).

2.4.1 Water sector in Botswana

Botswana is a water-scarce country and experiences drought and varied rainfall (Segosebe & Parida, 2006). The total population of the country is estimated at 2,024,904 with an annual growth of 1.9 percent (Statistics Botswana, 2014). Most of the population resides in the eastern part of Botswana, which receives higher amounts of rainfall than the western part of the country (Setlhogile & Harvey, 2015). Botswana's rainfall ranges from 650mm in the north to 250mm in the south-west (Setlhogile & Harvey, 2015). Botswana's water sources mainly comprise groundwater (in aquifers) and surface water (in dams and rivers). In Botswana groundwater resources are unevenly spread and limited in both quantity and quality (BNWMP, 2006), therefore it depends on transboundary water resources such as the Okavango, Zambezi and Limpopo rivers. Surface water in the country is sourced from 10 dams namely (Bokaa, Dikgatlhong, Gaborone, Letsibogo, Lotsane, Mogobane, Nnywane, Ntimbale, Shashe and Thune), yet the dams are unable to meet the demand for water by various sectors across the nation (Botswana Water Accounting, 2016).

As an approach to address water challenges as well as ensuring efficient and sustainable water management, institutional reforms were adopted. Thus, in 2009, the Government of Botswana appointed Water Utilities Corporation (WUC) as the main supplier of freshwater and wastewater management services across the country (Setlhogile & Harvey, 2015). WUC is a government-owned parastatal which was established in 1970 to manage a water supply and distribution project in the Shashe Development area. Previously both the Department of Water Affairs (DWA) and the district councils provided water while the Department of Waste Management and Pollution Control were responsible for wastewater management services. The DWA was now mandated for water resources planning, development, and management of large

water infrastructures such as dams (Setlhogile & Harvey, 2015). The Water Resources Council substituted the Water Appointment Board (National Water Report, 2005).

Water tariffs are fully controlled by the government in urban and rural areas (National Water Report, 2005). WUC has to recover its full supply costs and subsidisation for customers is provided to ensure sustainability for all (National Water Report, 2005). Urban water pricing depends on the principles of equity and affordability (all citizens should have access to drinkable water to meet their basic needs) (National Water Report, 2005). The other principle is efficiency which implies that water supply should be cost-effective, and people should conserve water (National Water Report, 2005). Botswana uses the increasing block rate structure (National Water Report, 2005). Unit charges of this structure differ by use band (the higher the use band, the more the unit charges), as shown in Table 2.

Table 2: Water Utilities Corporation Tariffs - Effective 1st April 2017

Tariff Block Category	**Domestic, Commercial and Industrial Potable water tariffs**	
	Excluding VAT (Pula)	Including VAT (Pula)
Minimum charge	0	0
0-5 KL	3.50	3.92
>5-15 KL	10.40	11.65
>15-25 KL	18.20	20.38
>25-40 KL	28.00	31.36
`>40 KL	35.00	39.20

*Domestic consumers only – First 5KL exempt from VAT

Source: Water Utilities Corporation, 2018

Water access and use in Botswana is governed by the Water Act (1968), National Water Policy (2012), Water Management Plan (2010) and the Botswana Integrated Water Resource Management and Efficiency Plan (2013) and other water-related policies (Gondo & Kolawole, 2016). Botswana like other regional countries faces water challenges (Kujunga *et al.*, 2014,

Mogomotsi *et al.,* 2018). The total water consumption in Botswana is 167 million cubic meters [MCM] (Botswana Water Accounting, 2016). The agricultural sector is the main user of water, which accounts for 42% of the available water, followed by households with 25%, mining 23%, other industries, which account for 7%, and the government accounting for 5% of the water (see Table 3).

Table 3: Water supply and use in Botswana

Source	Total Water consumption in 2014-2015 (MCM)	Water consumption in (%)
Agriculture	70	42
Households	41	25
Mining	39	23
Other industries	12	7
Government	5	3
Total	167	100

Source: National Water Accounting, 2016

Water demand management is viewed as a crucial strategy to maintain balance in water supply and demand systems (BNWMP, 2006). Considering the limited available water sources, the essence of demand management is to control water use, reduce waste and increase water use efficiency (Hambira, 2007). Concerning the situation of limited resources, water demand management is considered as a solution to ensure sustainable use of water resources as opposed to supply management, which addresses demand by increasing supply (BNWMP, 2006). In Botswana, there are various water demand management tools (Arntzen *et al*., 1999). These include restrictions of water use, rainwater collection, water loss reduction and use efficiency (Arntzen *et al*., 1999). Similarly, NDP 11 aims to implement strategies such as harvesting of rainwater, construction of community dams, drilling of boreholes particularly in rural areas and reuse and recycling of wastewater to reduce pressure on available resources (NDP 11, 2016).

2.5. Water demand management

Water demand management (WDM) refers to any activity that reduces the amount of water used or allows efficient use of water (Brooks, 2006). It can also be defined as "a management approach that aims at conserving water by controlling demand through the application of measures such as regulatory, technological, economic and social, at all levels" (Nyambe *et al*., 2002). There are various approaches to WDM. The approaches can be categorised into two groups namely, economic, and non-economic approaches.

Whereas economic approaches entail water pricing and water metering, non-economic approaches include restrictions, water rationing, education campaigns, water-efficient technologies, etc. (Cheruiyot, 2016). Water pricing as an economic approach comprises three methods, which include flat, constant and block rate tariffs (Mohayidin *et al*., 2009). Flat rate entails a specific fixed rate that is imposed on the customer regardless of the amount of the water used (Mohayidin *et al*., 2009). This is the commonest approach used in water pricing in areas where water is in excess. It does not encourage water saving since the consumers are not likely to economise water because there are no increased charges for increased water consumption (Olmstead & Stavins, 2009). Flat rate tariffs are less ineffective in encouraging water conservation (Olmstead & Stavins, 2009). If flat rate tariffs are used it is important to consider how excessive water consumption will be addressed and whether there will be extra charges for consumption of a certain level to manage water demand. Constant rate pricing depicts a constant fixed charge for each unit which is imposed on the customer (Mohayidin *et al*., 2009). A meter is used to monitor the amount of water consumed and the meter readings are used for calculating the charges. Block rate pricing is whereby the unit price differs according to the quantity consumed (Olmstead & Stavins, 2009). Block rate pricing is of two

types: increasing and decreasing block rate which is the commonest pricing for urban water demand management (Araral & Wang, 2013).

Water pricing theories guide resource allocation, more especially drinking water because of its scarcity (Mohayidin *et al*., 2009). There are numerous economic theories, which explain the pricing of water supplies to people (such as marginal cost pricing, short-run, and long-run marginal cost pricing, average pricing, block rate and fixed-rate and so on). All the theories attempt to equate marginal cost or average cost pricing to ensure efficient use of resources (Olmstead & Stavins, 2009). Marginal cost pricing is the additional cost of producing or selling one incremental unit (Mann & Schlenger, 1982). Therefore, the marginal cost of water service is the cost experienced in providing more water service. If marginal cost pricing is being used, then the economy operates at minimum costs and maximum efficiency (Carter & Milon, 1999). The disadvantage of marginal cost pricing is that it fails to recover all utility costs (Carter & Milon, 1999). On the other hand, average cost pricing is a regulatory measure used by governments to control monopoly markets of goods or services (Merrill, 1994). The advantage of average cost pricing is that the utility recovers its costs and including profits (Merrill, 1994). However, its disadvantage is that tariffs may be too low resulting in the formation of inefficient decisions and wasteful of resources (Carter & Milon, 1999; Merrill, 1994).

Non-price approaches such as water reuse and recycling reduce water consumption by using waste or greywater for specific activities such as flushing toilets and watering gardens. Incentive programs may be used as well to reduce water consumption (Bamezai, 1996; Mayer *et al*., 1999). For this reason, water service providers have offered incentives to convince households to purchase water-saving appliances and technologies such as low flow toilets and dual flush toilets (Goemans *et al*., 2006). Goemans et al. (2006) urge that restrictions and prohibitions also reduce water consumption. Water providers or utilities impose restrictions and

forbid water use during drought for activities that are not vital such as washing cars (Goemans *et al*., 2006). Water restrictions are designed to control water use behaviours. For example, a study by Dziegielewski and Kiefer (2010) shows that outdoor water restrictions are the most practiced as a water conservation strategy in developed countries to limit lawn irrigation. Thus, households are encouraged to water their lawns during certain days of the week (Dziengieleski & Kiefer, 2010). Another study reveals that in the absence of a restrictive pricing policy, water restrictions alone may be ineffective in achieving reductions in water use (Brennan *et al.,* 2007). Mandatory water use restrictions may limit the total volume of water that can be used. These are more effective as compared to voluntary restrictions (Olmstead & Stavins, 2009). Public information campaign initiatives can also be used to alert customers on water rates and bills.

In Botswana, the above strategies have been implemented to manage water demand (Hambira *et al*., 2011; Segosebe & Parida, 2006). The drought period which happened in 1980s resulted in a reduction in water consumption of up to 45% in Gaborone city (Arntzen *et al*., 1999). In addition, during drought eras of 1992 to 1994 restrictions were imposed in villages and towns such as Maun, Mochudi, Molepolole, and Moshupa (Arntzen *et al*., 1999). This study aimed to assess the determinants of residential water demand in Ngamiland Maun because it is one of the areas largely affected by a high demand for water and low supply as earlier highlighted in the problem statement.

2.6. Conceptual framework

A conceptual framework is not only a collection of concepts but, rather, a construct in which each concept plays an integral role (Jabareen, 2009). According to Mile and Huberman (1994), a conceptual framework "lays out the key factors, constructs, or variables, and presumes a relationship among them" (p. 440). A conceptual framework provides a comprehensive

understanding of a phenomenon. Conceptual frameworks contain ontological, epistemological and methodological assumptions of the study. The ontological assumptions relate to knowledge of the "way things are," "the nature of reality," "real" existence, and "real" action (Guba & Lincoln, 1994). The epistemological assumptions relate to "way of knowing" and "how things work" in an assumed reality (Jabareen, 2009;51). The methodological assumptions relate to the process of building the conceptual framework (Jabareen, 2009). Therefore, this thesis used the determinants of residential water demand conceptual framework developed with insights from the neoclassical economic theory of supply and demand, and the Social Practice Theory (SPT). The former was used in the analyses of the effects of economic factors (such household income and water bills or payments) on household water demand, whereas the latter was employed to understand the influence of water use activities/behaviours in relation to residential water demand.

Supply and demand theory propounded by Alfred Marshall in 1890, which focuses on the effects of perception of the usefulness of products on market forces (supply and demand) (Marshall, 1892; McCloskey, 1996; Nagel, 1963). The theory states that at higher prices, producers tend to supply more but with the attendant decrease in consumers' demand. At lower prices, consumers tend to demand more whereas producers would reduce supply. According to Marshall (1996: 20) the following are the assumptions of the theory:

> 1) 'Choices on economic issues are always made rationally, based on complete information about a product or service; 2) Consumers compare goods and make a final decision based on the perceived utility; 3) The consumer's main aim is to capitalise on the satisfaction given by the use of the product; 4) The main aim of producers is to maximise profits, and 5) The market equilibrium is attained when

both the customer and producers achieve their respective goals of consumer satisfaction/utility and profit maximisation.'

In the context of this study, an increase in prices will result in a decrease in the quantity of water demanded, all things being equal. Water customers would have to reduce water use and change unnecessary water use behaviours. At lower prices of water, people tend to buy and use water in larger quantities, but there is a limit on how much water anybody can use. The world population and standard of living continue to increase, as a result, this may lead to water shortages to meet various purposes. Therefore, charging prices that reduce consumption may assist in water resource sustainability. It may also encourage people to seek alternative water sources hence this may contribute to water conservation. Behaviour changes and demand management strategies currently fail to take cognisance of the reasons why people use resources and how they are changing in everyday life (Wilhite *et al*., 2000). This oversight is worrisome because practices continue to change, often leading to increased resource use, and as a result, contributing to water resource depletion.

Social Practice Theory propounded by Bourdieu (1977) and Giddens (1984) provides an integrated approach to understanding consumer behaviour. It posits that resource consumption is governed by people's daily social practices (Giddens, 1984). Reckwitz (2002: 249-50) defines practices as, "…a routinised type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, 'things' and their use, background knowledge in the form of understanding, know-how, state of emotion and motivational knowledge."

Based on this conceptual understanding, material infrastructures such as technologies and systems of water provision do not exist independently of practice, but rather essential to the

practice itself (Reckwitz, 2002; Warde, 2005). For example, neither would showering happen without a shower nor the use of a washing basin without access to water. Additionally, this practice of showering would be pointless without common understanding and rules regarding hygiene, body odour and presentability (Hand *et al.*, 2003). Practical knowledge is necessary for showering activity to be carried out (Moore, 2014). Hence Social Practice Theory has three elements namely stuff (material and infrastructures), skills (learned bodily and mental routines) and images (common understanding). Bourdieu (1977: 248) explains to them as follow:

Material infrastructures incorporate objects, tools, hardware and the human body itself, which provide the means through which practices occur. Practical knowledge is the information and understanding which informs everyday activities. Common understanding informs acceptable and unacceptable practices. Bourdieu (1997) refers to them as 'right' and 'wrong' ways of doing things. Moreover, they are denoted as norms, customs, traditions, common sense or public opinion (Turner, 1991). Social Practice Theory places an emphasis on materialism in which technologies and infrastructures are regarded as active elements (Reckwitz, 2002; Shove & Pantzar, 2012). Similarly, Social Practice Theory provides a clear difference between social practices as entities and social practices as performance, even thou the two are naturally bound together (Reckwitz, 2014, Shove & Pantza, 2012).

Water consumption has been transformed over the past years because of the introduction of piped water in households and new technologies such as the use of electricity and other appliances in heating water (Moore, 2014). In Botswana, the most common water consuming activities in a household are cooking, dishwashing, laundry, plant or garden watering, bathing or showering, toilet flushing and cleaning of cars. Over time these daily activities have become more water-intensive due to common understanding, knowledge, and skills associated with hygiene (Moore, 2014). Furthermore, material and infrastructures used in conjunction with

water consumption change over time and it is expected that water use may change as well. For example, increased use in bathroom products may lead to increased commitment to hygiene and may increase customers' urge for such products leading to an increase in water demand.

2.6.1. Residential water demand

Residential water involves both indoor and outdoor water uses (Wentz & Gober, 2006). The available literature reveals that residential water demand studies in developing countries have been of interest since the late 1960s and there are various factors affecting water demand (Yan, 2015). Two principal categories of variables that influence demand are utility controlled, and non-utility controlled (environmental) variables (Gegax *et al*., 1998). Utility controlled variables comprise water price, rate structures, conservation programs such as water restrictions and public education (Gegax *et al*., 1998, Gonzalez & Garcia-Rubio, 2018). Non-utility-controlled variables involve climate factors (rainfall and temperature), socio-economic (household income and size, dwelling type of households, home technologies and other factors) and demographic factors (age, gender, educational level, etc.) (Kenny *et al*., 2008). The demand for household water entails essential needs such as cooking, personal hygiene, laundry, drinking and other activities such as the watering of gardens, swimming pool and car washing (Schleich & Hillenbrand, 2009). This thesis narrowly focusses on the non-utility-controlled factors or variables. The factors are discussed below:

2.6.1.1. Demographic and socio-economic factors of residential water demand

Demographic (age, gender, etc.) and socio-economic factors of residential water demand such as household size, household income, educational level, household composition, and

employment status are some of the elements that influence household water demand (Lux, 2008; Pricing & Tribunal, 2004). Household size is a significant element affecting water consumption (Ballings *et al*., 2008; Jones, 2008). The total volume of water used for showering and toilets is generally higher in bigger households with a large number of children (Willis *et al*., 2011). However, Arbues et al. (2010) suggest that small households can respond better to water pricing due to the capacity to control factors.

Age increase is also significantly related to water demand (Schleich & Hillenbrand, 2009). Previous studies conducted in Phoenix, Arizona, and Germany reveal that older and retired people use more water, as they spend more time at home doing various activities such as gardening, cooking, cleaning and have frequent baths for health reasons (Ballings & Gober, 2007; Schleich & Hillenbrand, 2009). This may be true since children do not engage in some of the household chores such as cooking and washing whilst teenagers assist in households although not as much as compared to older or retired people. In contrast to these studies, other investigations in Sweden, on age distribution in relation to water demand reveal that older people use less water compared to children and teenagers (Hanke & Mare, 1982). The reason is that older people are always cautious in all they do, compared to adolescents. A study conducted by Layman (1992) in Moscow, Russia, proposes that the highest water users are children under the age of 10 and the lowest users are young people aged between 10 and 20. The varying results show that water demand and water use behaviour vary from one place to the other.

Gender is a vital factor in water demand due to variations in water use between women and men (van Koppen, 2001). Females are expected to use more water as compared to males because they are responsible for carrying out the majority of water-related activities such as laundry, cleaning, and cooking in the household. In addition, females are more likely to take

long baths compared to males (Makki *et al*., 2003). This thesis attempts to fill the gap by finding out how demographic variables (such as gender, age), socio-economic variables (educational level, household size, income size, etc) and psychological variables (attitudes, knowledge) influence household water demand in Ngamiland District, Botswana.

Household composition in relation to water demand mainly reflects the effect of age, gender, and the number of members (Lyman, 1992). A study on the relationship between dwelling ownership and water consumption in Sydney, reveals that people who rent houses tend to be reluctant in implementing water-saving practices compared to those living in their own houses and they barely replace inefficient water appliances (Troy & Randolph, 2006). This may be due to the reason that house-owners are responsible for paying for water bills therefore tenants tend not to be aware of the volumes of water they use. Dwelling type and ownership of water-consuming appliances also influence water consumption (Troy & Randolph, 2006). The more the use of water related appliances and facilities such as washing machines, gardens and swimming pools, the greater the quantity of water consumed in a household.

Individuals' educational level influences household water demand. The logic is that highly educated people are expected to have more knowledge and consciousness on environmental and sustainability issues (Kollmus & Agyeman, 2002). Contrary-wise, high education levels may be associated with high income that can trigger high water consumption (Howarth & Buttler, 2004). However, household water demand is positively correlated with income Corbella & Pujol, 2009). An increase in income level is associated with higher living standards, which implies a change of housing to bigger apartments, a higher range of new water-consuming appliances and water demanding outdoors such as gardens and swimming pools (Corbella & Pujol, 2009). It is believed that households with a higher level of income have a higher water demand compared to households with low income (Willis *et al*., 2011). In a study

by Ballings and Gober (2007), results show that in southern Arizona, a 10% increase in the average household income results in a 3% increase in water use. Therefore, this thesis aims to investigate the relationship between household income and water demand.

Price is regarded as an important financial factor influencing household water demand (Arbues *et al*., 2003). It is an effective tool for saving water (Corbella & Pujol, 2009; Inman & Jeffrey, 2006). The logic behind the pricing is that high water prices lead to lower demand for water (Corbella & Pujol, 2009). This follows the economic theory of supply and demand. Price influences quantity of water demanded if the elasticities are different from zero (Arbues *et al*., 2003). The elasticity of demand is a measure of how changes in price and other variables or goods affect the quantities demanded. Price elasticity of demand is the rate at which quantity demanded changes with respect to price (Arbues *et al*., 2003). Likewise, price elasticity of supply is the rate at which quantity supplied changes as price changes (Arbues *et al*., 2003). Specifically, the price elasticity of demand gives the percentage change in household water use in response to a 1 percent change in price (all other factors being equal, for example, holding all other determinants such as income, household size, constant) (Reynaud *et al*., 2018).

When analysing water demand, economic theory and econometric models such as logarithm functions are applied. The price elasticity of demand (PED) is defined as the percentage change in quantity demanded over the percentage change in price (Arbues *et al*., 2003; Fibich *et al*., 2005; Kenny *et al*., 2008). The PED measures the responsiveness of water use to a change in water price, all other factors being equal (Reynaud *et al*., 2018). There are several types of PED. These include the unit elastic demand which means PED is equals to one (PED=1), inelastic denoting that PED is less than one (PED<1) or i.e., price-insensitive and elastic demand meaning PED is greater than one (PED>1) (Metaxas & Charalambous, 2005). Scholars argue that (1) since water has no other alternative in most of its uses, it should be treated as a special

economic good because it has a variety of features that differentiate it from other economic goods (Madigele, 2016). Such features include that water is essential for humanity and ecosystems, it is irreplaceable, it is scarce, etc. (2) Household expenditure on the water is usually a relatively small share of the typical household budget, and (3) water is regularly demanded mutually with some other complementary good.

Literature reveals that most economists and scholars working on household water use generally find out that household water consumption responds to changes in water prices (Arbues & Villanua, 2006; Garcia & Reynaud, 2004; Nauges & Thomas, 2003). However, studies reveal that household water demand function is price inelastic, denoting that water consumption decreases by less than 1% for every 1% increase in price, with price-elasticity varying between -0.1 and -1.0 (Reynaud *et al*., 2018). Inman and Jeffrey (2006) estimate the average price elasticity for residential water demand of Europe, Eastern and the Western United States and Australia to be -0.28, -0.005, -0.17, and -0.60, respectively. Schleich and Hillenbrand (2009) analyse several economic, environmental and social factors for the per capita water demand in about 600 water supply areas in Germany and estimated the price elasticity of water demand in Germany to be -0.24. This result implies that the price elasticity of water is inelastic, indicating low responsiveness to price changes.

Previous studies reveal that outdoor water use is more price elastic with a price elasticity of -1 (Corbella & Pujol, 2009; Garcia *et al*., 2003; Gaudin, 2006). Additionally, a meta-analytic study of WDM in the United States of America, Europe and Australia by Worthington and Hoffman (2006) argues that price elasticity estimates are generally in the range of 0 to 0.5. The findings of another meta-analysis study in Australia shows that price is a vital determinant of residential consumption of water (Arbues *et al*., 2003). The impact of price on water consumption differs

based on several factors such as the household economic status water metering and household's acceptance of the pricing (Gaudin, 2006; Renwick & Green, 2000).

2.6.1.2. Psychological factors

A wide range of literature indicates that psychological factors such as attitudes and beliefs are essential determinants of consumers' behaviour (Fielding *et al.,* 2012; Russel *et al.*, 2010). According to Stern (2000), the determinants of conservation behaviour can be grouped into five causes namely, attitudes, beliefs, habits or personal routines, personal capabilities and contextual factors. Within psychological literature, attitudes are defined as an assessment of a component such as an object or a behaviour (Ajzen & Fishbein, 2000; Schultz *et al*., 2004). Attitudes toward the environment are associated with the engagement level of conservation behaviours (Arbues *et al*, 2003; Fielding *et al*., 2013). Fielding et al. (2013) reveal that if people realise the importance and scarcity of water resources, they are more likely to become more committed to water conservation actions.

A study of water consumption in Spain by Domene and Sauri (2016) shows that there is a significant correlation between attitudes and household water consumption. This may be due to the reason that people who are concerned with the environment are more likely to conserve water. Additionally, attitudes can be the overall evaluation of carrying out behaviour as positive and negative (Rusell & Fielding, 2010). For example, seeing water conservation as a constructive action reflects a positive attitude towards water conservation. Other examples of attitudinal factors include restriction intentions such as taking short showers, turning off the tap while cleaning teeth, and others. Efficiency intentions include installation of an efficient showerhead and dual flush toilets, and others.

Beliefs entail principles about the relationship of people within the natural environment (Schultz *et al*., 2004). Habits or routines are stable behavioural patterns, which have been reinforced in the past and result from automatic responses (Bamberg & Moser, 2007; Stern, 2000). They include water conservation intentions and behaviours. Personal capabilities include knowledge and skill influences on water consumption and conservation (Clark & Finley, 2007; Mayer, 1999; Stern, 2007). Stern (2000) contends that demographic and socio-economic factors can be proxies of personal capabilities. For instance, people with higher education and income may have greater awareness about conservation and greater ability to install water-efficient technologies that can reduce household water consumption. The relationship between age and water conservation may vary. For example, a study conducted in Blagoevgrad, Bulgaria by Clark and Finley (2007) reveals that older people are more likely to conserve water. This is due to the reason that age influences attitudes towards water conservation. Other authors urge the opposite, for example, a research study in Devon, England, by Gilg and Barr (2006) unveils that older people are less likely to conserve water.

Contextual factors are crucial considerations in examining water conservation behaviours because of their ability to facilitate behaviour (Gilg & Barr, 2006; Stern, 2000). Stern (2000) defines contextual factors as physical infrastructures and technological facilities such as bathtubs, showers and washing machines that are available within a household. It also includes a whole complex of factors such as household size, type of dwelling, welfare status and so on. For example, a household with a greater number of members consumes more water compared to a household with fewer members (Jeffery & Gearey, 2006). Gilg and Barr (2006) argue that households with fewer members tends to engage in water conservation.

2.6.1.3. Environmental factors

Environmental factors such as climate influence residential water demand (Gato *et al*., 2007). Temperature and rainfall are the most influential climate variables, which mainly influence outdoor water use (Ballings *et al*., 2007; Corbella & Pujol, 2009; Jones, 2008). Hotter days often lead to an increase in water demand due to garden watering, swimming pool use, personal hygiene (Hoffmann *et al*., 2006). In other words, high temperature increases human and plant hydration due to evapotranspiration. Rainfall is expected to affect outdoor activities, specifically water gardening since it determines the need for water by plants (Corbella & Pujol, 2009, Gato *et al*., 2007).

2.6.1.4.Technological factors

Water-efficient technologies play a role in reducing household water demand. Low flow appliances would increase water conservation and efficiency in households (Borg *et al*., 2013). A study by Beal *et al*. (2010) discloses that efficient front-loading washing machines used significantly less water (11.3 L/p/d) compared with top loaders. Mayer *et al*. (2004) also opine that the use of more efficient washing machines and the replacement of old and high flow shower heads with more efficient low flow fittings reduce household water consumption. Beal *et al*. (2010) argue that the installation of high efficiency (low flow) shower heads could result in a reduction of approximately 20% of water consumption based on per capita and household. Low flush toilets are more water-efficient compared to high flush toilets (Lee *et al*., 2011). Replacement of the older toilets conserve water as well as reduce water loss due to the reduction of leaks (Inman & Jeffrey, 2006). Other studies show that efficient technologies can have a significant effect on reducing average daily water consumption (Stewart *et al*., 2010; Willis *et al*., 2010).

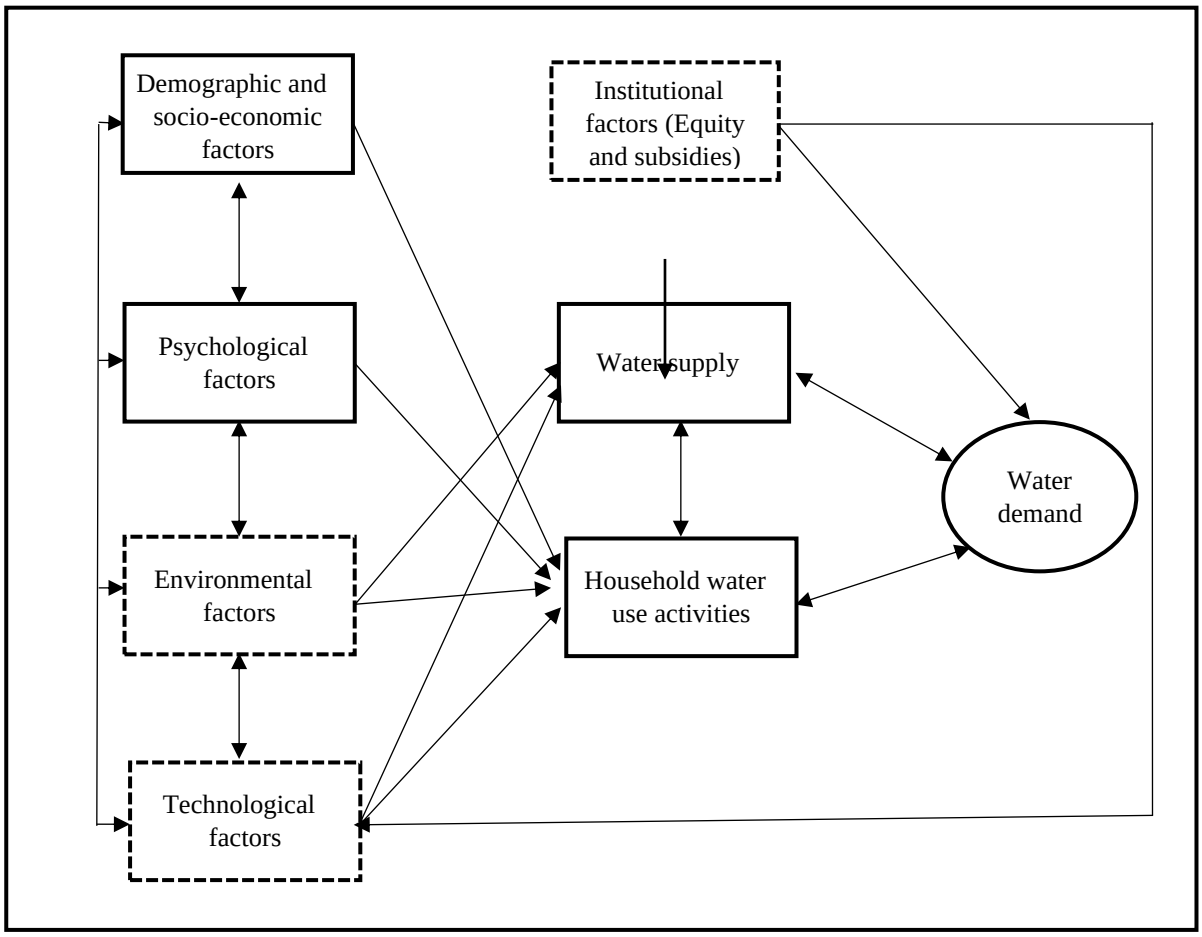
2.6.1.5. Household water use behaviour

According to Gregory and De Leo (2003) and Stern (2000), behaviour is not always rational and reasoned. It is, at times, guided by automatic routines and habits. Routines and habits are defined as automatic behavioural trends that arise as a result of the repetition and practice of actions in similar situations (Quellette & Wood, 1998). Water-using behaviours are actions that are performed frequently and end up becoming habitual (Quellette & Wood, 1998). People can develop positive water use habits (such as turning off taps when brushing their teeth) and are also likely to practice negative habits (such as taking long showers). When these actions are repeated over time, they may influence the amount of water consumed in the household. Gregory and De Leo's (2003) study in Sydney, Australia, indicates that households with lower water consumption have greater awareness of water conservation and tend to form habits in relation to lower water consumption. Accordingly, water use behaviour may have a significant impact on household water consumption.

Household water use behaviour includes water consumption activities performed by people daily (Shan *et al*. 2015), such as showering/bathing, toilets, laundry, watering, and cooking. It also encompasses the frequency and duration of water use of water-consuming appliances or activities within a household. A household is expected to demand 150 litres of water per day for health and sanitation (WHO, 2004). A study by Gilg and Barr (2006) reveals that water-saving behaviours are positively related to factors such as household ownership status, educational level, etc. A study conducted in Australia by Beal et al. (2011) projects the average water use consumption based on data from published studies and suggests the following water use allocation on various household activities, outdoor uses (21.9%), taps (19%), shower (25%), toilet flushing (12%) and washing machine (17.6%).

In North America, an analysis of residential end-users of water indicates that in single-family households, outdoor activities such as irrigation and swimming pools use more than half of the water consumed (58.7%) than for indoor uses (Mayer *et al*., 1999). According to the study, the top three activities are toilet flushing (26.7 %), washing machine use (21.7 %) and showering (16.8 %). Per capita, water use differs depending on conditions such as the source of water, dwelling type, ownership status and lifestyle of the water user among other factors. In Africa, it has been estimated that the majority of households in rural areas demand an average of 20-40 litres per person per day (Wallingford, 2003). In Ethiopia, water consumption is estimated at 6.68 litres per person per day (Rohrdrommel, 2017). A study conducted in Boro village within the Ngamiland District estimates the average per capita water use to be 20.6 litre per person per day (Oageng & Mmopelwa, 2014). In Botswana, there is a lack of or limited information on household behaviour. This study is, therefore, guided by the conceptual framework presented in Figure 1 to assess the determinants of residential water demand in Ngamiland District, Maun.

Figure 1 shows the conceptual framework for the study based on factors determining residential water demand, government, water supply and household water use practices/behaviours. It shows that there are seven groups of factors that affect water demand. The figure shows that the factors have two-way interaction among them. For instance, psychological variables (such as attitudes) influence demographic variables like age. Socio-demographic variables such as gender and household income also influence the purchase of technological appliances; a household with a higher income may be able to adopt water use efficient appliances which in return influence water demand. Environmental variables such as temperature influence psychological variables such as attitudes towards water use. For example, during summer people use lots of water for personal hygiene. The environment will determine the kind of technology to be utilised and vice versa. A good example is Maun where submersible pumps are installed right in the middle of water channels.



Key

_____ Factors included in the objectives

-------- Factors not rigorously investigated in the study

⟶ Arrow showing a one-way interaction between factors and other concepts

⟷ Arrow showing a two-way interaction between factors

Figure 1: Conceptual framework for residential water demand (Source: developed by author)

All the factors discussed in the above sub-sections influence household water use activities and consequently affect demand. For example, socio-economic variables such as household income determine the quantity of water a household can afford and use. Households with high levels of

income are associated with high demand for water because of the installation of water use technologies such as showers, swimming pools, among others. Demographic variables such as gender, influence the demand for water, for example, women are said to use more water compared to males because they are responsible for carrying out most household activities. Attitudes and knowledge towards water conservation influences water use practices. For example, the demand for water is expected to increase if households continue exercising unnecessary behaviours (such as brushing teeth while running tap water, washing dishes without plugging the sink). Water supply is influenced by environmental and technological factors. For example, low levels of rainfall results in less water available for supply hence households have to use the available water sustainably. Similarly, during summer (hotter days), households use more water for personal hygiene, therefore increasing the demand for water.

The institutional factors such as equity considerations and subsides influences water supply and demand. Generally, water pricing depends on the principles of equity and affordability (Molinos-Senante & Donoso, 2016; Raina & Suwal, 2020). Therefore, the government provides subsidies to the citizens to ensure water provision for everybody such that water from standpipes is provided for free in some of the remote areas in the country. The government is responsible for providing water infrastructures. Despite plenty of rain, water suppliers may limit water provision to households hence this may influence households to demand more water. Household water use activities have a two-way relationship with water supply, thus when supply decreases households tend to reduce their water demands. Similarly, when water supply increases households water demand increases. All these factors either affect demand negatively or positively.

2.7. Chapter summary

This chapter reviewed literature related to water demand (global to local) and conceptual framework of the study. Globally, water is one of the major essential resources (food and electricity included). It is limited in quantity and vulnerable, therefore should be managed in an integrated manner. Water has an economic value and should be recognised as a purely economic good, considering affordability and equity criteria. Water shortages are a problem everywhere due to increasing demands resulting from human activities, increasing population growth rate, among other factors. As a result, governments have embarked on integrated water resource management to reduce the demand and ensure supply for all. In Botswana, residential water demand (25%) ranks second after agricultural water demand (42%) as shown in Table 2 of this chapter. It is this manner that it is important to study the determinants of residential water demand to fill the gap on the subject matter. These factors include demographic, socio-economic and psychological factors. Household water use behaviour is also crucial in understanding water use and conservation for sustainable use.

Economic theories such as the neoclassical economic theory have been adopted by many economists and researchers in analysing water demand. Combined with SPT, the thesis analysed the determinants of residential water in Ngamiland District, Botswana. Various studies have been done on residential water demand although little or lack of such studies in Botswana. Hence this thesis seeks to fulfil the gap of knowledge in this field by assessing the determinants of residential water demand in Ngamiland District through answering four research questions outlined in Chapter One by applying the methodology developed in the next chapter.

CHAPTER 3

METHODOLOGY

3.1. Introduction

This chapter explains how this research is designed and implemented. It discusses the research framework adopted for data collection and data analyses meant for answering the research questions of the study. The justification for using the selected methods is also provided. It thus outlines pertinent information about the study area first. Research approaches are discussed, the research design, sampling procedure, instrumentation and measurement of variables, validity and reliability of instruments. The next section discusses the methods of data collection adopted by the study. Then the next one provides detailed description of methods for data analysis. Finally, the issue of ethical consideration is reflected on.

3.2. Study area

Ngamiland District is in the north-western part of Botswana, and it is bordered by Chobe District in the north-east, Central District in the east and Ghanzi in the south. The district covers an area of 109, 130 km^2 and has a population of 158, 104 (Statistics Botswana, 2014). Ngamiland District is under the administration of the North-West District Council. It is divided into two sub-districts authorities, Maun sub-District Authority and Okavango sub-District Authority, administered from Maun and Gumare, respectively. Maun village is the district headquarters and has a population of 58, 877 (Statistics Botswana, 2014). Tourism and livestock rearing are the main sectors in the district (Motsholapheko *et al*., 2011). People in Ngamiland

District also rely on natural resources (both aquatic and terrestrial) for transportation, fishing, handicraft materials, reeds, employment, etc. (Kgomotso & Swatuk, 2006). The study focuses on Maun in the southern (distal) part of the Okavango Delta and Gumare in the north-western part.

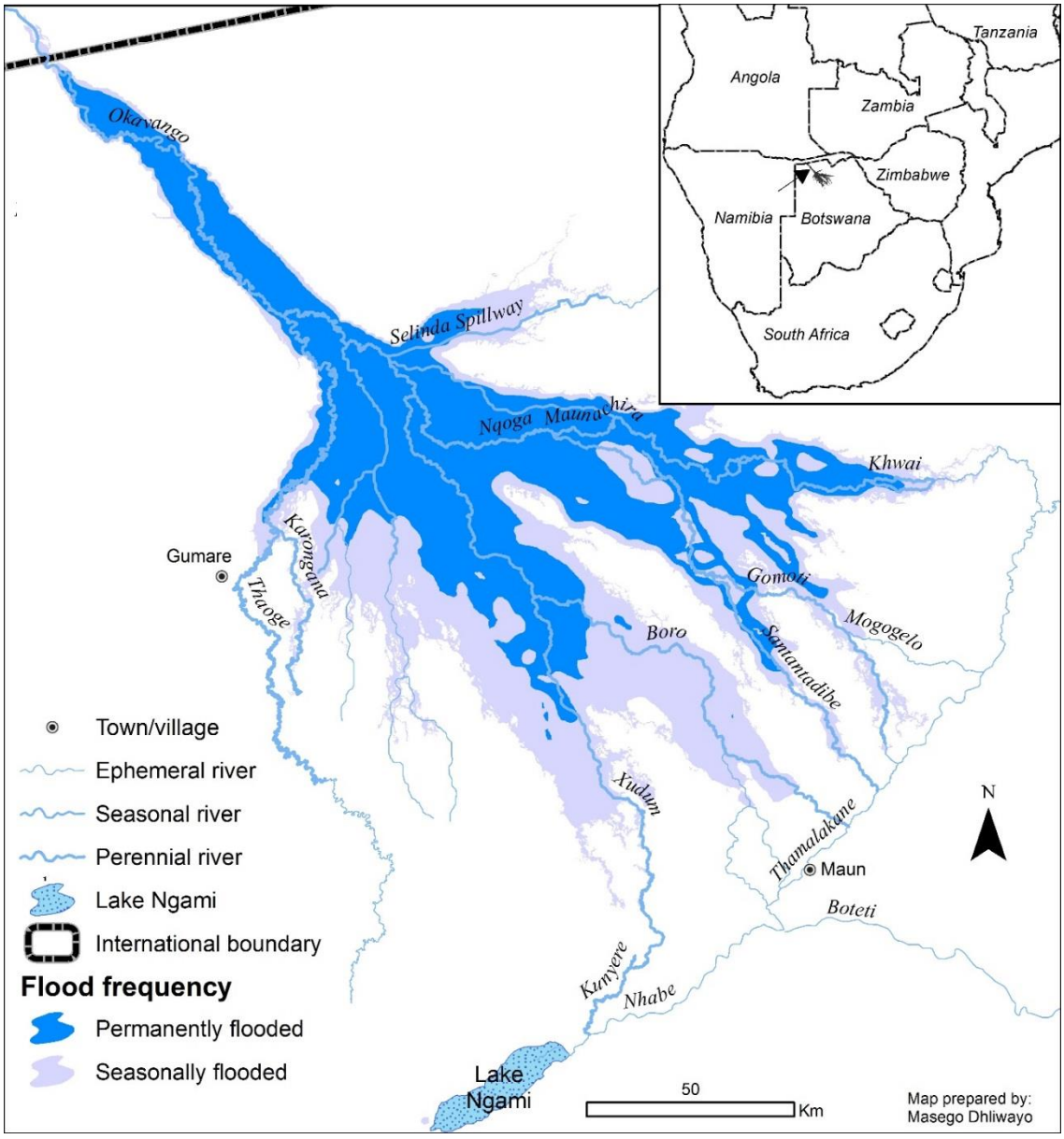


Figure 2: Map showing the study sites (Source: Okavango Research Institute)

The ethnic groups found in Maun include the Batawana, Bayei, Hambukushu, Baherero and others. Maun is selected as the study area because it has been experiencing the highest demand for water over the years compared to other areas in the district due to its large population.

Furthermore, it has the highest level of water demand in the country after Molepolole, out of the 17 major villages in Botswana (Botswana Water Statistics, 2009). Gumare is a rural village located in the north-west district of Botswana and it is the administrative headquarters for the Okavango sub-district. The population of Gumare is 8,212 (Statistics Botswana, 2014). The main ethnic groups found in Gumare are the BaYei, BaTawana, BaSubiya, BaHerero and Hambukushu. The major economic activities in Gumare include subsistence fishing, livestock rearing and farming. Gumare, like other villages in Ngamiland District, is challenged with high water demand due to population increase, hence its selection for the study.

3.3.Research design

A research design denotes how the study is organised, and it is used as a guide for data collection and analysis (Neuman, 2006; Neuman & Wiegand, 2000). It can also be defined as a set of procedures to be followed in addressing a research problem (Bless & Higson-Smith, 2000). This study adopted the cross-sectional design and mixed-method approaches. The cross-sectional design provides a snapshot of the scenarios and characteristics associated with the population being studied at a specific point in time (Levin, 2006). It has the advantage of providing data on the whole population under study (Hall & Lavrakas, 2008). A cross-sectional research design was selected to be used in this study because it is cost-effective (Levin, 2016). Additionally, data on characteristics of respondents, variables and perceptions about the phenomenon are collected at the same time and completed within a short period (Levin, 2006).

In this study, cross-sectional data was analysed using non-parametric statistical techniques to determine the relationships between the quantity of household ‘s monthly water demand (dependent variable) and independent variables such as gender, age, educational level of

household head, employment status, household income, household size, housing ownership, water bills, etc. One of the disadvantages of cross-sectional data is that the effects of changes in policy-related variables such as tariffs and income on water demand cannot be observed due to the short time interval of data collection. However, the cross-sectional survey has been used by researchers to estimate household water demand function in developing countries (Arbues *et al*., 2003; Espey *et al*., 1997; Worthington & Hoffman, 2008).

This study also adopted the mixed-method approach. A mixed-method approach overcomes the limitations of a single method approach and provides more comprehensive and stronger results (Cagdas & Stubjkaer, 2009). According to Punch (2014), a mixed-method approach is a combination of qualitative and quantitative data, and it provides a better understanding of the research problem. The quantitative approach entails the collection of close-ended data that can be analysed statistically (Creswell *et al*., 2003; Creswell, 2011). The quantitative approach assumes that knowledge can be objectively measured (Silverman, 2000). According to Cagdas and Stubjkaer (2009), quantitative approach uses statistical processes, strength, reliable, objective and reliable results that can be generalised from the sample to the larger population. It also includes the testing of known theories against hard empirical evidence with the help of statistical procedures (Bryman, 2008; Creswell, 2009). Therefore, in this study quantitative data were collected using an interview schedule, which intended to draw links between the dependent and independent variables. For example, determining the relationship between household water demand and household size. Moreover, it provided relationships between household income and attitudes towards water conservation and other variables.

A qualitative approach, on the other hand, is the collection of open-ended data that can be interpretive (Creswell, 2009). It can focus on subjectivism where realities are interpreted by the people involved in the research (Creswell, 2009). Qualitative approach is more suitable for

research that aims to explore and understand the nature of phenomena being studied (Cagdas & Stubjkaer, 2009). Hence, qualitative data were collected using a household interview schedule and key informant interview guide, which was designed to explore the perceptions, attitudes and knowledge towards residential water demand in respective study areas. The use of a qualitative research approach, helps to understand the reasons and values that influence people's perceptions about water use and everyday activities, overcomes the disadvantage of solely utilising quantitative techniques that engenders 'scientific reductionism' (Kolawole, 2010: 229).

3.4. Sampling procedure

This study used both probability and non-probability sampling techniques. A multistage sampling procedure was used to select respondents of the study. Firstly, Ngamiland District was purposively selected because it is one of the areas affected by high water demand in Botswana (Botswana Water Statistics, 2009; Moffat & Thukuza, 2011). Secondly, Ngamiland District is stratified into two groups, Ngamiland-East and Ngamiland-West. From the two groups, Maun and Gumare were selected as study areas using a purposive sampling technique. These are the major villages in the district, and they are the most affected by water demand. The next sub-sections discuss how households and key informants were sampled from the study areas.

3.4.1. Household sampling

The total number of households in Maun is 14,349 while Gumare is 2,001 (Statistics Botswana, 2014). Stratified sampling was used to select households in the study. A total of 26 wards in

Maun and 7 wards in Gumare were obtained from the administration authorities of both villages. The wards were stratified into two categories: serviced and non-serviced lands. Serviced land is where water supply, sewage lines, and stormwater drainage systems are availed whereas non-serviced land is where such infrastructures are not availed. Serviced wards are those located in serviced lands whereas non-serviced wards are in non-serviced land. The wards from both serviced and non-serviced lands have heterogeneous characteristics, including developed land, which is planned, traditional housing, modern housing with and without sewage systems. The wards were categorised into two homogenous groups namely, serviced land which consists mostly institutional houses by the government, council, Botswana Housing Corporation, etc. and non-serviced land which include private housing.

Of the 26 wards in Maun, three are located in serviced wards whereas 23 are located in non-serviced area. Gumare has a total of seven wards of which 3 are in serviced areas while four wards are located in non-serviced areas. From the serviced wards in both settlements, one ward was selected randomly. Non-serviced wards were further stratified into three categories: small medium and large based on the land coverage and population of the wards. One ward was selected randomly from each category using a research randomiser giving a total of three non-serviced wards selected in both of Maun and Gumare. Finally, there were four wards selected for sampling in each village (Table 4). Residential maps were obtained from the Tawana Land board and Gumare sub-land board. The housing list was also obtained from the administrative authorities. A household listing was prepared through numbering using the data obtained and a household listing was conducted in Gumare. Sampling of households was done proportional to the number of households in each ward (see Table 4). The households interviewed were selected randomly from the numbers generated to avoid bias. Household heads were identified in each sampled residential plot. Where there was more than one household in a plot, such households were listed, and one household was selected by simple random sampling.

The sample size was determined at a confidence level of 95% and a margin of error of ($^{+/-}$6). The sample size was calculated using the Raosoft sample size calculator, which uses the formula below to determine the sample size (n) and margin of error (E):

$$x = Z\left(\frac{c}{100}\right)^2 r\,(100 - r) \qquad \text{Eq. (1)}$$

$$n = \frac{Nx}{(N-n)E^2 + X} \qquad \text{Eq. (2)}$$

$$E = Sqrt\left[\frac{(N-n)x}{n(N-1)}\right] \qquad \text{Eq. (3)}$$

Where: *N* = population size

r = Fraction of response

Z (c/100) = Critical value for the confidence level *c*

Table 4: Number and proportion of listed and sampled households

Village	Ward	Serviced/non-serviced ward	Number of listed households	Number of sampled households
Maun	Chobe	Serviced	254	53
	Shashe	Non-serviced	603	124
	Boyei	Non-serviced	249	52
	Thitoyamokole	Non-serviced	159	33
Gumare	Bothatogo	Serviced	188	59
	Legonono	Non-serviced	265	84
	Subiya	Non-serviced	166	53
	Kgosing	Non-serviced	122	39
Total			**2,006**	**497**

Source: Field work, 2020

The sample size for this study was 497 households. A total of 2,006 households were listed and 497 households were interviewed in both Maun and Gumare villages (Table 4). The selection criteria qualified households with water system connections from the source by piped water networks provided by the Water Utilities Corporation (WUC). Households using other sources other than private tap connection as their main source of water were excluded from the sample to avoid bias in the findings of the study. All the 497 households sampled responded.

3.4.2. Key informants

The purpose of key informant interviews was to get reliable information regarding water demand and supply issues in the study areas. This was crucial in verifying and supplementing information collected from other sources. Understanding household water demand and management entails probing institutions involved in water management, community participation, water policies, programmes about water conservation measures and challenges associated with them. A purposive sample is a non-probability sample that is selected based on characteristics of a population and objectives of the study (Etikan *et al*., 2016; Tongco, 2007). Therefore, a purposive sampling technique was used to select key informants in this study. The criteria used in the selection of key informant interviewees in this study was expertise. An expertise-oriented approach entails the identification and selection of participants that have knowledge and experience on the subject matter (Creswell & Clark, 2011). A total of eight key informants with knowledge on water supply and demand issues in Maun and Gumare were interviewed. The participants included the chiefs, Village Development Chairperson (VDC) and WUC representatives from both study sites.

The following sub-section discusses the data collection instruments used to obtain data from the two primary data sources (questionnaire survey and key informant interview).

3.5.Instrumentation and measurement of variables

Based on the objectives of this study, an interview schedule and key informant guide were used for data collection. The interview schedule was used for collecting data from 497 household heads. The key informant guide was used to collect data from 8 key informants from the WUC, village chiefs and VDC chairpersons.

3.5.1. Interview schedules

Interview schedules are selected as the most appropriate data collection tool because a large number of respondents can be reached easily. They provide quantifiable answers to the research issue and the data collected is easier to analyse (Giuffre, 1997; Williams, 2003). However, an interview schedule may not necessarily reflect the respondents' true reality as most questions may be quantitative. To avoid that, qualitative questions were collected through open-ended questions and other additional tools. The shortcomings of an interview schedule were overcome through pre-testing, which enabled the researcher to identify the loopholes in the instrument before the actual survey.

A questionnaire was used to collect primary data from households in the study areas. Household heads or adults above 18 years of age who are familiar with household water practices participated in the survey. The questionnaire was written in English and Setswana languages for easy communication between the enumerators and the respondents. It was administered by the researcher with the help of one research assistant with a university social science degree. To ensure the quality of the survey, the researcher interviewed the research assistant and training was provided through revising the questionnaire to ensure that it was understood.

The questionnaire had both open and close-ended questions. The data collected on households included demographic and socio-economic information (section A), water demand and supply questions (section B), questions on psychological factors affecting residential water demand (section C), household water use behaviour about residential water demand (section D). Section E included questions on water demand in Ngamiland District, Botswana.

A total of 9 Likert-scale items/statements were framed to reflect households' negative perceptions about residential water demand issues. The statements were ranked on a 5-point Likert-scale from strongly agree (SA) which was assigned 1-point to strongly disagree (SD) assigned 5-points. The maximum points possible for a household was 45 while the minimum was 9 points for each statement. The perception scores were calculated by taking the average of the total scores of the Likert-item. Higher scores meant more positive perceptions towards residential water demand and vice-versa. The results revealed that households exhibited positive perceptions of residential water demand. The calculated mean score for perceptions was 3.25 with a standard deviation of 1.01. The household heads level of agreement varied from one statement to another based on their perceptions on residential water demand in the district.

3.5.2. Key informant interview guide

The strengths of key informant interviews are that data is collected from people who can provide relevant knowledge and understanding of the problem (Marshall, 1996). Data is also collected from people such as professionals, leaders or residents who have first-hand knowledge about the community. The weaknesses of key informant interviews may reflect in the possibility of bias if informants are not selected with care, difficulty in proving data validity, and much time required in a systematic analysis of a large qualitative data (Marshall, 1996).

In addition to the household questionnaire, this study also relied on a semi-structured interview guide written in English containing semi-closed and open-ended questions. The key informant guide was used to collect data on the challenges in water supply and demand, alternative water sources during periods of water shortages and alleviation measures taken during periods of water shortage. Data such as water challenges, strategies for enhancing water demand management, information on other sources of water were collected from chiefs and VDC chairpersons of the study settlements. The respondents were also recorded after seeking permission to do so. The next sub-section discusses the validity and reliability of the instruments used in the study.

3.6.Validity and reliability of instruments

Validity determines whether the results truly measure the phenomenon being studied (Joppe, 2000). The instrument of the research can collect the information that they were intended to. The questionnaire and key informant interview guide were prepared with the guidance of experts to ensure that they are the right tools for the study. This guaranteed the content validity of the instruments before they were used for data collection.

Reliability is the degree to which results are consistent after being repeated over time (Joppe, 2000). Reliability was ensured through a pre-testing that involved households that did not participate in the actual study. The pre-test was conducted in Matlapana Village which is not part of the study areas for this research. A total of 15 households were interviewed. A pre-test assisted in assessing whether the questions are easily understood by the respondents. In addition, questions that were not answered as expected were amended and unnecessary

questions were deleted. Triangulation was used to compare data collected from different sources, to ensure consistency of the information.

3.7. Data collection

A comprehensive household survey, key informant interview schedule and document reviews are the three data collection methods that were used to attain the objectives of the study. Both qualitative and quantitative data were collected using interview schedules. Thus, the four specific questions on demographic/socio-economic factors, water supply and demand, psychological factors and household water use behaviour were addressed through the household questionnaire. A key informant interview guide was used to source additional information on water demand and supply from experts in both study areas of Maun and Gumare. The data were collected once between January and February 2020 because the study adopted a cross-sectional research design. Additionally, secondary data such as household water demand, population and household size of the study areas, estimation of water demand for the district per month, water tariff, literature on water demand and its determinants among others were acquired from national reports such as WUC reports, water policy, BNWMPR, NDP 11, Vision 2036, Statistics Botswana, journal articles and reports. National documents related to water were selected purposively. Journal articles and reports were selected based on their relevance to the subject matter. The following section provides a detailed discussion on the data analysis techniques used for this study.

3.8.Data analysis

This study applied a mixed-method approach. Using interview schedules to collect information

from the respondents, both quantitative and qualitative data obtained from the household survey were analysed, accordingly. Also, additional qualitative data obtained from key informants were analysed as well. The data collected were coded, entered into a spreadsheet, cleaned, and analysed using Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics (frequency, percentages, and charts), measures of central tendency (mode, median and mean) and measures of dispersion (standard deviation and variance) were used in summarising the data.

Qualitative data were analysed thematically using content analysis. The content analysis includes categorisation of data into themes and sub-themes to enable comparison (Joffe & Yardley, 2004; Hsieh & Shannon, 2005; Moore & McCabe, 2005). It is an approach to the analysis of documents and text that seeks to quantify content in terms of predetermined categories and in a systematic and replicable manner (Bryman, 2008: 275). It includes searching for underlying themes in the text material that contain information contributing to a theme of the research (Gibbs, 2002). The core advantage of content analysis is that it simplifies data collected, at the same time creating results that may be measured using quantitative methods (Joffe & Yardley, 2004). Thematic analysis is disadvantaged when compared to other methods, as it does not allow the researcher to make claims about language use (Braun & Clarke, 2006). Thematic analysis is flexible although this could lead to inconsistency and lack of coherence when developing themes derived from the data of the study (Holloway & Todres, 2003).

In this study qualitative analysis was informed by the six steps to carry out the content analysis, as outlined by Robson (2002: 352-357). These six steps start with the research question, decide on a sampling strategy, define the coding, construct categories for analysis, test the coding of the text and assess reliability, and carry out the analysis. The text from the interviews, observations and field notes were coded. The codes applied were alternative water source, satisfactions of water pricing, attitudes, knowledge, water use behaviour, among others. The

notes were placed under specific categories of analysis. The notes placed under water demand and supply were alternative water sources, water price. Similarly, attitudes, knowledge variables were structured under psychological factors influencing residential water. The processes involved were summarisation of field notes, coding and identification of themes and patterns, production of categories. Then the coded materials and notes were used for thematic analysis and interpretation.

Quantitative data were tested for normality using the Shapiro-Wilk (SW) test to determine whether to use parametric or non-parametric tests in drawing inferences. Originally the SW test was limited to a sample size of less than 50 and it was improved by Royston (1982) to the sample size of 2000 (Razali & Wah, 2011). It is preferred among other tests such as the Lilliefors and Kolmogorov-Smirnov tests because of its good power properties of a wide range of alternative distributions (Mendes & Pala, 2003). According to Razali and Wah (2011), the SW test is the most powerful test of all types of distribution and sample sizes whereas Kolmogorov-Smirnov test is the least powerful. Nevertheless, the power of SW test is still low for small sample sizes (Razali & Wah, 2011). Mendes and Pala (2003) and Keskin (2006) also support the findings that SW test is the most powerful normality test.

According to the SW test, sample data is normally distributed if the significant value is greater than 0.05 ($p > 0.05$). If it is less ($p < 0 .05$) then the data is not normally distributed (Razali & Wah, 2011; Shapiro & Wilk, 1965). For this study, the normality test indicated that the data was not normally distributed. Therefore, non-parametric tests such as Spearman's correlation test, Chi-square test of independence, Mann-Whitney U and Kruskal Wallis tests were used to make inferences in analysing quantitative data. The limitations of non-parametric tests are generally less statistically efficient compared to parametric procedure when the data are approximately normal (Nahm, 2016). Non-parametric results may not be accurate because they

are distribution free. Secondly, the results of non-parametric tests are often not easy to interpret as compared to the results of parametric tests (Hoskin, 2012).

Although the results obtained from the normality test conducted in this study showed that the data obtained were not normally distributed, the central limit theorem (CLT) posits that when the sample size is large (such as in this study), the sampling distribution tends to be normal, and the violation of normality will not affect the results (Anderson, 2010; Islam, 2018). Thus, the sample means of moderately large samples are often well-approximated by a normal distribution even if the data are not normally distributed. In addition, parametric tests have higher statistical power in the sense that they are able to detect statistical significance (if it exists) where non-parametric tests (which do not require probability distribution) have failed (Kwak & Kim, 2017). Given this scenario, parametric tests were conducted in some of the variables in this study.

According to McHung (2013), Chi-square test independence also known as the Pearson Chi-square test or simply Chi-square is a distribution free tool designed to analyse group differences when the dependent variable is measured at a nominal level. Unlike most statistics, the Chi-square ($\chi 2$) can provide information not only on the significance of any observation differences, but also provides detailed information on exactly which categories account for differences found (Bewick, Cheek & Ball, 2004; Scott, Flaherty & Curral, 2013:54:3-8). In this study Chi-square test of independence was used to assess the relationship between two categorical variables. It was used to test association between household's monthly water demand which is the dependent variable with certain variables from the four objectives of the study as outlined in section 1.1.3 of Chapter One. For example, Chi-square test of independence was used in the first objective to determine the association between demographic and socio-economic variables, household's average monthly water demand/consumption. Household's monthly water demand

data were categorised and tested with independent variables such as gender, age group, education level, household income among other variables.

Spearman's correlation coefficient, (ρ, also signified by r_s) measures the strength and direction of association between two ranked variables (Sedgwick, 2014; Zar, 2005). It also measures the association between two continuous variables or ordinal variables, or one ordinal and one continuous variable. Spearman's correlation test was used in determining associations between household's monthly water demand and variables from all the objectives of the study. Mann-Whitney U test, also known as the Wilcoxon rank sum test, is used to test for differences between two groups on a single, ordinal variable with no specific distribution (MacFarland & Yates, 2016; Man & Whitney, 1947; McKnight & Najab, 2010). Mann-Whitney U test is referred to as the non-parametric version of the parametric t-test. According to McKnight and Najab (2010), the independent t-test requires a single variable to be measured at the interval or ratio level, rather than the ordinal level, and to be normally distributed. Therefore, in this study Mann-Whitney U test was used in addressing Object Three which assess the influence of psychological factors on residential water demand. Specifically, Mann-Whitney U test was used to determine the difference in males and female perceptions on residential water demand.

Kruskal-Wallis H test (sometimes called the "one-way Analysis of variance/ANOVA on ranks") is a non-parametric test that assesses the differences among three or more independent variables on a single, non-normally distributed continuous or ordinal variables (Kruskal & Wallis, 1952; McKnight & Najab, 2010). It is considered the non-parametric alternative to the one-way ANOVA, and an extension of the two-group Mann-Whitney U test (Hecke, 2012). When addressing Objective Three of this study, Kruskal-Wallis test was used to determine if there were significant differences between household's monthly water demand and awareness on water conservation by different respondents. It was also applied in Objective Four to assess

if there were significant differences between household's monthly water demand and different household members frequency for bathing/showering per day. Other variables such as different household frequency for doing laundry per week were also assessed using Kruskal-Wallis H test.

Parametric tests make assumptions about the parameters of a population, whereas nonparametric tests do not include such assumptions or include fewer (Mishra *et al.,* 2019). For example, parametric tests assume that the sample has been randomly selected from the population it represents and that the distribution of data in the population has a known underlying distribution (Tabachnick *et al.,* 2007). The most common distribution assumption is that the distribution is normal. The advantage of parametric tests is that they allow one to make generalisation from a sample population. The other one is that parametric tests are that they can provide trustworthy results when the groups have different variability (Mishra *et al.,* 2019).

Parametric tests such as the independent-samples T-test and one-way Analysis of Variance (ANOVA) were carried out on some variables. Prior to carrying out the tests the variables were transformed. Transforming of variables involves mathematically modifying the scores using various formulas until the distributions looks normal (Tabachnick *et al.,* 2007). According to Rojewski et al. (2012) independent-samples T-test is used to compare the mean score, on some continuous variable, for two different groups or subjects while ANOVA compares the means of more than two groups, thus it compares the variability between the different groups with the variability within each of the groups (Emerson, 2017; Kim, 2014).

3.9.Ethical considerations

Ethical approval was attained from the Office of Research and Development (ORD) of the University of Botswana. Followed by a request for a research permit from the MLMWSS. This research comprises officials from DWA, WUC, household heads and chiefs. The participation of respondents in this study was voluntary, and there was no threats or punishment for refusing to take part. The targeted people were not obliged to participate in the study, they had the right not to participate if they did not want to. The research considered the cultural and religious differences of the participants and therefore privacy was assured throughout the study by ensuring that only authorised people had access to data collected from respondents. Data was stored properly to ensure confidentiality and used for academic purpose only.

3.10. Chapter summary

This chapter focused on the methods for the thesis. It covered the study area, research design, sampling procedure, instrumentation and measurement of variables, validity and reliability, data collection, data analysis and ethical consideration. The chapter described the study area including population size, lifestyles of the people in the area and provided the justification for their selection. The study adopted the cross-sectional design and mixed-method approaches. Quantitative approach was used in this study to determine associations and correlations between variables while qualitative approach was used to supplement the data. The study used a sample size of a total of 497 households from Maun and Gumare. Random sampling was applied in selecting the households to be interviewed. Validity of the instruments were ensured through the guidance of experts before being used for data collection whereas reliability was ensured through a pre-testing which involved households that did not participate in the actual study.

The chapter also provided a detailed discussion of data collection methods. In this study multiple techniques of data collection were applied in order to triangulate evidence from different sources. Data collection methods included the interview schedule, key informant document reviews and observation. Descriptive statistics, measures of central tendency and measures of dispersion were used in summarising the data whereas non-parametric tests such as Chi-square test of independence, Spearman's rank-order correlation, Mann-Whitney U and Kruskal-Wallis H tests were used to make inferences. Ethical approval was attained form the relevant authorities before the study was carried out. The next chapter presents the results and discussions based on the objec8tives of the study as outlined in Chapter One of the thesis.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter presents the analyses and discussions of the findings obtained from the household surveys that were conducted in two villages in Ngamiland District of Botswana from January to February 2020. The summary of the quantitative statistical analyses is presented in tables and charts. The findings discussed in this chapter are grounded on the research objectives of the study. The chapter is divided into four sections. These include: i) demographic and socio-economic factors influencing residential water demand, ii) water supply and demand, iii) impacts of psychological factors on residential water demand and iv) relationship between household water use behaviour and residential water demand.

Chi-square test of independence was conducted to determine the associations between household's monthly water demand (dependent variable) and demographic and socio-economic attributes of the respondents, psychological and household water use behaviour variables (independent variables). Spearman rank order correlations were performed to determine the strength and direction of the relationships between variables. This is vital in drawing inferences on how these variables influence household water demand in the district. Kruskal-Wallis test was used to determine if there were significant differences between household's monthly water demand and other independent variables. ANOVA tests was used to compare means between two or more groups. Mann-Whitney U test was conducted to compare means between independent groups, namely Maun and Gumare, in order to determine whether the statistical means were significantly different. The test revealed no significant difference between

household's monthly water demand and the study sites. Therefore, this study used the two villages as a single cohort.

4.2. DEMOGRAPHIC AND SOCIO-ECONOMIC FACTORS INFLUENCING HOUSEHOLD WATER DEMAND

This section focuses on the analysis of demographic and socio-economic factors influencing residential water demand in Ngamiland District. Demographic and socio-economic factors partly describe the make-up of any community. These variables include gender, age, education level, employment status, household size, household income, house ownership among other factors.

4.2.1. Gender and household's monthly water demand

Most of the household heads (75.7%) were females (Table 5). This is reflected in the Botswana Demographic Survey Report 2017 which estimates 92.3 males per 100 females countrywide (Statistics Botswana, 2018). Sex ratios of Ngamiland East and Ngamiland West are estimated at 88.8 and 80.2 males per 100 females, respectively (Statistics Botswana, 2018).

Table 5: Demographic attributes of the respondents

Variable	Frequency (n=497)	%	
Gender			
Male	121	24.3	
Female	376	75.7	
Total	497	100	
Age group			
Less than 29	106	21.3	Mean=41.6
30-39	162	32.6	Median=38
40-49	103	20.7	Std. Deviation=14.5
50-59	61	12.3	
60 and above	65	13.1	
Total	497	100	
Marital status			
Single	353	71	
Married	124	24.9	
Widowed	15	3	
Divorced	5	1	
Total	497	100	
Ethnic group			
Batawana	71	14.3	
Bayei	201	40.4	
Baherero	14	2.8	
Basarwa	18	3.6	
Hambukushu	55	11.1	
Others	138	27.8	
Total	497	100	

Source: Field survey, 2020

Figure 3 shows the percentage distribution of gender and household's monthly water demand. Results reveal that almost (60%) of the females used between 1001-4000 litres of water per month. In contrast, 16.5 percent of the males used the same quantities within the same period. Also, 9.3 percent of the females and 2.6 percent of the males revealed that they used 4001 litres and above per month. Overall, the results reveal that females demanded more water compared to the males. This is because females carry out most of the household water-related activities as they are the caretakers or homemakers (Green & Bargen, 1995). Similarly, research by Weng and Nitivattananon (2007) in Malaysia observed that women are the main water managers both

at home and offices and they are considered vital in conservation. According to the study, women also make decisions on the installation of water saving appliances.

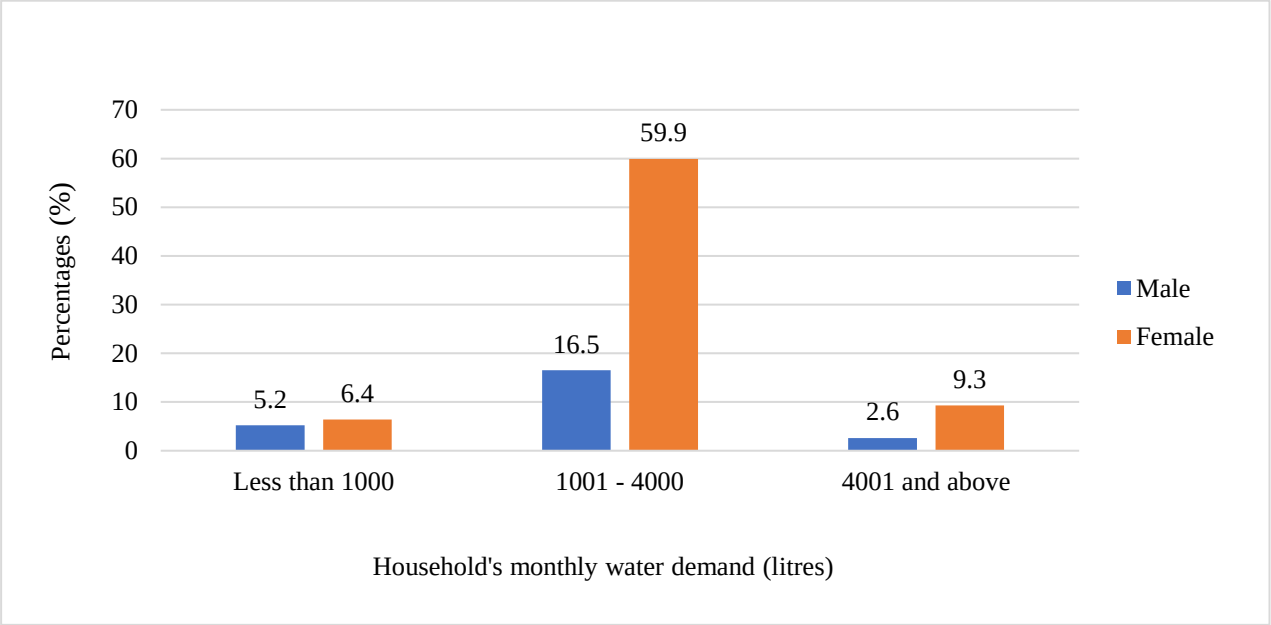


Figure 3: Gender of the respondents and monthly water demand

The Pearson Chi-Square (χ^2) test of independence was used to determine if there is a significant association between household's monthly water demand and gender of the household head. Results on Table 6 reveal that there is a significant association between gender of the respondents and household's monthly water demand ($\chi^2 = 14.961$; $\rho < 0.05$). Previous studies have also shown that gender has a significant association with household water demand (Jordan-Cuebas *et al.* 2018; van Koppen, 2001; Makki *et al*, 2018). For example, a study by Makki et al. (2018) found that females are likely to take long baths compared to males, all things being equal.

Table 6: Chi-square of gender and households' monthly water demand

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14.961[a]	2	0.001
Likelihood Ratio	13.337	2	0.001
N of Valid Cases	497		

a. Cells (0.0%) have expected count less than 5. The minimum expected count is 14.12.

4.2.2. Age and household's monthly water demand

Age is another important variable that influences household water demand. Results of the study indicate that the average age of the household heads was 41.6 years, with a standard deviation of 14.5 (Table 5). As illustrated in Table 5, 32.6 percent of the respondents were within the age group 30-39 years. This analysis showed that most of the household heads were still in the youth stage. Only 13.1% of the household heads were 60 years and above.

Figure 4 depicts the distribution of age group of the respondents and household's monthly water demand. The results show that among the age groups of the respondents, 3.4 percent who demanded less than 1000 litres were in the age group of less than 29 years. Almost 30 percent of the respondents who demanded between 1001–4000 litres of water were between the age group of 30–39 years. However, results suggest that household heads aged between 30–39 years demanded more water compared to the other age groups. Moreover, most of the household heads fall within this age group as depicted in Table 5. Results show that most of the households (76.5%) demanded between 1000-4000 litres of water per month. This is explained on the ground that people having water-use facilities (such as showers, water system toilets, etc.) tend to demand for more water.

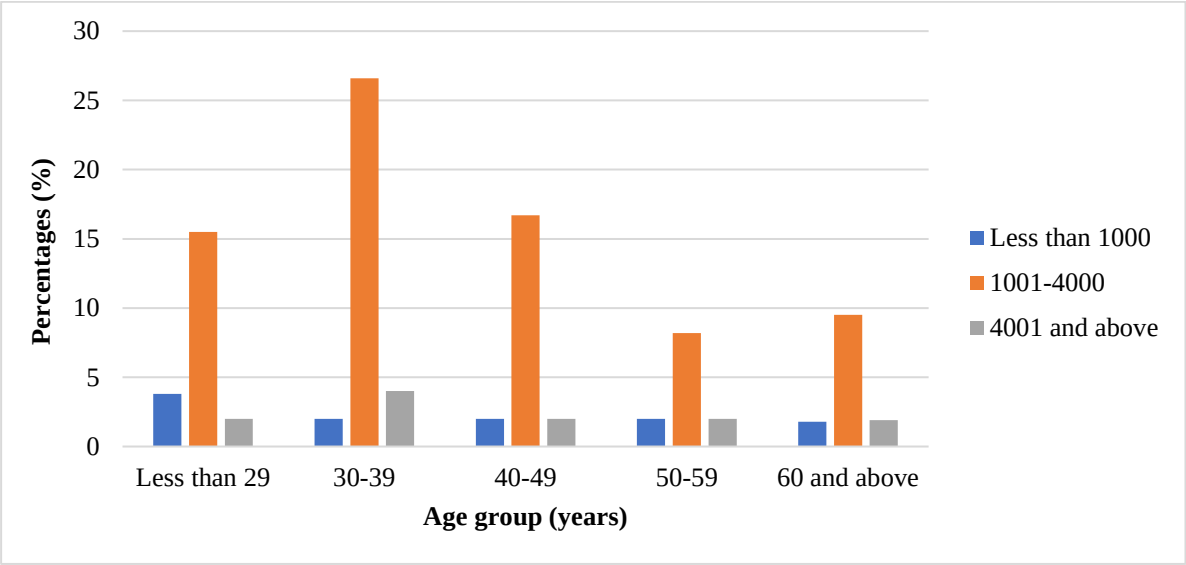


Figure 4: Age of the respondents and monthly water demand

A Spearman's correlation test was performed to assess the relationship between household's monthly water demand and age group of the household head. The test revealed that there was a very weak but positive relationship between age group and household's monthly water demand ($r_s = 0.045$ and $\rho > 0.05$. Similarly, the results of one-way between-groups ANOVA test showed that there was no statistically significant difference at F (1.4), $\rho > 0.05$ level in households' monthly water demand for the five age groups. However, previous studies have shown that age has a significant relationship with water demand (Dale *et al*., 2009; Kenney *et al*., 2008; Lyman, 1992). For example, findings by Billings and Gober (2009) and Schleich and Hillenbrand (2009) revealed that older people use more water as compared to other age groups because they spend most of their time at home, although older people are more careful when using water compared to children who tend to play with water. Gondo and Kolawole (2019) also showed that age influenced rural household water management decisions in the Okavango Delta. The results of the study differ from those in other studies because most of the households consisted of respondents who were between 30-39 years (a combination of youth and adults). The results

also reflected that this age group demanded water unlike other groups such as older people (60 years and above) and people below 29 years old.

4.2.3. Education level and household's monthly water demand

Results indicate that the average number of years spent in school by household heads was 10 years with a standard deviation of 4.8 (Table 7). The data were further categorised into different education levels. The majority (44.1%) of the household heads had secondary education, either Junior Certificate (JC) or Botswana General Certificate of Secondary Education (BGCSE). The survey results also show that 27.2 percent of the respondents had tertiary education (certificate, diploma, bachelor's degree, and master's degree). About 17.7 percent of the respondents had primary qualification, 2.2 percent had attended non-formal education whereas 8.9 percent had not attended any education at all. Generally, most (88.9%) household heads in the study area had acquired formal education. In this study, 27.2 percent of the respondents in both Maun and Gumare had tertiary qualifications. Arguably, such households afford water-consuming facilities such as flush toilets, showers, washing machines, etc.), which implies more use of water.

Table 7: Socio-economic attributes of the respondents

Variable	Frequency (n=497)	%	
Education level			
None	44	8.9	Mean=10.0
Non-formal	11	2.2	STD = 4.8
Primary	88	17.7	
Secondary	219	44.1	
Tertiary	135	27.2	
Total	497	100	
Employment status			
Formally employed	195	39.2	
Self-employed	57	11.5	
Unemployed	245	49.3	
Total	497	100	
Income level			
Less P3000	77	30.5	Mean=2347.7
3001-4000	18	7.1	STD=4758.9
4001-5000	18	7.1	
5001 and above	99	39.3	
Did not disclose their salaries	40	15.9	
Total	**252**	**100**	

Source: Field survey 2020

Figure 5 presents the relationship between education level of the respondents and monthly household water demand. Results show that among households with non-formal education, 1.4% of the household demanded less than 1000 litres, 8.2 percent demanded 1000-4000 litres. Five percent of the respondents with secondary education demanded less than 1000 litres, 33.4 percent demanded 1001-4000 litres and 5.6% demanded 4001 and above litres. Two percent of the respondents with tertiary education demanded less than 1000 litres, 22.5 percent demanded 1001-4000 litres and only 2.6 percent demanded 4001 and more litres of water. Generally, the respondents with secondary education demanded more water.

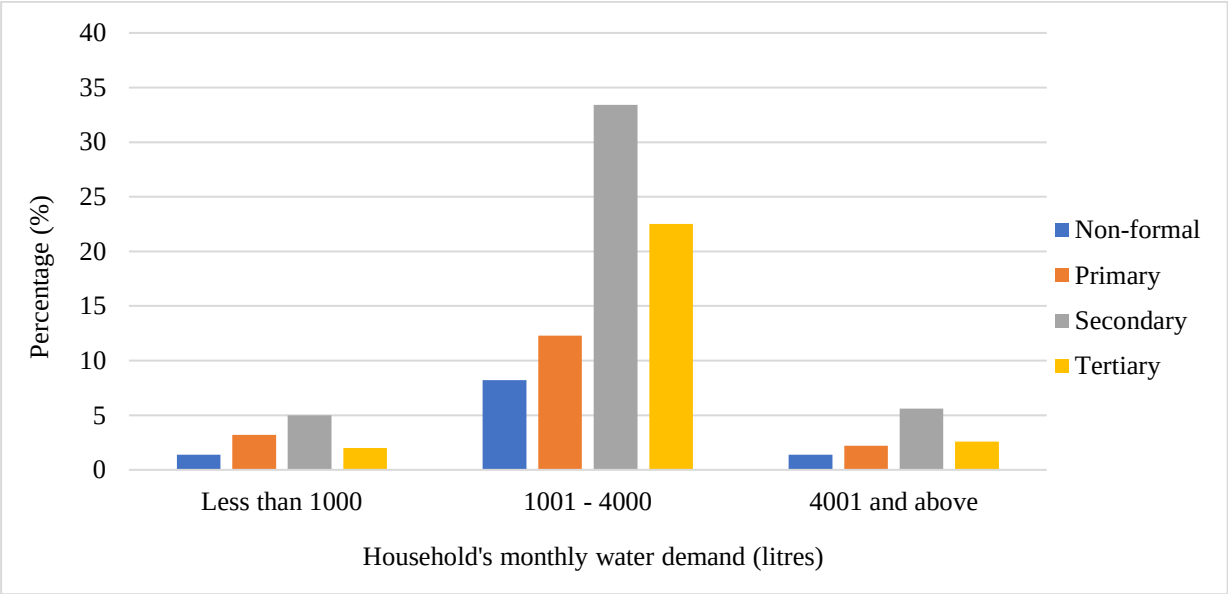


Figure 5: Education level and households' monthly water demand

Chi-Square test of independence showed no significant association between monthly household's water demand and education level of the household heads, ($\chi^2 = 10.069$; $\rho > 0.05$). A Spearman's correlation test was calculated to measure the strength of the relationship between monthly water demand and education level groups of the household head. The result indicates that there is a very weak but positive correlation ($r_s = 0.032$ and $\rho > 0\ .05$) between household's monthly water demand and different education level groups of the household in the study sites. Likewise, a study on factors determining residential water demand in North-western Ethiopia argued that education level of household head did not have significant effects on water demand (Dagnew, 2012). Similarly, findings of a study by Salman, Al-Karablieh and Haddadin (2008) discovered that the impact of education level on household water demand is insignificant, although the per capita model showed a slight decrease as education level improved. In contrary to these findings, Wolters (2014) reported that higher education levels correlate with higher levels of water. Moreover, some studies have argued that higher education level is often associated with improvement in an individual's lifestyle (Babel, Gupta & Pradhan, 2007; Nauges & Whittington, 2010).

4.2.4. Employment and household water demand

The results on Table 7 reveal that 39.2 percent of the household heads had formal employment. Approximately, 11.5 percent of the respondents were self-employed. Almost half (49.3%) of the household heads were unemployed. The number for the unemployed people from the survey is high as this is one of the key challenges not just in Botswana but across the globe.

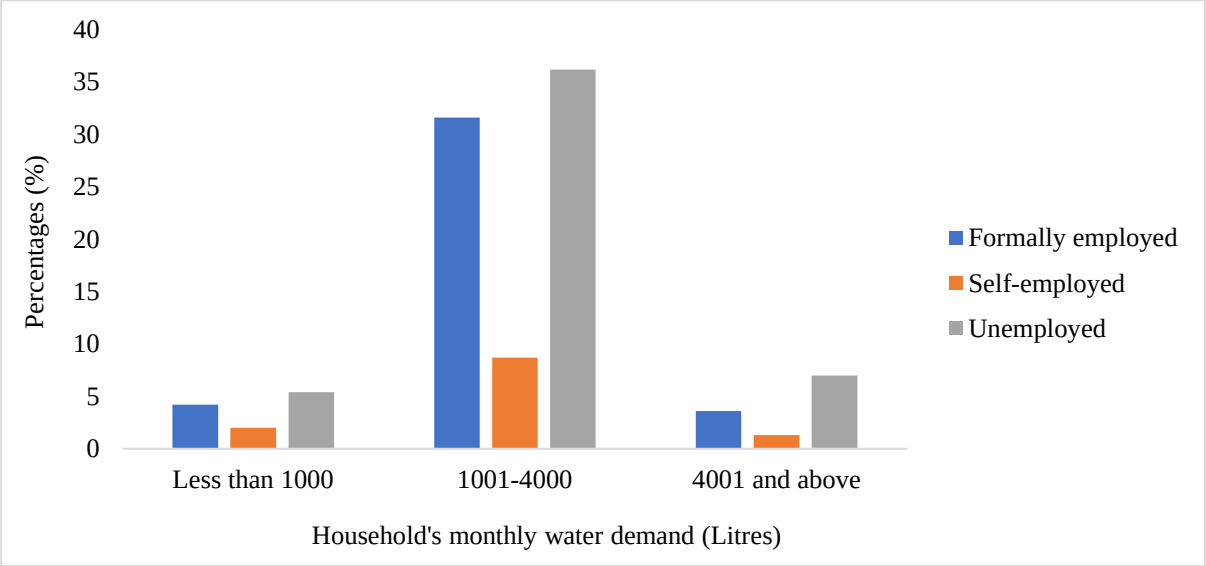


Figure 6: Employment status and household's monthly water demand

Figure 6 depicts that 5.4 percent of the respondents who demanded less than 1000 litres were unemployed whereas 4.2 percent were formally employed and 2% were self-employed. According to the study it shows that the unemployed household heads' water demand is more compared to the formally employed and self-employed. This may be due to that the unemployed people stay home most of the time hence they tend to carry out more water related activities. The majority (76.5%) of the respondents demanded between 1001 – 4000 litres of water. Chi-Square test revealed that there was no significant association between employment status and monthly water demand, ($\chi^2 = 4.656$; $\rho > 0.05$).

4.2.5. Household income and household's monthly water demand

Analysis shows that the average monthly income of respondents is BWP2,357.70[1] with a standard deviation of 4,758.9. About 39.3 percent of the employed respondents falls within a range of income group of BWP5,001.00 and above per month (Table 7). The large value of the standard deviation may have been influenced by the large variation between the minimum and maximum monthly income of household heads.

The results of the Spearman's correlation test indicated that there is a very weak but positive correlation (r_s = 0.096 and $\rho < 0$ .05) between monthly water demand and different income groups of the household heads in Ngamiland District. This implies that an increase in household's monthly income leads to increasing water demand. The results suggest that households with high income demand more water because they can afford high income water-consuming facilities such as water systems toilets and showers. These findings are similar to those of Arbues and Villanua (2006); Dandy, Nguye and Davies (1997); Gaudin (2006); Gondo *et al.* (2020); and Schleich and Hillenbrand (2009). For each of the water use category, the largest number of households heads were unemployed. The reason could be that most of unemployed households had a large number of family members resulting in more water demand compared to families with fewer members.

Even though efficient water-consuming facilities could be purchased, households may still fail to control their water misuse behaviours (Grafton *et al*., 2009). In contrast, low-income households are less likely to purchase efficiency facilities but may possess money-saving habits, such as washing dishes only when there is a full load. A study conducted in Australia

[1] US$ 1 = BWP 11.08

by Willis et al. (2011) found that households with a higher level of income have a higher water demand compared to households with low income. Likewise, Ballings and Gober (2007) show that in southern Arizona, a 10 percent increase in the average household income results in a 3 percent increase in water use.

4.2.6. Household size and household's monthly water demand

The results showed that the average household size is 5.5 with a standard deviation of 3.8. This is bigger than Botswana's average household size of 3.3 persons per household (Statistics Botswana, 2017). Analysis indicates that 63 percent of the households had between 1-5 members. About 25.8 percent of the household had 6-10 people and 11.3 percent had 11 members and above (Table 8).

Table 8: Socio-economic attributes of the respondents

Variable	Frequency (n=497)	%	
Household size			
1-5 people	313	63	Mean=5.5
6-10 people	128	25.8	STD=3.8
11 people and above	56	11.3	
Total	497	100	
Household ownership			
Fully owned	340	68.4	
Renting-private	50	10.1	
Renting-public	107	21.5	
Total	497	100	
Location of household			
Serviced land	112	22.5	
Non-serviced land	385	77.5	
Total	**497**	**100**	

Source: Field survey, 2020

As illustrated in Figure 7, 9.9 percent of the households consisting of 1–5 people used approximately less than 1000 litres of water. Among the households interviewed, almost half (49.7%) demand between 1001 – 4000 litres. These results mean that households with higher number of people (11 and above) demanded more water compared to other household sizes. Generally, most of the households demanded between 1001 – 4000 litres. Nevertheless, a study conducted in Germany by Schleich and Hillenbrand (2008), found out that household size had a negative impact on per capita demand.

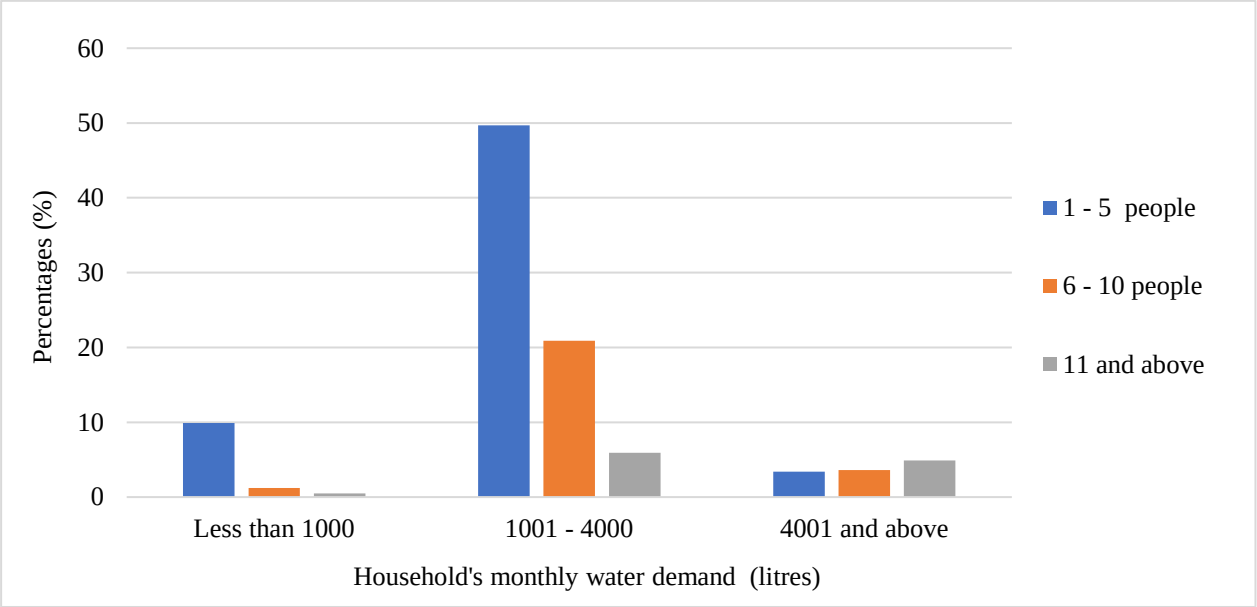


Figure 7: Household size and monthly water demand

Chi-Square results indicate a significant association between household size of the respondents and household's monthly water demand ($\chi^2 = 75.465$; $\rho < 0.05$). Spearman's correlation test was run to assess the relationship between monthly water demand and household size. The results indicate that there is a moderate positive and significant correlation between monthly household's water demand and different household size groups in Ngamiland District, $r_s = 0.422$ and $\rho < 0.05$. One-way between groups ANOVA test also revealed a statistically significant difference between households' monthly water demand and households' size, F (4.9), $\rho < 0.05$.

These results suggest that larger households tend to demand more water compared to smaller size households in Ngamiland District. This is because they require large volumes of water for activities such as bathing, cooking, laundry and others. This is verified by Arbues et al. (2010) who indicated that a larger household size implies higher water consumption. On the contrary, a study in the Okavango Delta found that water consumption was relatively higher in small households than in large ones (Gondo *et al.,* 2020). This corresponds with the observation of Sarabia-Sánchez and Rodríguez-Sánchez (2013) who found that large household size implies great consumption, though consumption per capita is not proportional to the number of people since there are economies of scale at work. Therefore, households with few people, water consumption is higher than in those with more people on a per capita basis.

4.2.7. House ownership and households' water demand

The results reveal that the majority (68.4%) of the respondents owned homes and 21.5% were renting government houses (Table 8). The distribution of households in terms of house ownership and monthly household water demand are shown in Figure 8. The results reveal that 6.8 percent of the respondents who demanded less than 1000 litres of water owned houses whereas 4 percent of those renting private houses demanded the same litres of water. The findings show that 76.5 percent of the respondents demanded 1001– 4000 litres of water. Within this category, 51.9 percent of the respondents owned houses, 18.9 percent rented government apartments and only 5.7 percent rented private housing. This means house owners demanded more water compared to renting private or institutional houses. This is because house owners are free to carry other activities such as brick making and gardening unlike when you reside in a government house governed by regulations.

A Spearman's correlation test was run to assess the relationship between house ownership and monthly household water demand. The results (r_s = -0.422 and ρ > 0.05) indicated that there is a negative and no significant correlation between house ownership and monthly water demand in the two study locations combined. One-way between groups ANOVA test also revealed that there was no statistically significant difference between households' monthly water demand and households' size, F (4.9), ρ > 0.05. However, Troy and Randolph (2006) argued that there is a positive correlation between house ownership and monthly water demand.

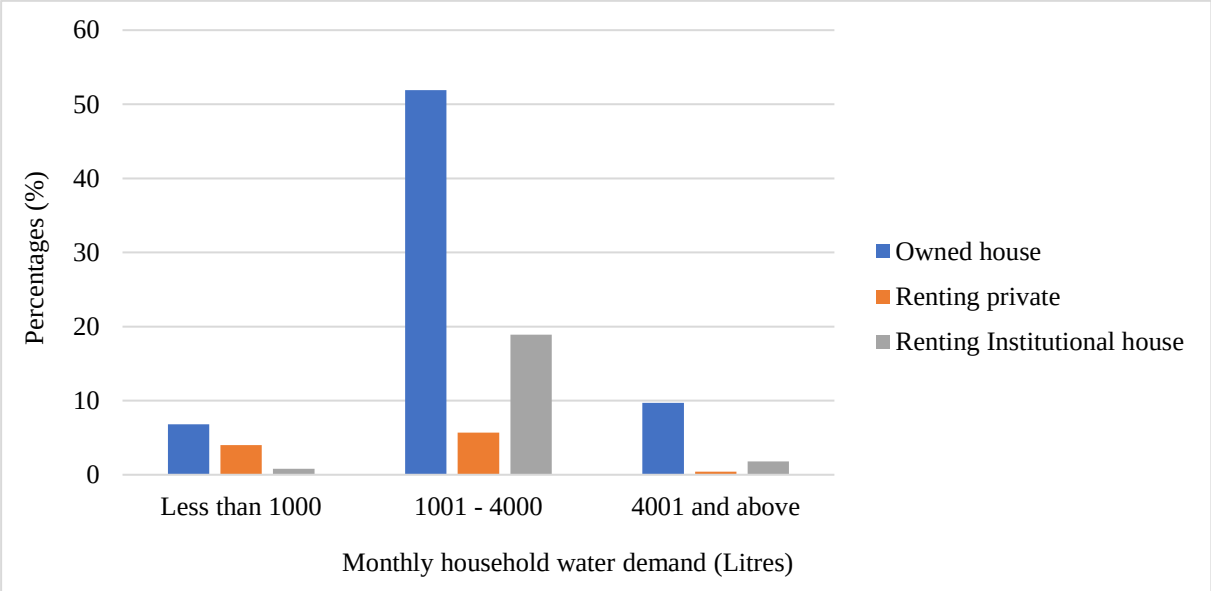


Figure 8: House ownership and monthly water demand

4.3. WATER SUPPLY AND DEMAND IN MAUN AND GUMARE

This section of the study focuses on water demand and supply issues in Maun and Gumare villages. It analyses variables such as in-house water connection, alternative water sources, the experience of water shortage, factors contributing to water shortage, the ranking of household water use activities, outdoor water use, payment for water services by the respondents, payment schedule, methods of water billing, satisfaction and reason for not being satisfied by the water

charges. Descriptive statistics are used in summarising the data whereas Chi-square test of independence was conducted to determine the associations between household's monthly water demand (dependent variable) and water supply and demand variables (independent variables).

4.3.1. Household water sources

As shown in Table 9, all the 497 surveyed households had a private water connection to the piped network, which is the main source of water for the households under study. Most households (51.5%) had home or yard taps (outside the house) and 48.5 percent had house connection (indoor taps).

Table 9: Frequency of households by type of water connection

Water connection system	Frequency (n=497)	%
House connection	241	48.5
Yard tap	256	51.5
Total	**497**	**100**

Source: Field survey, 2020

Results on Table 10 indicate that 4.2% of households with house connections and 7.6 percent of household with yard tap connections used 1000 litres of water. Moreover, 39.2 percent of households with house connections and 37.2 percent of households with yard tap connections used between 1001–4000 litres. This implies that households with house connection demand more water compared with those with yard taps. The reason could be due to the availability of water-consuming facilities.

Table 10: Type of water connection and households' monthly water demand

Water connection	Grouped household's monthly water demand (litres)			
	Less than 1000	**1001-4000**	**4001 and above**	**Total**
House connection	4.2	39.2	5.2	48.6
Yard tap	7.6	37.2	6.6	51.4
Total	**11.8**	**76.4**	**11.8**	**100**

Source: Field survey, 2020

Chi-Square results on Table 11 revealed a significant association between household water connection system and monthly water demand ($\chi^2 = 6.233$; $\rho < 0.05$). The results suggest that the variables household water connection system and monthly water demand are associated with each other.

Table 11: Chi-square test for households' water connection and monthly water demand

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.233a	2	0.044
Likelihood Ratio	6.322	2	0.042
N of Valid Cases	497		

a. Cells (0.0%) have expected count less than 5. The minimum expected count is 28.12.

Data analysis on Table 12 shows that monthly water demand for households with house connections was estimated at 2440.5 litres on average, whereas the average monthly demand of yard tap connected households was 2310.1 litres. These results indicate a significant variation in both households' water consumption patterns.

Water consumption varies from household to household. The average household's monthly water consumption for both house connection and yard tap connected households was calculated to be 2373.3 litres. The average number of days in a month (30), average 5.5 family size estimated by this study, were used to estimate the volume of water consumed by per person per household. The estimated average consumption was 14.4 litres per capita per day (lpcd) as shown in Table 12. This is far lower than the per capita consumption recommended by the UN, which is 50 litres per day (UNDP, 2015). This is because water supply in Ngamiland District is low, and this would require some attention. The average lpcd by household with piped connections varies across places. For example, it was estimated to be 72 litres lpcd in a group of provincial towns in Cambodia (Basani, Isham & Reilly, 2008). This is estimated at 88 lpcd in Fianarantsoa, Madagascar, Larson et al. (2006), 120 lpcd in Buon Ma Thuot, Vietnam, Cheesman et al. (2008) and 130 lpcd in Salatiga City, Indonesia, Rietveld et al. (2000). As mentioned in Chapter Two of this thesis, water demand in rural areas in Africa has been estimated at 20-40 litres/person/day (Wallingford, 2003). In Ethiopia, consumption is estimated at an average of 6.68 lpcd (Legamo, 2018).

Table 12: Estimated average households' monthly water demand in Maun and Gumare

Water connection system	**Estimated average monthly HWD (Litres)**	**Litres per capita per day (lpcd)**
House connection	2440.5	14.8
Yard tap	2310.1	14.0
Average	**2373.3**	**14.4**

Source: Field survey, 2020

Data analysis shows that lpcd in study location is low compared to previous results for other studies. This may be that the study was conducted during a period that the villages were

experiencing water shortage due to the drying up of the rivers as a result of low inflows due to climatic variability. As earlier mentioned in the thesis, previous findings have shown that Ngamiland District is undergoing water shortages (Kujinga *et al.,* 2014; Oageng & Mmopelwa, 2014; Setlhogile & Harvey, 2015). This led to an increase in household water demand by residents.

4.3.2. Alternative household water sources

Findings show that most (76.9%) of the households indicated that they have alternative sources of water and only (23.1%) of the household heads stated that they did not have alternative sources of water, making them dependent on tap water connected to their yards. Most people may have resorted to alternative water sources because Ngamiland District was undergoing water shortages.

Table 13 indicates the different alternative sources of water used by households during periods of water shortages. Results reveal that 27.9 percent of the households bought water from private companies and individuals during periods of water shortages. This includes people who did not drink from the water taps in their households but would rather purchase mineral water from private companies. It was observed that there was a higher number of respondents who bought water in Gumare. This may be that the effect of water shortages was felt more in Gumare as compared to Maun. The study identified other alternative water sources such as institutional houses, river, storage tanks (commonly known as *jojo*), workplace among other sources.

As opined by most respondents, access to water supply has been a challenge because water from taps is only available at an interval of two to three weeks during which waterflow would last for less than two hours. One of the respondents' said: "It is so difficult for us to live without

water, and I wonder if we are going to suffer like this in heaven". Besides, borehole water is not even treated, people drink it directly, although a few respondents indicated that they boiled it. Another respondent said: "Water is problematic in Gumare village. We are reusing bathing water by storing it and boiling it the next day to be used for bathing again. Sometimes we bathe our children and then add a few litters of warm water to the same water so that adults could have a bath". This showed that the supply of water needs attention given that people's health may be in jeopardy as they have to use low-quality water.

A few of the respondents (0.8%) in Gumare village stated that they fetched water from government houses while one percent got water from their workplace (Table 10). One of the key informants confirmed that; "Gumare settlement is the worst affected by water shortages". He also disclosed that:

> 'At my house, I have two storage tanks. Normally, during water shortages, people come to ask for water and there is no way I can refuse their request since I know how bad the water situation is in my village. Some people cannot afford to purchase the storage tanks. They mostly store water in 20-litre containers which do not last for long.'

Acknowledging the severe water shortages being witnessed in the study area, another respondent from Gumare settlement said:

> 'We have to purchase water, which is more expensive, from private companies and individuals because Water Utilities Corporation is failing to supply water to us. One 20-litre container costs BWP10 plus transportation cost of BWP25. Life is difficult for us in Gumare - we are thirsty.'

Table 13: Alternative household water sources

Alternative water sources	Frequency (n=497)	%
Buying water	139	27.9
Do not have an alternative water source	115	23.1
Neighbours' tap	99	19.9
Borehole	46	9.3
Public tap	40	8
Storage tanks	20	4
Neighbour's tap and buying water	13	2.6
River	5	1
Fetch water from work	5	1
Borehole and neighbour's tap	4	0.8
Institutional houses	4	0.8
Workplace and other wards	3	0.6
Neighbouring institutional houses	2	0.4
Public tap and borehole	2	0.4
Borehole and buying water	1	0.2
Total	**497**	**100**

Source: Field survey, 2020

Observations during the research showed that water supply is low both in quantity and quality more especially in Gumare village. The water from the supply systems was coloured and had particles. One of the respondents from Maun also confirmed this by saying that "Diarrhoea is common especially in babies and school children because of the dirty water that we drink. This causes our children to miss school lessons, which could have an impact on their performance". A few numbers of the households (8%) use public taps as an alternative source of water. One respondent claimed that:

> 'Even though we have water supply from public taps at times, I am unable to fetch water at all because those who stay near the tap tend to line-up a lot of water storage containers. They do not even allow some of us who stay far from the standpipe to fetch one container of water. Sometimes they even connect hosepipes from the standpipe to their houses, which is very unfair.'

Chi-Square results revealed that there is no statistically significant association between alternative household water sources and household's monthly water demand. Independent-samples T-test indicated that there is no significant difference between households with alternative water sources (M = 2358.5, SD = 1678) and those without alternative water sources (M = 2266.2, SD = 1857.5); t (495) = 0.91 ρ = > 0.05. This may be that alternative water sources such as rainwater are seasonal. It was also discovered that some people fetch water from boreholes at the cattle post or arable crop fields. Water from the boreholes is of low quality and most of the households do not treat it. One of the key informants also confirmed that water was a challenge. The respondent said, "People had to travel long distances of about 10 kilometres in search of water". The study also revealed that those who could not afford to pay for transportation had to personally carry it to their homes. It was also observed during the research that villagers without boreholes had to offer litres of fuel in exchange for water.

4.3.3. Experience of water shortage

Analysis on Table 14 indicates that 42.9 percent of the respondents stated that they frequently experienced water shortages, 35.3 percent said they experienced it sometimes and 21.8 percent revealed that water was not always available. The respondents further revealed that they could go up to two weeks without water from the taps thus making them search for water from alternative sources. Buttressing the dire water situation, one of the respondents in Gumare village opined that, "At times when it is restored, we can only get one 20 litres bucket".

Table 14: Proportion of households by their experience of water shortages

Experience of water shortage	Frequency (n=467)	%
Frequently	200	42.9
Sometimes	165	35.3
Always	102	21.8
Total	**467**	**100**

Source: Field survey, 2021

4.3.4. Factors contributing to household water shortage

Most household heads (57.5%) stated that water shortages were caused by persistent droughts in the villages. From the results in Table 15, 54.6 percent of the respondents agreed that water shortages are due to inadequate water supply. Results indicate that 31.9 percent of the household heads opined that water shortages were as a result of high-water demand while 26.8 percent of them agreed that water shortages were caused by persistent droughts. Population growth and household water use behaviour also contribute to water challenges in the study areas. One of the key informants confirmed this by noting that, "The demand for water in Ngamiland District exceeds supply. Water plant infrastructures are not performing well, and they are limited in capacity more so that the population is growing". This may be due to lack of water infrastructures, advanced technologies, and skills to supply water for various uses, among other factors. This results in low water supply and high demands by households.

One of the key informants from WUC also revealed that, "Currently the quantity of water required in Gumare area is estimated at 1.7 million litres per day but only less than half, 732,000 litres is being supplied per day". Similarly, "Water demand in Maun is at 14.7 million litre per day but only 7.5 million litre per day is available due to the drying up of the river". The above quote demonstrates that there is shortage of water supply in Ngamiland District. As such, there is need for serious interventions to address the issue. The key informant added that water supply

Table 15: Proportion of households by perceptions on factors contributing to water demand

Variable	Contributing factor (n=497)	Not a contributing factor (n=497)	Total (%)
Persistent drought	286 (57.5)	211 (42.5)	100
Low water supply	271 (54.6)	226 (45.4)	100
High demand for water	159 (31.9)	338 (68.1)	100
Poor management of infrastructures	133 (26.8)	364 (73.2)	100

*Percentages are in parenthesis ()

is affected by vandalism of infrastructures such as water pipes and drains by communities which leads to a decrease in supply. It was disclosed that farmers are the ones who mostly destroy pipes to provide water to their livestock. This in turn results in water wastage and shortage for domestic, agriculture, or other water uses. The issue of vandalism had been addressed in *Kgotla* meetings where the District Commissioner and the Botswana Defence Force were involved although it persists.

Results show that the most common factors that contributed to water shortages were poor management of infrastructures and low water supply. Furthermore, this study revealed that water plant infrastructures were of limited capacity and not performing well to meet the supply for the entire population. This resulted in their inability to service the whole community.

4.3.5. Ranking of household water use activities

Data analysis showed that bathing/showering activity had the most responses at 37.2 percent followed by laundry at 29.8 percent as presented in Table 16. Results showed that most of the household heads did not have any garden as such they had no outdoor water use activities. However, some disclosed that they occasionally washed cars. From the observations, there were no swimming pools in the households sampled and water-use activities such as gardening

were not common within households. It was also observed that household indoor water use exceeded outdoor water use.

Table 16: Households' water use activities

Household activity	Most water consuming (%)
Bathing or showering	37.2
Laundry	29.8
Toilet flushing	20.1
Cooking	5.6
Dish washing	2.8
Drinking	2.6
Gardening	1.4
Total	**100**

Source: Field survey, 2020

4.3.6. Payment for water services by the respondents

All the respondents (100%) indicated that they were required to pay for water services. Results in Table 17 show that the majority (85.9%) of the households paid water bill every month while 4.6% of them paid every two months. Only 1.6% of the respondents paid water bills whenever they got money. Data obtained from qualitative approach revealed that respondents who were self-employed mainly depended on menial jobs (such as domestic work, farming, and others) as means of livelihoods. Some stated that they paid water bills when they felt like paying and others revealed that they paid after they received the bill. Some respondents said they never received their bills and they had to check for themselves at the WUC office.

Table 17: Households' payment schedule

Variable	Frequency (n=497)	%
Monthly	427	85.9
Every 2 months	23	4.6
Every 3 months	22	4.4
Every 4 months	1	0.2
Every 6 months	3	0.6
Yearly	6	1.2
Whenever we have money	8	1.6
When we feel like paying	6	1.2
Depends on when the bill has come	1	0.2
Total	497	100

Source: Compiled by the author, field survey 2020

4.3.7. Method of household water charge

Most household heads (90.5%) paid monthly water bills based on meter reading by the WUC (Figure 9). This group constituted household heads who owned homes and those who resided in government apartments. Analysis shows that some of the respondents (7.6%) said that they paid a flat fee to settle water bills. These were household heads who rented houses and whose water bills were included in the monthly house rental payment. A few of the households (1.4%) revealed that they did not know how they were charged.

Water bills are calculated based on the meter readings. The use of meters is common in most countries and considered as a vital water management tool (Araral & Wang, 2013; Olmstead & Stavins, 2009; Sonderlund *et al.,* 2014). Qualitative results showed that most of the household heads did not understand how their monthly water bills were calculated where some did not even know how to read their meters. This was confirmed by one of the respondents who said, "I don't know how my monthly water use is calculated, neither do I know how the water meter is read. I only see lots of numbers moving on my meter".

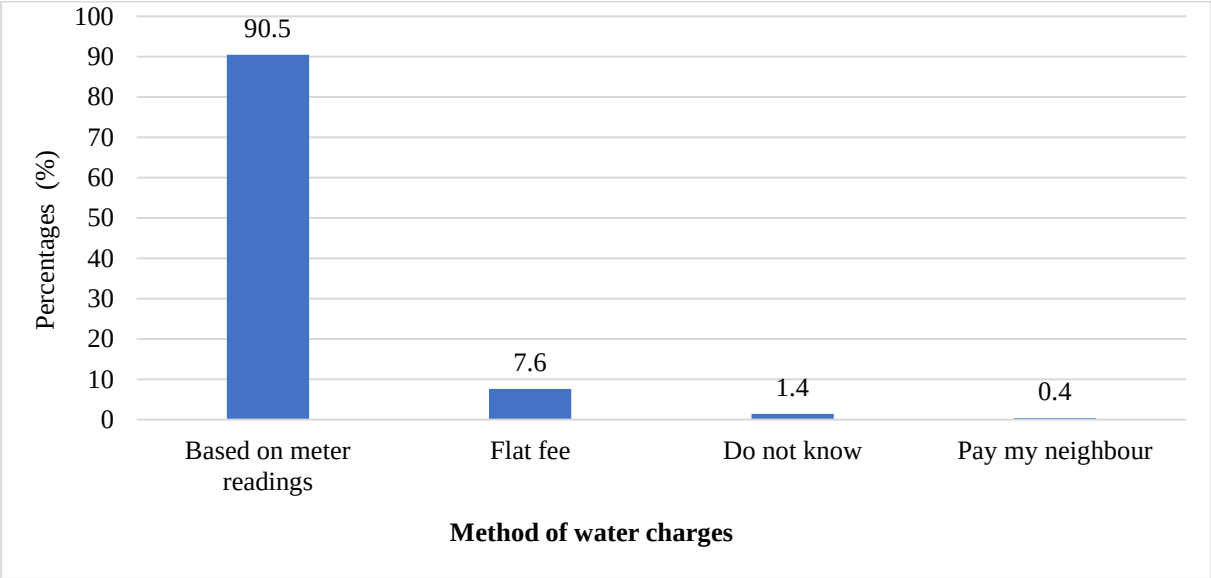


Figure 9: Methods of water charges

Most of the household heads (53.7%) showed that they were not satisfied with the charges they get from water usage while 46.1% revealed that they were satisfied. It was also observed that people who said they were not satisfied, displayed their anger or frustration which could be seen through their facial expressions and tones when responding to the questions. One of the respondents argued that:

> 'I stay alone and spend most of my time at the cattle post, but it surprises me how my monthly bills keep on escalating. I had even gone to WUC offices, and they could not give reasons for the high charges. All they say is that only the WUC headquarters office in Gaborone could provide answers.'

From qualitative data, respondents showed that they were not happy about services provision by WUC due to irregularity in water supply and high bills. One of the respondents said:

> ‘During the years when Department of Water Affairs was responsible for the supply of potable water, it was far much better both in availability and affordability, we wish WUC can be set aside, and Department of Water Affairs be allowed to take over.’

One of the respondents opined that: “The water bills are inconsistent and keep on escalating”. Another respondent pointed out that: *“*Even though we are unsatisfied with the water bills, we still pay because if we fail to pay WUC will disconnect our taps from supply sources”. The respondent also said, “WUC is failing to supply us with good quality and sufficient water”.

4.3.8. Household’s water demand and average monthly water bills

The average monthly water bills among the households were estimated at BWP124.82 on average with a standard deviation of 153.14. Spearman’s rank correlation coefficient test was performed to determine the relationship between household’s average monthly water bills and monthly water demand. The results revealed that there was a significant weak positive correlation between household’s monthly water demand and average monthly water bills, r_s = 0.125 and $\rho < 0.05$. This means that an increase in household’s monthly water demand is likely to result in an increase in monthly bills. Literature reveals that microeconomic theory assumes that people decrease consumption when prices increase, to avoid paying more for water (Gaudin, 2006).

Gaudin revealed that provision of detailed water pricing information on household’s bills significantly increase the price elasticity of water demand. This means that when households were presented with clear pricing information with regards to their bills, they were much more sensitive to increase in water pricing. These results imply that the use of price mechanisms can be more effective by increasing knowledge and awareness of water prices (Gaudin, 2006). This

could assist in households avoiding unnecessary water use behaviours to reduce demand. Olmstead et al. (2007) found elasticity of household water demand to be inelastic. This means that water consumption decreases by less than 1 percent for every 1 percent increase in price, the price elasticity varying from -0.1 and -1.0 (holding all other determinants of demand, such as income, constant) (Reynaud & Romano, 2018).

Table 18 shows that 29 percent of the household heads paid high water bills yet there was no water supply. Other respondents (24.7%) stated that they paid but water supply was very low. One of the respondents confirmed this by arguing that: "…we have been experiencing water shortages since 2018 yet we are still expected to pay for a service that we do not consistently receive". A significant percentage (53.5%) of the respondents were unsatisfied with water bills although some respondents who resided in government apartments showed that they were satisfied with the charges. This may be because they could afford to pay for the service. One of the respondents from government apartments said that: "Water is cheap, we even pay upfront.".

Table 18: Reasons for not being satisfied with water charges

Variable	Frequency (n=497)	%
High water charges yet there is no water	144	29
We pay while there is low water supply	123	24.7
Not applicable	230	46.3
Total	**497**	**100**

Source: Field survey, 2020

4.4. PSYCHOLOGICAL FACTORS AND RESIDENTIAL WATER DEMAND IN NGAMILAND DISTRICT

This section of the results addresses the third objective of the study, which aims at assessing the influence of psychological factors on residential water demand. It analyses household heads' perceptions on residential water demand and conservation; awareness of household heads on water conservation; the degree of knowledge on water issues; attitudes towards household water use activities; the willingness of household heads to reduce water use; and the challenges to water use.

Descriptive statistics was used in summarising the data, Chi-square test of independence conducted to determine the associations between household's monthly water demand and water supply and demand variables. Mann-Whitney U was used to compare two variables drawn from the same population, where the dependent variable is ordinal or continuous whereas Kruskal-Wallis test was performed to compare three or more independent variables on a single, non-normally distributed continuous or ordinal variable. Spearman's rank order correlation test was used to measure the strength and direction of association of the two ranked variables. The non-parametric tests employed in this chapter are described in Chapter Three, section 3.8 of the thesis. The analysis is supplemented by key informant interviews of relevant stakeholders.

4.4.1. Perceptions of household heads on residential water demand

The results on Table 18 show the distribution of household heads by their perceptions of residential water demand. A 5-point Likert-scale ranging from Strongly Agree (SA) to Strongly Disagree (SD) was applied measuring the perceptions of water demand. The results reveal that

households had positive perceptions of residential water demand. The calculated mean score for the perceptions was 3.25 with a standard deviation of 1.01. A minimum value of 1.0 and a maximum value of 5.0 could be obtained by the respondents. The household heads level of agreement varied from one statement to another based on the perceptions of households. The statements on the perception of household heads on residential water demand are discussed in the following sub-sections.

Results on Table 19 indicate that 50.3 percent of the respondents strongly agreed that “People should have the right to as much water as they want”. Only 6.6 percent disagreed with the statement and only (3.2%) had no opinion on it. This implies that most household heads believed that they should be provided with as much water as they want. Even though every human being has the right to water, there is a need for the management of the scarce resource for sustainable use. This could be done through water use restrictions as practiced by most countries and enforcement of other water demand management techniques (Ghernaout *et al.,* 2019; Jorgensen *et al.,* 2009).

Approximately 42 percent of the household heads strongly agreed with the statement “The government should not place restrictions on the amount of water a household can use” while 32.2 percent strongly disagreed with the statement. Analysis shows that the forty percent of the respondents from the household survey strongly disagreed with the statement, “Water supply in Ngamiland District is adequate to meet the needs of its residents”. Only 5.8 percent agreed with the statement. One of the respondents confirmed this by saying, “Water supply is very low in our district and with the dry river in our settlement, we are dependent on groundwater which is also limited in quantity”. Another respondent affirmed that, we could go for more weeks without or with very limited water supply.

The results reveal that 41.6 percent of the interviewees strongly disagreed with the statement, "I don't believe that over-use of water diminishes the resources available", while 18.1 percent disagreed with the statement. A proportion (12.1%) of the household heads were undecided about the statement. From the analysis the majority (59.7%) of households confirmed that over-use of water diminished the resources available for use although one of the respondents strongly disagreed with the statement by saying, "we serve a living God who always provide for us and can never allow water resources to be finished".

Findings show that the majority (83.7%) of the household heads strongly disagreed with the statement, "I don't have any moral obligation to conserve water". About 5 percent disagreed with the statement, only 2.8 percent of them did not have an opinion on it. The results show that in Maun and Gumare villages, people believe that it is their responsibility to conserve water. In almost every household whenever kids play with water it is the mandate of the elders to discipline them.

Results reveal that 40 percent of the household heads strongly disagreed with the statement that, "Wastewater cannot be effectively treated and used for purposes such as flushing, watering plants and other outdoor activities". About 8.5 percent disagreed and 7 percent of the household heads gave a neutral response to the statement. Generally, the respondents believed *that wastewater* can be treated and re-used for outdoor activities. Some of the respondents disclosed that they re-use water from bathing and laundry to flush toilets or water the garden although forests and plant specialists argue that soapy water is not recommended for watering of plants because it is toxic unless if done with adherence to the health precautions. Nevertheless, some did not believe in wastewater re-use. This was confirmed by one of the respondents who said, "I do not re-use water for bathing and laundry because it is too dirty to be re-used, besides, I haven't installed a water system toilet".

Table 19: Perceptions of households'' heads on residential water demand in Ngamiland District (n = 497)

Statement	SA	A	N	D	SD
People should have the right to as much water as they want	250(50.3) *	41 (8.2)	16 (3.2)	33 (6.6)	157 (31.6)
The government should not place restrictions on the amount of water a household can use	207 (41.6)	37 (7.4)	31 (6.2)	62 (12.5)	160 (32.2)
Water supply in Ngamiland District is adequate to meet the needs of its residents	142 (28.6)	29 (5.8)	33 (6.6)	94 (18.9)	199 (40)
I do not believe that over-use of water diminishes the (water) resources available	117 (23.5)	23 (4.6)	60 (12.1)	90 (18.1)	207 (41.6)
I do not have any moral obligation to conserve water	37 (7.4)	5 (1.0)	14 (2.8)	25 (5.0)	416 (83.7)
Wastewater cannot be effectively treated and used for flushing, watering plants and other outdoor activities	132 (26.6)	18 (3.6)	35 (7.0)	42 (8.5)	270 (54.3)
Wastewater cannot be effectively treated to the standard suitable for drinking	172 (34.6)	16 (3.2)	106 (21.3)	51 (10.3)	152 (30.6)
I use much water for personal hygiene during the summer season	284 (57.1)	47 (9.5)	22 (4.4)	42 (8.5)	102 (20.5)
I also use much water during the winter season	119 (23.9)	28 (5.6)	59 (11.9)	82 (16.5)	209 (42.1)

*Percentages are in parenthesis ()

n = stands for number of households; SA = Strongly Agree; A = Agree; N = neutral; D = Disagree; SD = Strongly Disagree

Source: Field survey, 2020

The results showed that reveal that 34.6 percent of the respondents strongly agreed that "Wastewater cannot be effectively treated to the standard suitable for drinking". Only 3.6 percent agreed and 21.3 percent of the household heads did not have an opinion on it. About, 10.3 percent disagreed with the statement and 30.6 percent of the household heads strongly disagreed with the statement. In summary, most of the respondent were against the statement. The researcher also confirmed this by observing the facial expressions of some of the respondents when responding to the statement. One of the respondents said, "I cannot drink water that I used for washing dishes and laundry even if it is effectively treated". Some of the respondents agreed that effectively treated water can be used for drinking. One of the key informants confirmed this by saying, "If indeed we are assured that wastewater is treated

effectively to a suitable standard of drinking, yes we can drink it, besides, it can reduce the high water demand we are experiencing in our village".

As economies continue to expand worldwide, water challenges are increasing as well. There is a need for an assessment of wastewater treatment and re-use to come up with strategies for water sustainability (López-Morales & Rodríguez-Tapia, 2019). Similarly, studies have shown that wastewater re-use can be adopted to achieve not only water needs but also food security inclusive (Kandiah *et al.,* 2019; Sapkota, 2019). This implies that wastewater re-use if treated effectively, can be of benefit to communities.

Analysis shows that 57.1 percent of the respondents strongly agreed that, "I use much water for personal hygiene during the summer season". Nevertheless, 8.5 percent disagreed while 20.5 percent strongly disagreed with the household heads with the statement. Generally, the results show that most of the people use more water for personal hygiene during the summer season. People tend to bath frequently during hot weather conditions to keep their bodies fresh. This was affirmed by a respondent who said, "I bath three times a day during summer and I use more than 20 litres of water for bathing on a daily basis".

Results reveal that 42.1 percent of the household heads strongly disagreed with the statement, "I also use much water during the winter season", 16.5 percent disagreed, and 11.9 percent of the household heads gave a negative response to the statement. In summary, most of the respondents did not agree with the statement. This may be because during the Winter season some people tend to decrease their frequency of bathing due to the fear of colds. One of the respondents affirmed, "I bath once per day during Winter because of low temperatures".

The results of the study indicate that households in Ngamiland District have positive perceptions on water conservation even though some of the responses were against water demand management from the statement that were provided. This is a concern since water shortage is a global issue and there is a need for sustainable use of water and implementation of facilities that save water in households. Psychological factors such as attitudes and beliefs are the essential determinants of consumers' behaviour (Fielding *et al.*, 2012). Syme et al. (2010) discovered that households with more positive attitudes towards water consumption used less water in the garden. Perceptions also influence household water-use behaviour. Therefore, it is appropriate to analyse the perceptions of households on residential water demand and to examine the variations across gender, age groups, education level and other variables in Ngamiland District.

A Mann-Whitney U test revealed that there is no statistically significant difference in perceptions of males (M=3.11, n=131) and females (M=3.33, n=376), U=21438.5, $\rho = 0.103 > 0.05$. Therefore, perceptions of residential water demand did not differ by gender. Spearman's correlation test was performed to assess the relationship between age group and education level. The test showed a very weak positive and no significant correlation in household heads' perceptions and age groups, $r_s = 0.054$, $\rho > 0.05$. Spearman's correlation test also revealed a very weak positive and no significant correlation between perceptions and education levels, $r_s = 0.048$, $\rho > 0.05$.

Spearman's correlation test was also performed to determine the relationship between household's monthly water demand and perceptions on residential water demand. The results ($r_s = 0.050$, $\rho > 0.05$) showed no significant correlation in household heads' perceptions and monthly water demand. Therefore, the more people have positive perceptions on water

residential water demand, the more they would control their water use to avoid excessive demands.

4.4.2. Awareness of household heads on water conservation

Findings show that most household heads (93.8%) were aware of water conservation whereas (6.2%) were not aware of it. This shows that people in Ngamiland District are informed about water conservation issues. Qualitative results showed there were different means through which households received information on water conservation. These include the mass media such as (radio stations, televisions, newspapers, pamphlets) and social media (such as Facebook, Twitter and others). WUC also conducted meetings to raise community awareness on water conservation and other water-related issues. Relatives and family members also play a vital role in water conservation.

Kruskal-Wallis H test was performed to determine if there were differences between household's monthly water demand and awareness on water conservation by the respondents. The results revealed a significant difference in household's monthly water demand and awareness on water conservation by different respondents [$\chi^2(1) = 5.7, \rho = < 0.05$]. This implies that awareness on water conservation had a positive influence on water demand in the study area. The results indicate that households in Maun and Gumare in Ngamiland District are aware of water conservation, and they are likely to conserve water. Similar findings by Willis et al. (2011) affirms that people with positive environmental and water conservation awareness consume significantly less water compared to those less concerned and aware. Gregory and di Leo (2003) also indicate that households who showed more engagement and awareness of water conservation used less water. The Spanish study by Domene and Sauri (2006) found also found a significant association of the influence of attitudinal variables on household's monthly water

consumption. Contrarywise, people may have a high consciousness towards water conservation whereas the actual practice is less (Tong *et al*., 2017).

4.4.3. Household heads' perceptions about water conservation

Table 20 depicts the distribution of household heads' perceptions on water conservation issues. The results reveal that households showed positive perceptions on water conservation. The calculated mean score for the household heads' perception is 4.47 with a standard deviation of 0.51, a minimum value of 1.8, and a maximum value of 5.0. The household heads level of agreement varied from one statement to another based on the perceptions of households on water conservation issues in the district. The statements are discussed in the following sections. The results of the study on Table 20 show that most of the household heads (89.5%) of the households strongly agreed and (6.0%) agreed that "In Ngamiland District, water demand exceeds supply, so water needs to be well conserved". Only 1.6 percent were neutral on the statement, 0.6 percent and 2.2 percent disagreed and strongly disagreed with the statement, respectively. This shows that the district was undergoing a water crisis because demand exceed supply. One of the key informants affirmed:

> 'The water source (river) in our village dried in the past years due to low rainfalls as such water demand is very high. The residents at times resort to fetch water from boreholes which is untreated, and they had to travel around 10km to reach the boreholes.'

The results reveal that the majority (76.9%) of the household heads strongly disagreed and (15.5%) agreed that "The household has a responsibility of contributing to Ngamiland District water conservation by reducing water consumption". However, 2.8% of the household heads

were undecided. Moreover, 2.4 percent disagreed while 2.4 percent strongly disagreed with the statement. The results indicate that people of Ngamiland District are aware of the water situation and hence use water carefully.

Analysis shows that most of the respondents (75.7%) agreed that "If each household reduces the amount of water it uses by just a little, it will make a big difference for the public". Furthermore, 14.1 percent agreed, and 5.6 percent of the household heads were neutral on the statement. However, 1.0 percent disagreed, and 3.6 percent of the households strongly agreed with the statement. Water conservation is a way of managing household water demand.

Table 20: Household heads' perceptions on water conservation (n = 497)

Statement	SA	A	N	D	SD
In Ngamiland District, water demand exceeds supply, so water needs to be well conserved	445(8.5) *	30 (6.0)	8 (1.6)	3 (0.6)	11 (2.2)
The household has a responsibility of contributing to Ngamiland District water demand management by reducing water consumption	382 (76.9)	77 (15.5)	14 (2.8)	12 (2.4)	12 (2.4)
If each household reduces the amount of water it uses by just a little, it will make a big difference for the public	376 (75.7)	70 (14.1)	28 (5.6)	5 (1.0)	18 (3.6)
Household willingness to pay for water contribute to water conservation	326 (65.6)	77 (15.5)	63 (12.7)	22 (4.4)	9 (1.8)
WUC and the community are jointly responsible for ensuring that there is enough water supply	293 (59.0)	88 (17.7)	61 (12.3)	25 (5.0)	30 (6.0)
I am aware of environmental pollution	357 (71.8)	39 (7.8)	40 (8.0)	15 (3.0)	46 (9.3)
My neighbours and friends always practice water conservation	218 (43.9)	62 (12.5)	187 (37.6)	13 (2.6)	17 (3.4)
I always check water bills regularly	336 (67.6)	39 (7.8)	54 (10.9)	26 (5.2)	42 (8.5)
It is important to conserve water to prevent water high charges	429 (86.3)	25 (5.0)	22 (4.4)	7 (1.4)	14 (2.8)
Making an effort to save water is an indication of good upbringing	455 (91.5)	22 (4.4)	10 (2.0)	4 (0.8)	6 (1.2)

*Percentages are in parenthesis ()

n = stands for number of households; SA = Strongly Agree; A = Agree; N = neutral; D = Disagree; SD = Strongly Disagree

Source: Field survey, 2020

Results reveal that most of the household heads (65.6%) strongly agreed that: "Household willingness to pay for water contributes to water conservation". Similarly, 15.5 percent agreed, and 12.7 percent of the household head were neutral on the statement. However, 4.4 percent and 1.8 percent of the household heads disagreed and strongly disagreed with the statement respectively. Generally, if people are willing to pay for water services this could compel them to conserve water. The results indicate that when households are committed to pay monthly water bills, consumption levels may decrease. Previous studies have shown that water pricing is a vital measure that is used worldwide by water authorities to manage consumption (Arbues *et al*., 2009; Inman & Jeffry, 2006). Other authors also confirm that price is an effective tool for water-saving (Arbues *et al.,* 2003; Corbella & Pujol, 2009). The Dublin statement also states that the role of water as an economic and life-sustaining good should be reflected in demand management practices, implemented through water conservation, efficient use, wastewater re-use, resource assessments, and financial tools (ICWE, 1992; Solanes & Gonzalez-Villarreal, 1999).

Analysis shows that 59.0 percent of the household heads strongly agreed that "WUC and the community are jointly responsible for ensuring that there is sufficient water supply". Communities play an important role in the management of water supply. Thus, the second principle of the Dublin principles set out in 1992 UN Conference of Environment and Development states that: "Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels" (ICWE, 1992). Several studies have been conducted to evaluate the role of community participation on the outcome of water supply projects. For example, Isham and Kähkönen (2002) indicated that community participation is influential in establishing well-designed/well-constructed water services. Prokopy (2009) argued that government and community collaboration improve project

effectiveness. The same study also revealed that women participation was crucial within collective action institutions such as community users.

Results reveal that 71.8 percent of the household heads strongly agreed with the statement that says, “I am aware of environmental pollution”. About 7.8 percent agreed and 10.9 percent were neutral on the statement. However, 5.2 percent of the household heads disagreed, and 8.5 percent strongly disagreed with the statement. Generally, the results indicate that the people of Ngamiland District were aware of environmental pollution. Thus, they were likely to conserve natural resources. Water pollution occurs when toxic substances enter waterbodies such as lakes, rivers, oceans, etc. (Soldán, 2003). This worsens water quality, thus degrading the environment and biodiversity, health conditions and the global economy (Artabe *et al.,* 2020; Zhang *et al.,* 2020). Polluted groundwater might end up in the households as contaminated water (Azizullah *et al.,* 2011). Additionally, water pollution leads to lack of potable water as pointed out by the UN that billions of people worldwide have no access to clean water for drinking or sanitation, particularly in rural areas, thus increasing household water demand (UN-Water, 2018).

Results reveal that 43.9 percent of the household heads strongly agreed that “My neighbours and friends always practice water conservation”. About 12.5 percent agreed, and 37.6 percent of the households were neutral on the statement. However, 2.6 percent and 3.4 percent of the household heads disagreed and strongly disagreed with the statement, respectively. The respondents indicated that they would never know whether their neighbours conserve water or not. This was affirmed by the respondent who argued that “I never pay attention to how my neighbour uses water in her household”. Some of the household heads who agreed that their neighbours use less water may be those who had closer relationships with them, as such they were likely to know some of their water use practices through discussions and observation.

Most household heads (67.6%) strongly agreed on the statement that “I always check water bills regularly”. The results also indicate that 7.8 percent agreed, and 10.9 percent of the household heads were neutral on the statement. Generally, the results imply that most people in Ngamiland District check on their bills regularly whereas some check sometimes or only when they got money to pay the bill. This was confirmed by one of the respondents who said that “I check on my water bill only when my children give me money to pay.” Constant checking of water bills could help households to reduce costs by minimising water consumption whenever the need arises (Kayaga *et al.*, 2003; Pagiola, 2002), and this in turn might help to reduce household water demand.

The findings of the study show that most of the household heads (86.3%) of the household heads agreed that “It is important to conserve water to prevent water high charges”. Moreover, 5.0 percent agreed, and 4.4 percent of the household heads were neutral about the statement. A few of the household heads (1.4%) disagreed and (2.4%) of the households strongly disagreed with the statement. The results reveal that people in the Ngamiland District are aware of the importance of water conservation. They were more likely to conserve water.

Most of the household heads (91.5%) of the household heads strongly agreed that “Making an effort to save water is an indication of good upbringing”. Only, 0.8 percent disagreed, and 1.2 percent of the household heads strongly disagreed with the statement. The results suggest that most people in the study areas understand that teaching the young ones about water conservation is a good practice that could be of benefit to the community.

It is imperative for households to conserve water to prevent water shortages. It is in this regard that this study reveals that water conservation prevents high water bills. Previous studies show that public education and awareness are crucial in water conservation planning (Al-Senaf *et al*.,

2008; Emoabino & Alayanda, 2008). Similarly, Dean et al. (2016) argue that sustainable approaches to water management require community engagement, which can result in people's acceptance of changes in policy, practice, and technology.

Spearman's correlation test was performed to assess the relationship between perceptions of households about water conservation and household's monthly water demand. The results indicated that there was a very weak positive but no significant correlation between monthly water demand and perceptions of household heads about water conservation in the study sites, $r_s = 0.016$, $\rho > 0.05$. That is, the more people have positive perceptions on water conservation, the more they try to avoid excessive demand.

4.4.4. Knowledge of household heads on water-related issues

Results on Table 21 indicate that 45.3 percent of the household heads showed that they had no knowledge about where their household water comes from while 27.9 percent said they had little knowledge. The results reveal that households with no knowledge at all demanded mostly between 1000–4000 litres of water. Those with little knowledge also demanded mostly between 1000 – 4000 litres. In summary, the households with no knowledge on water sources demanded more water compared to others. In this study, knowledge on water sources include households' understanding on water supplies and also water management strategies.

Table 21: Cross-tabulation of the household heads' knowledge on water resources and monthly water demand

Group household water demand		(Litres)			
		>1000	1001 - 4000	4001 and above	Total
Water sources	No knowledge at all	6.2	33.8	5.3	45.3
	Little knowledge	1.8	23.3	2.8	27.9
	Lot of knowledge	3.6	19.4	3.8	26.8
Total		**11.6**	**76.5**	**11.9**	**100**

Source: Field survey, 2020

The results (Table 22) revealed that the majority (65.2%) of the household heads had no knowledge on water tariffs. About 16.5 percent of the household heads had little knowledge and 18.3 percent had a lot of knowledge on the water pricing system. The results show that most of the households (76.5%) demanded between 1000 - 4000 litres of water. Within the demand category for 4001 litres and above 7.7 percent of the respondents revealed that they had no knowledge on water tariffs, 2.6 percent showed that they had a lot of knowledge while 1.6 percent had little knowledge. Generally, the respondents without knowledge on water pricing demanded more quantities of water compared to those with little and lot of knowledge. Knowledge on water tariffs implies having information about the prices of the water supplied by public utility for both freshwater and wastewater. Water tariffs determine the condition of service and monthly bills for water users in different categories (Martins *et al.,* 2013). As such, households' knowledge of water tariffs will most likely enable them to effectively manage water demand and use.

Table 22: Cross-tabulation of households' knowledge on water pricing and monthly water demand

Group household	Water demand	(Litres)			
		Less than 1000	1001 - 4000	4001 and above	Total
Water pricing	No knowledge at all	8.0	49.5	7.7	65.2
	Little knowledge	0.8	14.1	1.6	16.5
	Lot of knowledge	2.8	12.9	2.6	18.3
Total		**11.6**	**76.5**	**11.9**	**100**

Source: Field survey, 2020

Analysis on Table 23 shows that most of the household heads (50.1%) had a lot of knowledge of the re-use of greywater. About 16.3 percent of the household heads revealed that they had little knowledge and 33.6 percent of the household heads had no knowledge at all on the re-use of water in their households. The results show that from the categories demanded mostly volumes of water between 1000 - 4000 litres. While 4.8 percent of the respondents within the demand category for 4001 litres and above revealed that they had appreciable knowledge on grey water use, 4.3% showed lack of knowledge and only (2.8%) had little knowledge.

Knowledge and understanding of water issues in the community are considered as an important factor in solving water problems. Studies have shown that greater knowledge allows community members to contribute to innovation and problem solving (Buhr & Wibeck, 2014; Davis & Simon, 2012). Dean et al. (2016) showed that community knowledge is important in water management programmes. This study also revealed that most of the households in Ngamiland District had little knowledge of water supply sources and no knowledge of water tariffs. However, they had a lot of knowledge of household wastewater re-use which was commendable. Generally, there is a need for public education of water supply sources and tariffs as mentioned earlier.

Table 23: Cross-tabulation of households' knowledge on use of grey water and monthly water demand

Group household water demand		(Litres)			
		Less than 1000	1001 - 4000	4001 and above	Total
Use of grey water	No knowledge at all	5.0	24.3	4.3	33.6
	Little knowledge	1.0	12.5	2.8	16.3
	Lot of knowledge	5.6	39.7	4.8	50.1
Total		11.6	76.5	11.9	100

Source: Field survey,2020

4.5. RELATIONSHIP BETWEEN HOUSEHOLD WATER USE BEHAVIOUR AND RESIDENTIAL WATER DEMAND IN NGAMILAND DISTRICT

This section of the results discusses the fourth objective of the study, which assesses the relationship between household water use behaviour and residential water demand. It starts by tackling the results on the number of water use facilities in households, the most water-consuming facility, water use behaviours, thus, frequency for household water use habits (bathing/showering/laundry), and the household age group perceived to be using more water. Then household water use practices and challenges of water conservation are also addressed in this section. Descriptive statistics is used in analysing and displaying the data. Non-parametric tests such as Kruskal-Wallis H test, Chi-square test of independence and Spearman's rank-order correlation test are used in making inferences of the data.

4.5.1. Household water use facilities

As illustrated in Table 24, most of the household heads (97.9%) revealed that they do not own a dishwasher, two percent owned one and only 0.1 percent had two or more dishwashers. This study found that dishwashers were not common, the washing basin was used across most

households in Maun and Gumare. Results show that 87.1 percent of the household heads did not have washing machines, only 12.7 percent of the households own one washing machine. Results of the study show that washing machines are also not common in Maun and Gumare villages. This may be that the villages are going through severe water shortages. Some cannot afford to purchase washing machines. The other reason was that from those who owned washing machines, some revealed that they do not use it due to water shortages. A certain respondent claimed that "Water supply in Gumare is inconsistent, I cannot buy a washing machine because I will be wasting my money".

Table 24: Number of households' water use facilities

Water use facility types	Household water use facilities (%)		
	Not owned	**Owned (One)**	**Owned (Two or more)**
Double flush toilet	98.8	1	0.2
Dishwasher	97.9	2	0.1
Washing machine	87.1	12.7	0.2
Shower	82.5	17.3	0.2
Bathtub	65.4	32.4	2.2
Single flush toilet	60.4	36.6	3
Bath container	4.6	35.2	60.2

Source: Field survey, 2020

Analysis shows that most of the household heads (60.4%) of the household heads did not have single flush toilets and (36.6%) one single flush toilet. This may be that most of the households in the study area did not have in-house water connection systems. The study also revealed that most of the households in Ngamiland District had little knowledge on water supply sources and no knowledge about water tariffs. They had knowledge of household wastewater re-use. It was also observed that some of the households in new wards did not have water connections at all, for example, in Disaneng Ward (Phase 2) in Maun. The reason given for not being provided with water was that Thamalakane River, which provides water to the village and surrounding areas was dry in 2019 because the annual flooding from the upland plains of

Angola that normally arrives in the Okavango Delta around the months of May and June did not occur (Charles, 2019). This consequently led to low water supply, affecting household water connections in 2019. One of the residents of this ward summed it and said, “I had long applied and paid for water service provision in my yard but till now they have not done so. I even plan to go and claim my money since nothing is being done. I fetch water from the standpipe and at times it can be broken, and it takes much time to be fixed”.

Table 25 reveals that most (98.8%) of the household heads did not have double flush toilets while 1 percent showed that they had one double flush toilet. About 82.5 percent did not have showers and 17.3 percent had one shower. However, 0.2 percent of the household heads had two or more double flush toilets. About 65.4% of the household heads had stated that they had no bathtubs. The bath container, locally known as *“sekotele”* or *“bata”* was the most common facility among the households as 95.2 percent of the household stated that they had it. This was because it is affordable. Results show that most people in Maun and Gumare did not have water use facilities such as dishwasher and washing machines.

Table 25: Households' water consuming facilities used for personal hygiene

Facility	Frequency (n=497)	%
Bath container	359	72.2
Bathtub	66	13.3
Shower	51	10.3
Bucket	9	1.8
Bathtub and bath container	6	1.2
Shower and bath container	4	0.8
Shower and bath container	2	0.4
Total	**497**	**100**

Source: Field survey, 2020

The facilities used for personal hygiene included shower, bathtub, bath container, and bucket (Table 25). The majority (72.2%) of the household heads revealed that they used bath containers for personal hygiene. About 0.4 percent of the household heads showed that they use a combination of the shower and bathtub, bathtubs, and bath containers, and buckets. Most of the household revealed that they used nine-litre buckets as a way of saving water.

4.5.2. Household water use behaviour

This section aims to assess household water behaviour in relation to residential water demand. It presents results on household heads average time taken for water-use activities such as showering, frequency of bathing/showering per day, and frequency of laundry per week.

4.5.2.1. The average time taken by household members for showering

Table 26 presents the average time taken by the household members for showering. The results reveal that most of the household heads (84.5%) did not have showers. Therefore, only 15.5 percent had showers. Of the respondents with showers, 68.8 percent took less than 10 minutes to shower while 26.0 percent took an average time between 11 to 20 minutes. Generally, people in the study sites had not installed showers in their houses. This may be due to the ever-increasing demands for water and lack of finances to install water-use facilities.

Table 26: Average time taken by the households' members to shower

Average time taken	Frequency (n=77)	%
Less than 10 minutes	53	68.8
11 to 20 minutes	20	26.0
21 to 30 minutes	4	5.2
Total	77	100

Source: Field survey, 2020

Kruskal-Wallis H test was performed to determine if there were differences between the average time taken by different household members to shower and their household's monthly water demand. The results reveal no significant difference between the two variables [χ^2 (2) = 3.259, $\rho > 0.05$]. This shows that household's monthly water demand did not differ with average time taken by different household members to shower.

4.5.2.2. Household members frequency for bathing/showering per day

Results on Table 27 depicts the household members' average frequency for bathing/showering per day. The results showed that most of the respondents (79.1%) bath/shower twice per day in the mornings and evenings, only (14.1%) bath once a day.

Table 27: Households' members average frequency for bathing/showering per day

Average bathing or showering per day	Frequency (n=497)	%
Once	70	14.1
Twice	393	79.1
Three times	30	6.0
More than three times	4	0.8
Total	497	100

Source: Field survey, 2020

Kruskal-Wallis H test was performed to determine if there were differences in average bathing/showering frequency for different household members and their monthly water demand. The results reveal that there is no significant difference between the two variables measured [χ^2 (3) = 5.2, $\rho > 0.05$]. This implies that household's monthly water demand did not differ with average bathing/showering frequency for different household members.

4.5.2.3. Households' frequency of doing laundry per week

Table 28 illustrates that most of the household heads (68.8%) carry out the laundry activity once a week whereas (12.9%) of the household heads showed that they do laundry twice per week. Some of the respondents (5.4%) stated that they washed laundry items once a month, twice per month (5.2%), three times per week (2.2%), every day (3.0%) and (2.4%) washed only when water was available. Most of the household heads revealed that during the rainy season they collect rainwater and use it for laundry and for other water-use activities such as dishwashing and gardening.

Table 28: Households' frequency for doing laundry

Frequency of laundry	Frequency (n=497)	%
Everyday	15	3.0
Once per week	342	68.8
Twice per week	64	12.9
Three times per week	11	2.2
Once per month	27	5.4
Twice in a month	26	5.2
Wash only when water is available	12	2.4
Total	**497**	**100**

Source: Field survey, 2020

Kruskal Wallis test revealed that there is a significant difference [χ^2 (6) =13.959, $\rho < 0.05$] between frequencies for doing laundry for different household members with their monthly water demand. These results show that household's monthly water demand did not differ with frequencies for doing laundry.

4.5.2.4.Households' water use and age group

Results in Table 29 state that 27.2 percent of the household heads stated that the age group that used more water were the youth aged between 20-35 years. About 24.7 percent revealed that children under the age of 12 years used more water compared with other members of the household, 22.6 percent of the respondents showed that adults between 36-59 years old used more water. The respondents showed that from their observations, children have unnecessary water use behaviour, they use lots of water when carrying out activities such as dish washing compared with the youth and adults who may be having knowledge on water conservation. Sometimes they do not close the taps tightly as a result water is wasted. They also wash dishes under running water, and they tend to play with it, therefore using more water unnecessarily.

Table 29: Households' water use and age group of the respondents

Age group	**Frequency (n=497)**	**%**
Youth (20-35 years)	129	27.2
Children (under 12 years)	117	24.7
Adults (36-59 years)	107	22.6
Teenagers (13-19 years)	63	13.3
Others	42	8.9
Old age (60 years and above)	16	3.3
Total	**474**	**100**

Source: Field survey, 2020

Kruskal-Wallis test was performed to determine if there were differences between household's monthly water demand and different age groups. The results reveal that there is no significant difference between age groups and household's monthly water demand. [χ^2 (6) =12.104, ρ > 0.05]. Statistical analyses indicate that there is no significant difference between age groups and their monthly water demand. On the contrary, previous studies found different results. For example, a study conducted in Blagoevgrad, Bulgaria by Clark and Finley (2007) revealed that older people are more likely to conserve water. The reason is that older people are always cautious in all they do, compared to children, teenagers, and youth. A study in Devon, England, by Gilg and Barr (2006) unveiled that older people are less likely to conserve water. Previous studies conducted in Phoenix, Arizona and Germany revealed that older and retired people use more water, as they spend more time at home doing various activities such as gardening, cooking, cleaning and have frequent baths for health reasons (Ballings & Gober, 2007; Schleich & Hillenbrand, 2009).

4.5.3. Households water use activities

Table 30 shows the 10 water use activities adopted by households in the study. Analysis reveals that most of the household heads (68%) affirmed the statement that, "I turn off the water while brushing teeth" was not applicable to them. This meant that the household heads did not have in-house water system connections. Some of the respondents revealed that they use a cup for brushing teeth to avoid wasting water, 25.2 percent revealed that they usually turn-off the water when brushing teeth and 4.2 percent said sometimes. A few (1.4%) of the household heads revealed that they did not turn off the water while brushing teeth. Generally, households in the study sites saved water by using cups for brushing teeth.

About 57.9 percent of the household heads revealed that the statement, "I have short showers and do not fill in the bathtub" did not apply to them. This was a group of respondents without showers and bathtub facilities. About 33.6 percent revealed that they usually have short showers or do not fill in the bath. However, 5.8 percent of the household heads showed that they do have short showers and do not fill in the bath sometimes. The respondents revealed that mostly they use the 9 to 20 litres of water for bathing.

Table 30: Households' water use activities

Household water use activities	Usually	Sometimes	Occasionally	Not at all	Not Applicable
I turn off water while brushing teeth	125 (25.2) *	21 (4.2)	6 (1.2)	7 (1.4)	338 (68)
I have short showers or do not fill in the bathtub	167 (33.6)	29 (5.8)	6 (1.2)	7 (1.4)	288 (57.9)
I use a small bucket instead of a bigger one when bathing	312 (62.8)	16 (3.2)	5 (1.0)	5 (1.0)	159 (32.0)
I fix leaking taps wherever applicable	205 (41.2)	35 (7.0)	23 (4.6)	21 (4.2)	213 (42.9)
I use a sink or basin plug more often	124 (24.9)	16 (3.2)	23 (4.6)	34 (6.8)	300 (60.4)
I use a minimal amount of water whilst washing dishes or clothes in a washing basin	299 (60.2)	33 (6.6)	5 (1.0)	3 (0.6)	157 (31.6)
I do laundry or dishes only when there is full load be it using machines or doing manually	319 (64.2)	9 (1.8)	10 (2.0)	7 (1.4)	152 (30.6)
I reuse water for toilet flushing for outdoor activities such as plants watering, etc.	266 (53.5)	11 (2.2)	8 (1.6)	37 (7.4)	175 (35.2)
I replace old appliances with water saving appliances	197 (39.6)	24 (4.8)	44 (8.9)	52 (10.5)	180 (36.2)
I water the garden or plants during the coolest part of the day	172 (34.6)	13 (2.6)	5 (1.0)	40 (8)	267 (53.7)

*Percentages are in parenthesis ()

Source: Field survey, 2020

Analysis shows that most of the household heads (62.8%) revealed that they usually "… use a small bucket instead of a bigger one when bathing". Only 3.2 percent of the household heads showed that they use a small bucket sometimes and one percent did the same activity

occasionally. Generally, the results showed that people in the study sites used minimal water for bathing. This is an indication that water is being conserved. Results reveal that 42.9 percent of the household heads showed that the statement, “I fix leaking taps whenever applicable” was not applicable to them. This group of respondents showed that they did not have any leakages from their taps. Approximately 41.2 percent of the interviews revealed that they usually fix leaking taps and seven percent showed that they sometimes carried out the same activity.

Results show that most of the household heads (60.4%) of the household heads revealed that the household water use activity “I use a sink or basin plug more often” did not apply to them. This group of respondents included people without house water connection systems and those with the facilities but preferred to use containers for washing the dishes or other water use activities. Some respondents (24.9%) stated that they usually use the sink or basin plug while 2.4 percent reported that they sometimes used the plug. About 6.8 percent of the household heads revealed that they did not use the plug at all, meaning they carried out activities while water was running from the tap.

Analysis shows that most of the respondents (60.2%) usually *“*... use minimal water whilst washing dishes or clothes in a washing basin”, and 6.6 percent revealed that they used minimal water sometimes and 1 percent said occasionally. About 0.6 percent of the household heads showed that they did not at all use minimal water whilst washing. A significant proportion of the respondents (64.2%) stated that they usually “… did laundry or dishes only when there is full load be it using machines or doing manually”. Generally, the findings showed that the households in the study sites are more careful when using water even though some used more water for activities such as laundry and dishwashing. Results reveal that 53.5 percent of the household heads usually “… re-use water for toilet flushing for outdoor activities such as plants

watering, and others". About 2.2 percent of the respondents showed that they re-used wastewater sometimes and 1.6 percent of the respondents said occasionally.

The results further indicate that 39.6 percentage of the household heads usually "… replace old appliances with water-saving appliance if there was need to do so". Only 4.8 percent of the household heads showed that they replaced an old appliance with water-saving appliances sometimes, whereas 8.9 percent did the practice occasionally. The results suggest that most of the respondents did not know the difference between water saving facilities and those that consume water. There is need to raise awareness in such areas. Analysis shows that most of the respondents (53.7%) of the household heads affirmed that the statement, "I water the garden or plants during the coolest part of the day", did not apply to them. These are the respondents who did not have gardens.

A Spearman's correlation test was performed to assess the relationship between water use activities and monthly household water demand. The results showed no significant and very weak positive correlation between household's monthly water demand and water use activities ($r_s = 0.068$ and $\rho > 0.05$). Therefore, 6.8% of the variation between household's monthly water demand is explained for by water use activities of the household. This implied that household water use activities are more likely to increase the levels of water demand.

A key strategy in managing water demand is through campaigns to conserve water through a change in water use practices (Grafton *et al.,* 2011). Generally, respondents showed positive responses on water use activities such as turning off the water when brushing teeth, not filling up the bathtub or bath containers, doing laundry only when there is a full load, and others. Some of the activities were not applicable to the respondents without water-consuming facilities such

as flush toilets, bathtubs, showers, and basins. According to the Social Practice Theory, resource use is controlled by people's daily social practices (Giddens, 1984). The more people use water for various household activities the greater the water demand.

4.5.4. Challenges of household water conservation

Most of the respondents (69.2%) agreed with statement that, "lack of information on water conservation" was a challenge to water conservation, while (30.8%) did not agree with the statement (Table 31). About 50.1 percent of the household heads also agreed that there was limited access to water-saving devices while 49.9 percent of the people interviewed showed that it was not a challenge. Results also show that 50.1 percent of the household heads agreed that lack of income to purchase water saving facilities was a challenge of household water conservation. About 62.4 percent of households disagreed that "water conservation is a low priority compared to other issues" while 37.6 percent agreed with the statement. Most of the respondents (52.9%) did not agree with the challenge "need for adequate water to maintain a high standard of living". Results showed that 64.4 percent of household heads did not agree with the statement that, "It is difficult to change water use behaviours that develop over time" while 35.6 percent agreed. Personal factors such as forgetfulness, laziness and others are also among the challenges of water conservation.

Table 31: Challenges of household water conservation

Challenges of household water conservation	Yes	No
Lack of information on water conservation methods	344 (69.2) *	153 (30.8)
Limited access to water-saving devices	249 (50.1)	248 (49.9)
Economic reasons	249 (50.1)	248 (49.9)
Water conservation is a low priority compared to other issues	187 (37.6)	310 (62.4)
Need for adequate water to maintain a high standard of living	234 (47.1)	263 (52.9)
It is difficult to change water use behaviours that develop over time	177 (35.6)	320 (64.4)
Personal factors	212 (42.7)	285 (57.3)

*Percentages are in parenthesis ()

Source: Field survey, 2020

The next and last chapter addresses the synthesis of the study. It starts by giving a summary of the results, conclusion, recommendations, future work, and limitations of the study.

CHAPTER 5

DETERMINANTS OF RESIDENTIAL WATER DEMAND IN NGAMILAND DISTRICT BOTSWANA: A SYNTHESIS

5.1. Introduction

Understanding the determinants of residential water demand is vital for policymaking in the domestic water supply sector, in light of a general shift in the focus of residential water management from supply-driven to demand-driven approach. Therefore, this thesis assessed the factors affecting residential water demand in Ngamiland District, Botswana. Specifically, the study addressed demographic and socio-economic factors influencing residential, water supply and demand in Maun and Gumare; impacts of psychological factors on residential water demand; and the relationship between household water use behaviour and residential water demand in Ngamiland District. This chapter presents a summary of the results of the thesis. recommendations, future work and limitations of the study. The conclusions drawn from the results of the study are presented in the following subsections.

5.1.1. Demographic and socio-economic factors influencing household water demand

The first objective of the study was to determine the demographic and socio-economic factors influencing residential water demand in Ngamiland District. This objective was achieved in Chapter Four, Section 4.2 using the empirical data collected through the methods described in Chapter 3 of the thesis. As mentioned earlier in the first chapter of the thesis, there is lack of understanding on the determinants of residential water demand and limitation of literatures on the subject in the study area. This study, therefore, addressed this research gap by assessing the

influence of demographic and socio-economic variables on residential water demand. In contrast to other studies on water demand, this study hypothesised that three variables (gender, household income and household size) have significant relationship with households' water demand in the study area. However, four variables (gender, education level, employment status and house ownership) were not significant in relation to household's monthly water demand.

Results of the study indicated that there was a significant association between gender and household's monthly water demand. Females used more water compared to males as they carried out most of the household water-related chores and are more likely to take long baths compared to males. This means that gender issues are crucial in this study as males and females have different roles in households. There is need for participation in water conservation by all.

Household income had a significant correlation with monthly water demand. Households with high income demanded more water compared to low-income households. This is because with more income people can purchase high water-consuming facilities. These results imply that income is an important variable in water demand; the more income a person earns, the greater they demand for water, all things being equal.

The study revealed that household size was found to be the most influencing variable on monthly water demand while other independent variables either showed a very weak or weak positive correlation. This means that a large household in Ngamiland District uses a significant amount of water compared to a small household.

5.1.2. Water supply and demand in Ngamiland District

The second objective of the study was to analyse water supply and demand in Maun and Gumare villages. The variables assessed were household water connection, alternative water sources, experience of water shortage, factors contributing to water shortage, ranking of household water use activities and method of payment for water services. This objective was achieved through Chapter 4, subsection 4.3.

The study revealed that water demand exceeded supply due to population growth, diminishing ground and surface water sources, institutional management, poor management of infrastructures, among other factors. Thus, as population grows household water demand increases. The results also indicated that most of the households in Ngamiland District had yard connected taps compared to in-house tap connections. Statistical analyses revealed a significant association between household water connection system and monthly water demand. This implied that households with house connection systems tended to demand more water compared to households with yard connections. This means water connection type contributes significantly to water demand. This thesis established that households whose monthly average income was higher were found to have higher water consuming facilities than low-income households. This is explained in terms of being either of house connected or yard connected taps. Therefore, there is need to promote efficient water use facilities within households in order to reduce water demand.

Results indicated that Ngamiland District experiences serious water shortages, thus water supply is low and inconsistent. This study estimated average household water consumption per person per day at 14.4 litres. This is less compared to the UN recommendation which is 50 litres of water use per member per day (UNDP, 2015). People in the district experience water

shortages which occur frequently in a month. As a result, people cope through alternative sources of water such as boreholes, rainwater harvesting and the use of storage tanks. In Ngamiland District, the most common factors that contributed to water shortages were poor management of infrastructures and low water supply. Water plant infrastructures were of limited capacity and not performing well to meet the demand of the entire population. Most of the households complained about high water bills they incurred even though water supply was inconsistent.

The thesis demonstrated that indoor water-use activities such as bathing/showering and laundry are the most water-consuming. Most of the households did not have gardens or plants due to water shortage and to some it was a choice not to have them. As a result of this, indoor water use exceeded outdoor water use in Ngamiland District. This implies that there is need for households to be informed on the importance of water management.

5.1.3. Influence of psychological factors on residential water demand in Ngamiland District

The third objective of the study was to analyse the influence of psychological factors on residential water demand in Ngamiland District. The variables analysed were perceptions, knowledge, and awareness of water demand. This objective was achieved in Chapter 4, subsection 4.4. The study showed that indicated that psychological factors (such as perceptions, knowledge, and attitudes) influenced household water demand. The study revealed that people in Ngamiland District had positive perceptions of residential water demand and conservation. If people are aware of the importance and scarcity of water resources, they are more likely to commit to water conservation activities.

The results revealed a significant difference in household monthly water demand and awareness of water conservation. Households who were aware of water conservation were more likely to consume less water than their counterparts who were not aware. People with positive attitudes towards the environment engage conservation behaviours since they are aware of the importance and scarcity of water resources. Therefore, water conservation attitudes are associated with household water-use pattens and water-saving behaviour. Results also showed that the respondents with no knowledge of water issues used more water compared to those with a measure of knowledge on water issues. It was also revealed that most households in Ngamiland District had little knowledge of water supply sources and no knowledge on water tariffs. However, they had a lot of knowledge on household wastewater re-use. It is, therefore, suggested that public education on water sources and tariffs could be used to encourage households to conserve water.

5.1.4. Relationship between household water use behaviour and residential water demand

The fourth and last objective of the study was to determine the relationship between household water use behaviour and residential water demand in Ngamiland District. The variables analysed included water consuming facilities, water use practices, willingness of the household head to change water use behaviours [which do not support water management and the challenges to household water conservation]. This objective was achieved in Chapter 4, subsection 4.5.

The study found that water consuming facilities such as dishwashers and washing machines were not common among households in the study sites due to water shortages and the issue of affordability. The results also highlighted the importance of both technological and behavioural

approaches to demand management. It was noted that water-saving facilities were essential in managing the demand for water. Most of the respondents stated that they used a 9-litre bucket for bathing and did laundry once per week. This implied good conservation behaviours within households in Ngamiland District.

Results indicated that there was a correlation between water use activities and household monthly water demand. Water use activities determined the level of water demand. Respondents showed positive responses on water use practices in the study area. Households in Ngamiland District performed laundry once per week on average although some people washed clothes once in a month, depending on the availability of water. The results showed that there was a relationship between household average frequency of bathing/showering by different respondents and monthly household water demand. The study found that the age group that used more water were the youth between 20-35 years. This was the most active group engaged in water related activities.

The study also identified challenges to household water conservation such as, lack of information on water conservation, difficulty to change water use behaviours that develop over time, among other challenges. The analysis of the study suggests that WDM policies including campaigns to promote household water-saving behaviours such as having short showers/not filling up the bathtub or bath container and the use of water-saving facilities such as dual-flush toilet could be more effective if households used prepaid water coupons. Therefore, these awareness strategies should be modified and implemented to curb water demands. The study also suggested that households need to adopt water saving facilities and avoid unnecessary behaviour.

5.2. Study's recommendations

The following recommendations/policy implications were provided based on the results and conclusions obtained from this study:

Demand-driven water management has become a major focus in the water sector regulations in most countries including Botswana. The study established that Ngamiland District experience high water demands vis a vis low water supply, thus making it crucial to have a good understanding of the determinants of residential water demand. Hence, this study filled in the knowledge gap by assessing the relationship and associations between various factors and residential water demand.

Based on the results, some of the demographic and socio-economic parameters (that is, gender, household income and household size) had significant influence on water demand. There is, therefore, need for policymakers to consider them when formulating water policy and devising conservation strategies. From a policy perspective, water needs to be further subsidised for female headed households since the study shows that they have higher demands for water as compared to their male counterparts.

The results also show that high income households consume more water than their low-income ones. Therefore, policy makers need to introduce safety net programmes, which target impoverished households to ensure that they can access water at affordable prices. It is imperative that the government minimises consumer costs by implementing measures, which ensures that well-off customers pay more than their underprivileged counterparts.

According to Statistics Botswana, the number of unemployed people is higher than that of the employed. Similarly, this study also showed that the number of the unemployed people was estimated at (49.3%) which far outweighs the number of people formally employed (39.2%) and self-employed (11.5%). It is, therefore, imperative for the government to extend social welfarism to those who are unable to pay for water bills.

As this study shows that water conservation reduces water consumption, the government might need to promote the implementation of WDM strategies such as rainwater harvesting, wastewater re-use, and others to reduce household water demand. Such strategies could be reinforced to reduce pressure on water sources, which triggers high water demands. Water demand management, water conservation and efficiency of water use facilities need to be emphasised in water supply and demand management planning. Based on Chapter 34:3, Part IV of Water Act of 1968,

> 'Any person who wilfully (Sic) or negligently misuses or wastes water or causes or allows to be misused or wasted any water from the waterworks shall be guilty of an offence and liable to a fine not exceeding BWP250.'
>
> The occupier of any premises where any water from the waterworks is wilfully (Sic) or negligently misused or wasted shall be guilty of an offence and liable to a fine not exceeding BWP250.'

From the policy perspective, there is need to enforce these charges hence this may assist in enforcing water conservation. Additionally, people's perceptions on water demand and supply are essential in guiding decisions and informing policymaking about the problem. Policymakers need to ensure community participation in water supply management. It is, therefore, imperative for the Botswana government to work hand in hand with all relevant stakeholders

most especially communities in devising pragmatic strategies for enhancing water demand management.

Water conservation behaviours could be promoted through developing a culture of water conservation in the household. School-based education may be of help in promoting conservation and facilitating two-way influence between parents and children. Public education through campaigns aimed at promoting household water-saving behaviours and the use of water-saving facilities should become an integral part of water provision. Awareness of the importance and scarcity of water resources to promote sustainable use of the resource should also be strengthened. Freshwater availability is finite therefore water conservation is not a responsibility reserved for only water suppliers, scientists, hydrologists, policy makers, farmers, household heads etc. but all stakeholders must work together to conserve water. From the policy standpoint, public interventions based on behavioural economics need to be implemented to create the right incentives and encourage efficient use of water resources.

Every household needs to be educated on how to calculate their monthly water usage to avoid claims of unfair bills. The study suggested that there is need for the government to consider installation of prepaid water meters in households to minimise the suspicions from customers that they are not being fairly charged for water services.

5.3. Suggestions for future research

The following issues are those, which this study has not addressed, and which need to be given priorities in future research in the study area:

(i) The study did not rigorously investigate and analyse environmental, institutional and technological factors influencing residential water demand. There is, therefore, a need to carry out a study, which addresses the three factors.

(ii) Residential water demand in different time-series observation is a crucial research area to be investigated in various seasonal factors. This could be achieved through the use of a longitudinal study design.

(iii) A comparative study on water demand management in similar regions and study areas might shed more light on the similarities and differences among rural areas in Botswana and other developing countries.

(iv) The impact of global and regional socio-economic, cultural and environmental shocks (including climate change, pandemics such as COVID-19, and others) on household water demand also need to be given attention.

REFERENCES

Ahmad, Q. K. (2003). Towards poverty alleviation: the water sector perspectives. *International Journal of Water Resources Development*, *19*(2), 263-277.

Aitken, C. K., McMahon, T. A., Wearing, A. J., & Finlayson, B. L. (1994). Residential Water Use: Predicting and Reducing Consumption 1. *Journal of Applied Social Psychology*, *24*(2), 136-158.

Ajzen, I., & Fishbein, M. (2000). Attitudes and the attitude-behavior relation: Reasoned and automatic processes. *European review of social psychology*, *11*(1), 1-33.

Allan, J. A. (2003). Virtual water-the water, food, and trade nexus. Useful concept or misleading metaphor? *Water international*, *28*(1), 106-113.

Alley, W. M., & Konikow, L. F. (2015). Bringing GRACE down to earth. *Groundwater*, *53*(6), 826-829.

Altman, J & Jackson, S. (2008). 'Indigenous Land Management', in D Lindenmayer, S Dovers, M Harris Olson, and S Morton (eds), Commitments: Reshaping the Lucky Country's Environment, pp 207-214.

American Water Works Association. (1999). *Water Meters-Selection, Installation, Testing and Maintenance (Vol. 6).* American Water Works Association.

Anderson, C. J. (2010). Central limit theorem. *The Corsini Encyclopedia of Psychology*, 1-2.

Araral, E., & Wang, Y. (2013). Water demand management: review of literature and comparison in South-East Asia. *International Journal of Water Resources Development*, *29*(3), 434-450.

Arbues, F., & Villanua, I. (2006). Potential for pricing policies in water resource management: estimation of urban residential water demand in Zaragoza, Spain. *Urban Studies*, *43*(13), 2421-2442.

Arbués, F., García-Valiñas, M. Á., & Martínez-Espiñeira, R. (2003). Estimation of residential water demand: a state-of-the-art review. *The Journal of Socio-economics*, *32*(1), 81-102.

Arbués, F., Villanúa, I., & Barberán, R. (2010). Household size and residential water demand: an empirical approach. *Australian Journal of Agricultural and Resource Economics*, *54*(1), 61-80.

Arnell, N. W. (1999). Climate change and global water resources. *Global environmental change*, *9*, S31-S49.

Arntzen, J. W., Kgathi, D. L., & Segosebe, E. (1999). Water demand management: Botswana country study. *Report prepared for IUCN-ROSA*.

Artabe, A. E., Cunha-Silva, H., & Barranco, A. (2020). Enzymatic assays for the assessment of toxic effects of halogenated organic contaminants in water and food. A review. *Food and Chemical Toxicology*, *145*, 111677.

Azizullah, A., Khattak, M. N. K., Richter, P., & Häder, D. P. (2011). Water pollution in Pakistan and its impact on public health—a review. *Environment international*, *37*(2), 479-497.

Babel, M. S., Gupta, A. D., & Pradhan, P. (2007). A multivariate econometric approach for domestic water demand modeling: an application to Kathmandu, Nepal. *Water Resources Management*, *21*(3), 573-589.

Balling Jr, R. C., Gober, P., & Jones, N. (2008). Sensitivity of residential water consumption to variations in climate: an intraurban analysis of Phoenix, Arizona. *Water Resources Research*, *44*(10).

Balling, R. C., & Gober, P. (2007). Climate variability and residential water use in the city of Phoenix, Arizona. *Journal of applied meteorology and climatology*, *46*(7), 1130-1137.

Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of environmental psychology*, *27*(1), 14-25.

Bamezai, A. (1996). Evaluation of water conservation programs in thorny nonexperimental settings. *Water Resources Research*, *32*(4), 1083-1090.

Barrett, G., & Wallace, M. (2009). Characteristics of Australian urban residential water users: implications for water demand management and whole of the system water accounting framework. *Water Policy*, *11*(4), 413-426.

Basani, M., Isham, J., & Reilly, B. (2008). The determinants of water connection and water consumption: Empirical evidence from a Cambodian household survey. *World development*, *36*(5), 953-968.

Beal, C., Stewart, R., Huang, T., & Rey, E. (2011). *South East Queensland residential end use study*. Brisbane, Australia: Urban Water Security Research Alliance.

Bewick, V., Cheek, L., & Ball, J. (2003). Statistics review 8: Qualitative data–tests of association. *Critical care*, *8*(1), 1-8.

Billings, B., & Jones, C. (2008). Forecasting Demand. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Billings%2C+B.%2C+%26+Jones%2C+C.+%282008%29.+Forecasting+Demand.&btnG= (Accessed 5th July 2018)

Bless, C., & Higson-Smith, C. (2000). Social research methods. *An African Perspective. Cape*.

BNWMP Review, Botswana national water master plan review, (Department of Water Affairs, Gaborone, Botswana. (2006).

Borg, M., Edwards, O., & Kimpel, S. (2013). A study of individual household water consumption. *The University of California-Davis Water Management Research Institute.* (Accessed 7th February 2017).

Botswana National water policy. (2012)

Botswana Water Accounting Report. (2016). Botswana Water Accounting Report 2014/15, (April).

Botswana Water Statistics. (2009). Botswana water statistics. *Gaborone, Botswana*.

Bourdieu, P. (1977). Outline of a Theory of Practice (translated by R. Nice).

Bourdieu, P. (1984). *Distinction: A social critique of the judgement of taste*. Harvard university press.

Bourdieu, P. (2005). *The social structures of the economy*. Polity.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3, 77–101. doi:10.1191/1478088706qp063oa.

Brennan, D., Tapsuwan, S., & Ingram, G. (2007). The welfare costs of urban outdoor water restrictions. *Australian Journal of Agricultural and Resource Economics*, *51*(3), 243-261.

Briscoe, J., Anguita, P., & Peña, H. (1998). *Managing water as an economic resource: reflections on the Chilean experience*. World Bank, Environment Department.

Brooks, D. B. (2006). An operational definition of water demand management. *International Journal of Water Resources Development*, *22*(4), 521-528.

Bryman, A. (2008). Why do researchers integrate/combine/mesh/blend/mix/merge/fuse quantitative and qualitative research. *Advances in mixed methods research*, 87-100.

Burke, J. J., Sauveplane, C., & Moench, M. (1999, November). Groundwater management and socio-economic responses. *In Natural Resources Forum (Vol. 23, No. 4, pp. 303-313).* Oxford, UK: Blackwell Publishing Ltd.

Çağdaş, V., & Stubkjær, E. (2009). Doctoral research on cadastral development. *Land Use Policy*, *26*(4), 869-889.

Calow, R. C., MacDonald, A. M., Nicol, A. L., & Robins, N. S. (2010). Ground water security and drought in Africa: linking availability, access, and demand. *Groundwater*, *48*(2), 246-256.

Carragher, B. J., Stewart, R. A., & Beal, C. D. (2012). Quantifying the influence of residential water appliance efficiency on average day diurnal demand patterns at an end use level: A precursor to optimised water service infrastructure planning. *Resources, Conservation and Recycling*, *62*, 81-90.

Carter, D. W., & Milon, J. W. (1999). *Marginal opportunity cost vs. average cost pricing of water service: Timing issues for pricing reform*. Gainesville, FL, USA: Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida.

Charles, T. (2019). Online document, https://www.mmegi.bw/features/maun-so-dry-hippos-feed-on-hay/news (Accessed 20th October 2021).

Cheesman, J., Bennett, J., & Son, T. V. H. (2008). Estimating household water demand using revealed and contingent behaviors: Evidence from Vietnam. *Water resources research*, *44*(11).

Cheruiyot, K. J. (2016). *Award of Degree of Master of Science in Hydrology and Water Resources Management in the School of Pure and Applied Sciences of* (Doctoral dissertation, Kenyatta University).

Clark, W. A., & Finley, J. C. (2007). Determinants of water conservation intention in Blagoevgrad, Bulgaria. *Society and natural resources*, *20*(7), 613-627.

Connor, R. (2015). *The United Nations world water development report 2015: water for a sustainable world* (Vol. 1). UNESCO publishing.

Corbella, H. M., & Pujol, D. S. (2009). What lies behind domestic water use? a review essay on the drivers of domestic water consumption. *Bulletin of the Association of Spanish Geographers*, (50), 297-314.

Cornes, R., & Sandler, T. (1996). *The theory of externalities, public goods, and club goods*. Cambridge University Press.

Creswell, J. W. (2009). Mapping the field of mixed methods research.

Creswell, J. W., Klassen, A. C., Plano Clark, V. L., & Smith, K. C. (2011). Best practices for mixed methods research in the health sciences. *Bethesda (Maryland): National Institutes of Health, 2013*, 541-545.

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., & Hanson, W. E. (2003). Advanced mixed methods research designs. *Handbook of mixed methods in social and behavioural research*, *209*, 240.

Dagnew, D. C. (2012). *Factors determining residential water demand in north western Ethiopia, the case of Merawi* (Doctoral dissertation, Cornell University).

Dalhuisen, J. M., Florax, R. J., De Groot, H. L., & Nijkamp, P. (2003). Price and income elasticities of residential water demand: a meta-analysis. *Land economics*, *79*(2), 292-308.

Dandy, G., Nguyen, T., & Davies, C. (1997). Estimating residential water demand in the presence of free allowances. *Land Economics*, 125-139.

Dean, A. J., Fielding, K. S., & Newton, F. J. (2016). Community knowledge about water: who has better knowledge and is this associated with water-related behaviors and support for water-related policies? *PloS one*, *11*(7), e0159063.

Definitions and Translations. (2018).

Dharmaratna, D., & Harris, E. (2012). Estimating residential water demand using the Stone-Geary functional form: the case of Sri Lanka. *Water resources management*, *26*(8), 2283-2299.

Domene, E., & Saurí, D. (2006). Urbanisation and water consumption: Influencing factors in the metropolitan region of Barcelona. *Urban Studies*, *43*(9), 1605-1623.

Dziegielewski, B. (2000). *Commercial and institutional end uses of water*. American Water Works Association.

Dziegielewski, B., & Kiefer, J. C. (2010). Appropriate design and evaluation of water use and conservation metrics and benchmarks. *Journal-American Water Works Association*, *102*(6), 66-80.

Emerson, R. W. (2017). ANOVA and t-tests. *Journal of Visual Impairment & Blindness*, *111*(2), 193-196.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics*, *5*(1), 1-4.

Falkenmark, M., & Lundqvist, J. (1998, February). Towards water security: political determination and human adaptation crucial. In *Natural Resources Forum* (Vol. 22, No. 1, pp. 37-51). Oxford, UK: Blackwell Publishing Ltd.

FAO. (2016). WFP (2015), The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. Food and Agriculture Organization Publications, Rome.

Fibich, G., Gavious, A., & Lowengart, O. (2005). The dynamics of price elasticity of demand in the presence of reference price effects. *Journal of the Academy of Marketing Science*, *33*(1), 66-78.

Fielding, K. S., Russell, S., Spinks, A., & Mankad, A. (2012). Determinants of household water conservation: The role of demographic, infrastructure, behavior, and psychosocial variables. *Water Resources Research*, *48*(10).

Fielding, K. S., Spinks, A., Russell, S., McCrea, R., Stewart, R., & Gardner, J. (2013). An experimental test of voluntary strategies to promote urban water demand management. *Journal of environmental management*, *114*, 343-351.

Garcia, S., & Reynaud, A. (2004). Estimating the benefits of efficient water pricing in France. *Resource and energy economics*, *26*(1), 1-25.

Gato, S., Jayasuriya, N., & Roberts, P. (2007). Temperature and rainfall thresholds for base use urban water demand modelling. *Journal of hydrology*, *337*(3-4), 364-376.

Gaudin, S. (2006). Effect of price information on residential water demand. *Applied economics*, *38*(4), 383-393.

Gegax, D., McGuckin, T., & Michelsen, A. (1998). Effectiveness of conservation policies on New Mexico residential water demand. *New Mexico Journal of Science*, *38*, 104-126.

Ghernaout, D., Elboughdiri, N., & Al Arni, S. (2019). Water Reuse (WR): Dares, restrictions, and trends. *Applied Engineering*, *3*, 159-170.

Gichana, Z. M., Njiru, M., Raburu, P. O., & Masese, F. O. (2014). Effects of human activities on microbial water quality in Nyangores stream, Mara River basin. *Int. J. Sci. Technol. Res*, *3*, 153-157.

Giddens, A (1984) The Constitution of Society: Outline of the Theory of Structuration. Cambridge: The Polity Press.

Gilg, A., & Barr, S. (2006). Behavioural attitudes towards water saving? Evidence from a study of environmental actions. *Ecological Economics*, *57*(3), 400-414.

Giuffre, M. (1997). Designing research survey design—Part two. *Journal of PeriAnesthesia Nursing*, *12*(5), 358-362.

Gleick, P. H. (1993). Water in crisis. *Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press. 473p*, *9*, 1051-0761.

Gleick, P. H. (1998). The human right to water. *Water policy*, *1*(5), 487-503.

Gondo, R., & Kolawole, O. D. (2016). Institutions and transboundary water resources management in southern Africa. Proceedings of the Sixth IASTED International conference, *Environmental and Water Resource Management (AfricaEWRM 2016).* Gaborone, Botswana.

Gondo, R., & Kolawole, O. D. (2019). Sustainable water resources management: Issues and principles of water governance in the Okavango Delta, Botswana. *International Journal of Rural Management*, *15*(2), 198-217.

Gondo, R., Kolawole, O. D., & Mbaiwa, J. E. (2019). Dissonance in customary and statutory water management institutions: issues of cultural diversity in the management of water resources in the Okavango Delta, Botswana. *Environment, Development and Sustainability*, *21*(3), 1091-1109.

Gondo, R.,,Kolawole, O. D., & Joseph E. Mbaiwa, and Moseki R. Motsholapheko. "Demographic and socio-economic factors influencing water governance in the Okavango Delta, Botswana." *Scientific African* 10 (2020): e00602.

González-Gómez, F., & García-Rubio, M. A. (2018). Prices and ownership in the water urban supply: a critical review. *Urban Water Journal*, *15*(3), 259-268.

Green, C., & Baden, S. (1995). Integrated water resources management: A gender perspective. *IDS Bulletin*, *26*(1), 92-100.

Gregory, G. D., & Leo, M. D. (2003). Repeated behaviour and environmental psychology: the role of personal involvement and habit formation in explaining water consumption 1. *Journal of Applied Social Psychology*, *33*(6), 1261-1296.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research, 2* (163-194), 105.

Guest, P. (2015). Botswana Is Running Out of Water, And It Could Undo Its Economic Success _ VICE News.

GWP, (2012). The Handbook of Integrated Resources Management in Transboundary Basins. International Basin Organisation (INBO) and The Global Water Partnership.

GWP.Dublin-Rioprinciples.1996. Online document: https://www.gwp.org/contentassets/05190d0c938f47d1b254d6606ec6bb04/dublin-rio-principles.pdf. (Accessed April 2018).

Hall, J., & Lavrakas, P. (2008). Cross-sectional survey design. *Encyclopedia of survey research methods, 1*, 172-173.

Hambira, W. L. (2007). Natural resources accounting: A tool for water resources management in Botswana. *Physics and Chemistry of the Earth, Parts A/B/C*, 32(15-18), 1310-1314.

Hambira, W. L., Moalafhi, D. B., & Mulale, K. (2011). Water demand management in Botswana: Reflections on the latest review of Botswana National Water Master Plan. *University of Botswana: Gaborone, Botswana*, 1-9.

Hand, H. (2003). The mentor's tale: a reflexive account of semi-structured interviews. *Nurse Researcher (through 2013), 10*(3), 15-28.

Hecke, T. V. (2012). Power study of anova versus Kruskal-Wallis test. *Journal of Statistics and Management Systems, 15*(2-3), 241-247.

Hoekstra, A. Y. (2003). Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade. In *Proceedings of the International Expert Meeting on Virtual Water Trade 12, Delft, 2003* (pp. 25-47).

Hoffmann, M., Worthington, A., & Higgs, H. (2006). Urban water demand with fixed volumetric charging in a large municipality: the case of Brisbane, Australia. *Australian Journal of Agricultural and Resource Economics, 50*(3), 347-359.

Holloway, I., & Todres, L. (2003). The status of method: flexibility, consistency and coherence. *Qualitative research*, *3*(3), 345-357.

Hoskin, T. (2012). Parametric and nonparametric: Demystifying the terms. In *Mayo Clinic* (Vol. 5, pp. 1-5).

Howarth, D., & Butler, S. (2004). Communicating water conservation: how can the public be engaged? *Water science and technology: water supply*, *4*(3), 33-44.

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative health research*, *15*(9), 1277-1288.

https://www.definitions.net/definition/residential+area (Accessed 24th September 2018).

Inman, D., & Jeffrey, P. (2006). A review of residential water conservation tool performance and influences on implementation effectiveness. *Urban Water Journal*, *3*(3), 127-143.

International Conference on Water and the Environment, 1992. The Dublin Statement and Report of the Conference. Development Issues for the 21st century. 26–31 January. Online document: http://www.wmo.ch/pages/prog/hwrp/documents/english/icwedece.html. (Accessed January 2010).

Isham, J., & Kähkönen, S. (2002). Institutional determinants of the impact of community-based water services: Evidence from Sri Lanka and India. *Economic development and cultural change*, *50*(3), 667-691.

Islam, M. R. (2018). Sample size and its role in Central Limit Theorem (CLT). *Computational and Applied Mathematics Journal*, *4*(1), 1-7.

Jabareen, Y. (2009). Building a conceptual framework: philosophy, definitions, and procedure. *International Journal of qualitative methods*, *8*(4), 49-62.

Jeffrey, P., & Gearey, M. (2006). Consumer reactions to water conservation policy instruments. In *Water demand management* (pp. 305-326). IWA.

Joffe, H., & Yardley, L. (2004). Content and thematic analysis. *Research methods for clinical and health psychology*, *56*, 68.

Joppe, M. (2000). The Research Process.

Jorgensen, B., Graymore, M., & O'Toole, K. (2009). Household water use behavior: An integrated model. *Journal of environmental management*, *91*(1), 227-236.

Kandiah, V. K., Berglund, E. Z., & Binder, A. R. (2019). An agent-based modeling approach to project adoption of water reuse and evaluate expansion plans within a sociotechnical water infrastructure system. *Sustainable Cities and Society*, *46*, 101412.

Kayaga, S., Calvert, J., & Sansom, K. (2003). Paying for water services: effects of household characteristics. *Utilities Policy*, *11*(3), 123-132.

Kenney, D. S., Goemans, C., Klein, R., Lowrey, J., & Reidy, K. (2008). Residential water demand management: lessons from Aurora, Colorado 1. *JAWRA Journal of the American Water Resources Association*, *44*(1), 192-207.

Kenway, S. J., Binks, A., Lane, J., Lant, P. A., Lam, K. L., & Simms, A. (2015). A systemic framework and analysis of urban water energy. *Environmental Modelling & Software*, *73*, 272-285.

Kerr, Y. H., Waldteufel, P., Wigneron, J. P., Delwart, S., Cabot, F., Boutin, J., ... & Juglea, S. E. (2010). The SMOS mission: New tool for monitoring key elements of the global water cycle. *Proceedings of the IEEE*, *98*(5), 666-687.

Keskin, S. (2006). Comparison of several univariate normality tests regarding type I error rate and power of the test in simulation based small samples. *Journal of Applied Science Research*, *2*(5), 296-300.

Kgomotso, P. K., & Swatuk, L. A. (2006). Access to water and related resources in Ngamiland, Botswana: Toward a more critical perspective and sustainable approach. *Physics and Chemistry of the Earth, Parts A/B/C*, *31*(15-16), 659-668.

Kim, H. Y. (2014). Analysis of variance (ANOVA) comparing means of more than two groups. *Restorative dentistry & endodontics*, *39*(1), 74-77.

Kohli, A., Frenken, K., & Spottorno, C. (2010). Disambiguation of water use statistics. *The AQUASTAT Programme of FAO, Rome, Italy*.

Kolawole, O.D. (2010). Inter-disciplinarily, development studies, and development practice. *Development in Practice*, 20(2), 227-239.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environmental education research*, *8*(3), 239-260.

Kruskal, W. H., & Wallis, W. A. (1952). Use of ranks in one-criterion variance analysis. *Journal of the American statistical Association*, *47*(260), 583-621.

Kujinga, K., Vanderpost, C., Mmopelwa, G., & Wolski, P. (2014). An analysis of factors contributing to household water security problems and threats in different settlement categories of Ngamiland, Botswana. *Physics and Chemistry of the Earth, Parts A/B/C*, *67*, 187-201.

Kusangaya, S., Warburton, M. L., Van Garderen, E. A., & Jewitt, G. P. (2014). Impacts of climate change on water resources in southern Africa: A review. *Physics and Chemistry of the Earth, Parts A/B/C*, *67*, 47-54.

Kwak, S. G., & Kim, J. H. (2017). Central limit theorem: the cornerstone of modern statistics. *Korean journal of anesthesiology*, *70*(2), 144.

Larson, B., Minten, B., & Razafindralambo, R. (2006). Unravelling the linkages between the millennium development goals for poverty, education, access to water and household water use in developing countries: evidence from Madagascar. *The Journal of Development Studies*, *42*(1), 22-40.

Lee, M., Tansel, B., & Balbin, M. (2011). Influence of residential water use efficiency

measures on household water demand: A four-year longitudinal study. *Resources, Conservation and Recycling*, *56*(1), 1-6.

Legamo, T. M. (2014). Determinants of Residential Water Demand in Hawassa, Ethiopia.

Levin, K. A. (2006). Study design III: Cross-sectional studies. *Evidence-based dentistry*, *7*(1), 24-25.

Li, P., & Wu, J. (2019). Drinking water quality and public health. *Exposure and Health*, *11*(2), 73-79.

López-Morales, C. A., & Rodríguez-Tapia, L. (2019). On the economic analysis of wastewater treatment and reuse for designing strategies for water sustainability: Lessons from the Mexico Valley Basin. *Resources, Conservation and Recycling*, *140*, 1-12.

Lux, A. (2008). Shrinking cities and water supply. *Population Dynamics and Supply Systems: A Transdisciplinary Approach, Frankfurt am Main*, 161-179.

Lyman, R. A. (1992). Peak and off-peak residential water demand. *Water Resources Research*, *28*(9), 2159-2167.

MacFarland, T. W., & Yates, J. M. (2016). Mann–whitney u test. In *Introduction to nonparametric statistics for the biological sciences using R* (pp. 103-132). Springer, Cham.

Madigele, P. K. (2016). The complexity of the economic conception of water: revisiting water resources management in developing countries. Proceedings of the Sixth IASTED International conference, *Environmental and Water Resource Management (AfricaEWRM 2016).* Gaborone, Botswana.

Makki, M. H., Abd-El-Khalick, F., & BouJaoude, S. (2003). Lebanese secondary school students' environmental knowledge and attitudes. *Environmental Education Research*, *9*(1), 21-33.

Manchin, M. J., & Ali, E. A. (2011). The European Union: economics and policies.

Mann, H. B., & Whitney, D. R. (1947). On a test of whether one of two random variables is stochastically larger than the other. *The annals of mathematical statistics*, 50-60.

Mann, P. C., & Schlenger, D. L. (1982). Marginal cost and seasonal pricing of water service. *Journal-American Water Works Association*, *74*(1), 6-11.

Marshall, A. (1892). *Elements of economics of industry* (Vol. 1). Macmillan.

Marshall, M. N. (1996). The key informant technique. *Family practice*, *13*(1), 92-97.

Martins, R., Cruz, L., Barata, E., & Quintal, C. (2013). Assessing social concerns in water tariffs. *Water Policy*, *15*(2), 193-211.

Masamba, W. R., & Mazvimavi, D. (2008). Impact on water quality of land uses along Thamalakane-Boteti River: An outlet of the Okavango Delta. *Physics and Chemistry of the Earth, Parts A/B/C*, *33*(8-13), 687-694.

Mas-Colell, A., Whinston, M. D., & Green, J. R. (1995). *Microeconomic theory* (Vol. 1). New York: Oxford university press.

Mayer, P. W., DeOreo, W. B., Opitz, E. M., Kiefer, J. C., Davis, W. Y., Dziegielewski, B., & Nelson, J. O. (1999). Residential end uses of water.

Mayer, P. W., DeOreo, W. B., Towler, E., Martien, L., & Lewis, D. (2004). Tampa Water Department Residential Water Conservation Study. *Final report by Aqua craft, Inc. to Tampa Bay Water and the US Environ. Protection Agency*.

McCloskey, D. N. (1996). The economics of choice. *Economics and the Historian*, 122-158.

McHugh, M. L. (2013). The chi-square test of independence. *Biochemia medica: Biochemia medica*, *23*(2), 143-149.

McKnight, P. E., & Najab, J. (2010). Mann-Whitney U Test. *The Corsini encyclopedia of psychology*, 1-1.

Meijerink, G. W., & Ruijs, A. J. W. (2003). *Water as an economic good; Points of interest for policy*. LEI

Mendes, M., & Pala, A. (2003). Type I error rate and power of three normality tests. *Pakistan Journal of Information and Technology*, *2*(2), 135-139.

Merrill, H. M. (1994). Interutility electricity pricing: Theory vs. how to do it. *Fortnightly;(United States)*, *132*(2).

Metaxas, S., & Charalambous, E. (2005). Residential price elasticity of demand for water. *Water Science & Technology*, *5*(6), 183-188.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. sage.

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. *Annals of cardiac anaesthesia*, *22*(1), 67.

Misra, A. K. (2014). Climate change and challenges of water and food security. *International Journal of Sustainable Built Environment*, *3*(1), 153-165.

Moffat, B., Motlaleng, G. R., & Thukuza, A. (2011). Households willingness to pay for improved water quality and reliability of supply in Chobe ward, Maun. *Botswana Journal of Economics*, *8*(12), 45-61.

Moffat, B., Motlaleng, G. R., & Thukuza, A. (2011). Households willingness to pay for improved water quality and reliability of supply in Chobe ward, Maun. *Botswana Journal of Economics*, *8*(12), 45-61.

Mogomotsi, G. E., Mogomotsi, P. K., & Mosepele, K. (2020). Legal aspects of transboundary water management: An analysis of the intergovernmental institutional arrangements in the Okavango River Basin. *Leiden Journal of International Law*, *33*(2), 391-408.

Mogomotsi, P. K., Mogomotsi, G. E., & Matlhola, D. M. (2018). A review of formal institutions affecting water supply and access in Botswana. *Physics and Chemistry of the Earth, Parts A/B/C*, *105*, 283-289.

Mohayidin, G., Attari, J., Sadeghi, A., & Hussein, M. A. (2009). Review of water pricing

theories and related models. *African Journal of Agricultural Research*, *4*(11), 1536-1544.

Molinos-Senante, M., & Donoso, G. (2016). Water scarcity and affordability in urban water pricing: A case study of Chile. *Utilities Policy*, *43*, 107-116.

Montgomery, D. C., Peck, E. A., & Vining, G. G. (2012). *Introduction to linear regression analysis* (Vol. 821). John Wiley & Sons.

Moore, D. S., McCabe, G. P., & Evans, M. J. (2005). Introduction to the practice of statistics Minitab manual and Minitab version 14. WH Freeman & Co.

Moore, J. (2014). A Case Study of Domestic Water Consumption in Feltwell, Norfolk: a Social Practice Theory Analysis.

Motsholapheko, M. R., Kgathi, D. L., & Vanderpost, C. (2011). Rural livelihoods and household adaptation to extreme flooding in the Okavango Delta, Botswana. *Physics and Chemistry of the Earth, Parts A/B/C*, *36*(14-15), 984-995.

Mukheibir, P. (2008). Water resources management strategies for adaptation to climate-induced impacts in South Africa. *Water Resources Management*, *22*(9), 1259-1276.

Mulwafu, W., Chipeta, C., Chavula, G., Ferguson, A., Nkhoma, B. G., & Chilima, G. (2003). Water demand management in Malawi: problems and prospects for its promotion. *Physics and Chemistry of the Earth, Parts A/B/C*, *28*(20-27), 787-796.

Murray-Hudson, M., Wolski, P., & Ringrose, S. (2006). Scenarios of the impact of local and upstream changes in climate and water use on hydro-ecology in the Okavango Delta, Botswana. *Journal of Hydrology*, *331*(1-2), 73-84.

Musekiwa, N., & Mandiyanike, D. (2017). Botswana development vision and localisation of UN Sustainable Development Goals. *Commonwealth Journal of Local Governance*, 135-145.

Mutembwa, A. (1998). *Water and the potential for resource conflicts in southern Africa*. Global Security Fellows Initiative.

Nagel, E. (1963). Assumptions in economic theory. *The American Economic Review*, *53*(2), 211-219.

Nahm, F. S. (2016). Nonparametric statistical tests for the continuous data: the basic concept and the practical use. *Korean journal of anesthesiology*, *69*(1), 8.

National Development Plan 11. April 2017-March 2023. Volume 11. http://extwprlegs1.fao.org/docs/pdf/bot175398.pdf. (Accessed 3rd March 2018).

Nauges, C., & Thomas, A. (2003). Long-run study of residential water consumption. *Environmental and Resource Economics*, 26(1), 25-43.

Nauges, C., & Whittington, D. (2010). Estimation of water demand in developing countries: An overview. *The World Bank Research Observer*, *25*(2), 263-294.

Neuman, W. L. (2006). Social Research Methods: Qualitative and quantitative approaches. Boston, MA et al.

Neuman, W. L., & Wiegand, B. (2000). *Criminal justice research methods: Qualitative and quantitative approaches*. Boston: Allyn and Bacon.

Nyambe, I. A., Mwasambili, R., Mate, L., Lungu, C., Kambole, M., & Maseka, C. (2002). Water demand management in Zambia: Towards promotion and adoption. *Final Country Study Report, IUCN (World Conservation Union) Southern Africa, Water Demand Management Phase II project Pretoria*.

Oageng, I., & Mmopelwa, G. P. (2014). Water consumption patterns in a rural setting in Ngamiland district, Botswana: the case of Boro village. *Journal of water, sanitation and hygiene for development*, *4*(4), 720-726.

Olmstead, S. M., & Stavins, R. N. (2009). Comparing price and nonprice approaches to urban water conservation. *Water Resources Research*, *45*(4).

Onyango, A. E., Okoth, M. W., Kunyanga, C. N., & Aliwa, B. O. (2018). Microbiological quality and contamination level of water sources in Isiolo County in Kenya. *Journal of Environmental and Public Health*, *2018*.

Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological bulletin*, *124*(1), 54.

Oxford Learner's Dictionaries. (2018). https://www.oxfordlearnersdictionaries.com/. (Accessed 19th January 2018).

Pagiola, S. (2002). Paying for water services in Central America: learning from Costa Rica. *Selling forest environmental services: Market-based mechanisms for conservation and development*, 37-62.

Postel, S. (1997). *Last oasis: facing water scarcity*. WW Norton & Company.

Postel, S. L. (2000). Entering an era of water scarcity: the challenges ahead. *Ecological applications*, *10*(4), 941-948.

Pricing, I., & Tribunal, R. (2004). Residential water uses in Sydney, the Blue Mountains and Illawarra. *Res. Pap*, *26*.

Prokopy, L. S. (2009). Determinants and benefits of household level participation in rural drinking water projects in India. *The Journal of Development Studies*, *45*(4), 471-495.

Punch, K. F., & Oancea, A. (2014). Introduction to research methods in education.

Ragab, R., & Prudhomme, C. (2002). Sw—soil and Water: climate change and water resources management in arid and semi-arid regions: prospective and challenges for the 21st century. *Biosystems engineering*, *81*(1), 3-34.

Raina, A., Gurung, Y., & Suwal, B. (2020). Equity impacts of informal private water markets: case of Kathmandu Valley. *Water Policy*, *22*(S1), 189-204.

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-darling tests. *Journal of statistical modeling and analytics*, *2*(1), 21-33.

Reckwitz, A. (2002). Toward a theory of social practices: A development in culturalist theorizing. *European journal of social theory*, *5*(2), 243-263.

Renwick, M. E., & Green, R. D. (2000). Do residential water demand side management policies measure up? An analysis of eight California water agencies. *Journal of environmental economics and management*, *40*(1), 37-55.

Reynaud, A., & Romano, G. (2018). Advances in the economic analysis of residential water use: An introduction. *Water*, *10*(9), 1162.

Reynaud, A., Pons, M., & Pesado, C. (2018). Household Water Demand in Andorra: Impact of Individual Metering and Seasonality. *Water, 10(3), 321*.

Rietveld, P., Rouwendal, J., & Zwart, B. (2000). Block rate pricing of water in Indonesia: an analysis of welfare effects. *Bulletin of Indonesian Economic Studies*, *36*(3), 73-92.

Ringersma, J., Batjes, N. H., & Dent, D. (2003). *Green water: Definitions and data for assessment* (No. 2003/2). ISRIC-World Soil Information.

Rogers, P., Bhatia, R., & Huber, A. (1998). *Water as a social and economic good: How to put the principle into practice*. Stockholm: Global Water Partnership.

Rogers, P., De Silva, R., & Bhatia, R. (2002). Water is an economic good: How to use prices to promote equity, efficiency, and sustainability. *Water policy*, *4*(1), 1-17.

Rohrdrommel, M. (2017). Master's Thesis Drivers of residential water demand – analysis and outlook of water utility consumption data.

Rojewski, J., Lee, I. H., & Gemici, S. (2012). Use of t-test and ANOVA in career-technical education research. *Career and Technical Education Research*, *37*(3), 263-275.

Rothert, S., & Macy, P. (2001). Obstacles and constraints to implementing water conservation/demand management in southern Africa. *The Potential of Water Conservation and Demand Management in Southern Africa: An Untapped River. International Rivers Network, California*.

Royston, J. P. (1982). An extension of Shapiro and Wilk's W test for normality to large samples. *Journal of the Royal Statistical Society: Series C (Applied Statistics), 31*(2), 115-124.

Russell, S., & Fielding, K. (2010). Water demand management research: A psychological perspective. *Water resources research, 46*(5).

Sapkota, A. R. (2019). Water reuse, food production and public health: Adopting transdisciplinary, systems-based approaches to achieve water and food security in a changing climate.

Sarabia-Sánchez, F. J., & Rodríguez-Sánchez, C. (2013). Attitudes towards saving water, household structural characteristics and water consumption. *Psychology*, *4*(2), 115-137.

Savenije, H. H. (2002). Why water is not an ordinary economic good, or why the girl is special. *Physics and Chemistry of the Earth, Parts A/B/C, 27*(11-22), 741-744.

Savenije, H. H., & Van Der Zaag, P. (2002). Water as an economic good and demand management paradigm with pitfalls. *Water international, 27*(1), 98-104.

Scheierling, S. M., Loomis, J. B., & Young, R. A. (2006). Irrigation water demand: A meta-analysis of price elasticities. *Water resources research*, *42*(1).

Schleich, J., & Hillenbrand, T. (2009). Determinants of residential water demand in Germany. *Ecological economics, 68*(6), 1756-1769.

Schultz, P. W., Shriver, C., Tabanico, J. J., & Khazian, A. M. (2004). Implicit connections with nature. *Journal of environmental psychology, 24*(1), 31-42.

Scott, M., Flaherty, D., & Currall, J. (2013). Statistics: Dealing with categorical data. *Journal of Small Animal Practice*, *54*(1), 3-8.

Sedgwick, P. (2014). Spearman's rank correlation coefficient. *Bmj*, *349*.

Segosebe, E., & Parida, B. P. (2006). Water demand management in Botswana: Challenges of a diminishing resource. *International Journal of Sustainable Development and Planning*, *1*(3), 317-325.

Serur, A. B., & Sarma, A. K. (2018). Current and projected water demand and water availability estimates under climate change scenarios in the Weyib River basin in Bale mountainous area of Southeastern Ethiopia. *Theoretical and Applied Climatology*, *133*(3), 727-735.

Setlhogile, T., & Harvey, R. (2015). Water Governance in Botswana.

Shan, Y., Yang, L., Perren, K., & Zhang, Y. (2015). Household water consumption: insight from a survey in Greece and Poland. *Procedia Engineering*, *119*, 1409-1418.

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, *52*(3/4), 591-611.

Sharma, S. K., & Vairavamoorthy, K. (2009). Urban water demand management: prospects and challenges for the developing countries. *Water and Environment Journal*, *23*(3), 210-218.

Shiklomanov, I. A. (1993). World Fresh Water Resource In: Gleick, PH (Ed.) Water crisis: A guide to world freshwater resources.

Shove, E., Pantzar, M., & Watson, M. (2012). *The dynamics of social practice: Everyday life and how it changes*. Sage.

Silverman, D. (2000). Analyzing talk and text. *Handbook of qualitative research*, *2*(0), 821-834.

Solanes, M., & Gonzalez-Villarreal, F. (1999). *The Dublin principles for water as reflected in a comparative assessment of institutional and legal arrangements for integrated water resources management* (p. 17). Stockholm: Global Water Partnership.

Soldán, P. (2003). Toxic risk of surface water pollution—six years of experience. *Environment International*, *28*(8), 677-682.

Sønderlund, A. L., Smith, J. R., Hutton, C., & Kapelan, Z. (2014). Using smart meters for household water consumption feedback: knowns and unknowns. *Procedia Engineering*, *89*, 990-997.

Sorinel, C. (2011). Water as a Global Public Good. *Ovidius University Annals, Economic Sciences Series*, *11*(1), 443-446.

Soto Rios, P. C., Deen, T. A., Nagabhatla, N., & Ayala, G. (2018). Explaining water pricing through a water security lens. *Water*, *10*(9), 1173.

Statistics Botswana. (2014). Population and housing census 2011 analytical report.

Stern, D. I., & Kaufmann, R. K. (2000). Detecting a global warming signal in hemispheric temperature series: A structural time series analysis. *Climatic Change*, *47*(4), 411-438.

Stern, P. C. (2000). New environmental theories: toward a coherent theory of environmentally significant behaviour. *Journal of social issues*, *56*(3), 407-424.

Stewart, R. A., Willis, R., Giurco, D., Panuwatwanich, K., & Capati, G. (2010). Web-based knowledge management system: linking smart metering to the future of urban water planning. *Australian Planner*, *47*(2), 66-74.

Strang, V. (2005). Common senses: Water, sensory experience and the generation of meaning. *Journal of Material Culture*, *10*(1), 92-120.

Swatuk, L. A., & Motsholapheko, M. (2008). Communicating integrated water resources management: From global discourse to local practice–Chronicling an experience from the Boteti River sub-Basin, Botswana. *Physics and Chemistry of the Earth, Parts*

A/B/C, *33*(8-13), 881-888.

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2007). *Using multivariate statistics* (Vol. 5, pp. 481-498). Boston, MA: Pearson.

Tong, Y., Fan, L., & Niu, H. (2017). Water conservation awareness and practices in households receiving improved water supply: A gender-based analysis. *Journal of cleaner production*, *141*, 947-955.

Tongco, M. D. C. (2007). Purposive sampling as a tool for informant selection. *Ethnobotany Research and applications*, *5*, 147-158.

Troy, P. N., & Randolph, W. (2006). *Water consumption and the built environment: a social and behavioural analysis*. Sydney, New South Wales, Australia: City Futures Research Centre.

Turner, J. C. (1991). *Social influence*. Thomson Brooks/Cole Publishing Co.

UN. (2010). Resolution on Human Right to Water and Sanitation. *New York: United Nations*.

UN. (2014). The United Nations Word Water Development Report, 2014. Water and Energy, volume 1. https://sustainabledevelopment.un.org/content/documents/1714Water%20Development%20Report%202014.pdf. (Accessed 3rd August 2020)

UNDP (2000). Overcoming human poverty. New York: UNDP

UNDP (2015). African Economic Outlook 2015: Regional Development and Spatial Inclusion.

UNDP. Sustainable Development Goals 2030. https://www.undp.org/content/dam/undp/library/corporate/brochure/SDGs_Booklet_Web_En.pdf (Accessed 20th April 2019).

United Nations. Committee on economic, social and cultural rights (2002). General Comment No. 15 (2002) The right to water (arts. 11 and 12 of the International Covenant on Economic, Social and Cultural Rights). *Agenda*, *11*, 29.

UN-Water (2018). Sustainable Development Goal 6: Synthesis Report on water and sanitation. Accessed: https://sustainabledevelopment.un.org/content/documents/19901SDG6_SR2018_web_3.pdf (Accessed 20th April 2019)

UN-Water/Africa. (2003). The Africa water vision for 2025: Equitable and sustainable use of water for socioeconomic development. *Addis Ababa, Ethiopia: Economic Commission for Africa*.

Van der Zaag, P., & Savenije, H. H. (2006). *Water as an economic good: the value of pricing and the failure of markets* (pp. 1-32). Unesco-IHE.

Van der Zaag, P., Seyam, I. M., & Savenije, H. H. (2002). Towards measurable criteria for the equitable sharing of international water resources. *Water Policy*, *4*(1), 19-32.

van Koppen, B. (2001). Gender in integrated water management: an analysis of variation. In *Natural Resources Forum* (Vol. 25, No. 4, pp. 299-312). Oxford, UK: Blackwell Publishing Ltd.

van Schaik, H., & Bakker, M. (2008). Climate changes water demand management. *Proc., Int. Expo Zaragoza, United Nations, New York*, 1-11.

Vörösmarty, C. J., Green, P., Salisbury, J., & Lammers, R. B. (2000). Global water resources: vulnerability from climate change and population growth. *science*, *289*(5477), 284-288.

Wallingford, H. R. (2003). Handbook for the assessment of catchment water demand and use.

Warde, A. (2005). Consumption and theories of practice. *Journal of consumer culture*, *5*(2), 131-153.

Webster, I. T., Parslow, J. S., Grayson, R. B., Molloy, R. P., Andrewartha, J., Sakov, P., ... & Wallace, B. B. (2001). Gippsland Lakes environmental study-Assessing options for improving water quality and ecological function.

Weng, C. N., & Nitivattananon, V. (2007). The role of gender in domestic water conservation in Malaysia. *Malaysian J Environ Manage*, *8*, 109-129.

Wentz, E. A., & Gober, P. (2007). Determinants of small-area water consumption for the city of Phoenix, Arizona. *Water Resources Management*, *21*(11), 1849-1863.

WHO/UNICEF Joint Water Supply, Sanitation Monitoring Programme, & World Health Organization. (2015). *Progress on sanitation and drinking water: 2015 update and MDG assessment*. World Health Organization.

Williams, A. (2003). How to… Write and analyse a questionnaire. *Journal of orthodontics*, *30*(3), 245-252.

Willis, R. M., Stewart, R. A., Panuwatwanich, K., Jones, S., & Kyriakides, A. (2010). Alarming visual display monitors affecting shower end use water and energy conservation in Australian residential households. *Resources, Conservation and Recycling*, *54*(12), 1117-1127.

Willis, R. M., Stewart, R. A., Panuwatwanich, K., Williams, P. R., & Hollingsworth, A. L. (2011). Quantifying the influence of environmental and water conservation attitudes on household end use water consumption. *Journal of environmental management*, *92*(8), 1996-2009.

Winkler, I. T. (2019). The human right to water. In *Research Handbook on International Water Law*. Edward Elgar Publishing.

Winpenny, J. (2005). *Managing water as an economic resource*. Routledge.

Wolters, E. A. (2014). Attitude–behavior consistency in household water consumption. *The Social Science Journal*, *51*(3), 455-463.

World Data Atlas. (2017). Online document: https://knoema.com/atlas/Botswana/Internal-renewable-water-resources-per-capita. (Accessed 1st October 2021)

World Health Organisation, & World Health Organisation Staff. (2004). *Guidelines for drinking-water quality* (Vol. 1). World health organization.

World Meteorological Organization. International Conference on Water and the Environment: Development Issues for the 21st Century (1992: Dublin, Ireland). (1992). *International Conference on Water and the Environment: Development Issues for the 21st Century, 26-31 January 1992, Dublin, Ireland: the Dublin Statement and Report of the Conference*. World Meteorological Organization.

Worthington, A. C., & Hoffmann, M. (2006). A state-of-the-art review of residential water demand modelling.

WWAP. (2017). The United Nations World Water Development Report. Wastewater: the untapped resource. UNESCO, 200. Online document: https://doi.org/10.1017/CBO9781107415324.004. (Accessed 12th October 2018)

Yan, L. (2015). The ethnic and cultural correlates of water consumption in a pluralistic social context–the Sydney Metropolitan Area.

Yıldız, D. (2017). The importance of water in development. *World Water Diplomacy & Science News*, *10006*(1-4), 1-7.

Zai, P. V. (2014). Modern approaches regarding public goods. *Post-crisis developments in Economics*, 133.

Zar, J. H. (2005). Spearman rank correlation. *Encyclopedia of Biostatistics*, *7*.

Zhang, H. H., & Brown, D. F. (2005). Understanding urban residential water use in Beijing and Tianjin, China. *Habitat International*, *29*(3), 469-491.

Zhang, H., Cheng, S., Li, H., Fu, K., & Xu, Y. (2020). Groundwater pollution source identification and apportionment using PMF and PCA-APCA-MLR receptor models in a

typical mixed land-use area in Southwestern China. *Science of the total environment*, *741*, 140383.

Zubaidi, S. L., Ortega-Martorell, S., Al-Bugharbee, H., Olier, I., Hashim, K. S., Gharghan, S. K., ... & Al-Khaddar, R. (2020). Urban water demand prediction for a city that suffers from climate change and population growth: Gauteng province case study. *Water*, *12*(7), 1885.

APPENDICES

APPENDIX 1: Household survey questionnaire

QUESTIONNAIRE FOR HEADS OF HOUSEHOLDS

My name is ..... from the University of Botswana. I am undertaking a study on the **Determinants of Residential Water Demand in Ngamiland District, Botswana**. This survey is for academic purposes only and the information you provide will be confidential. Your ideas will be analysed and used to inform policy makers and service providers for the improvement of water services.

Leina la me ke …… go tswa mmadikolo wa Botswana. Ke dira dithuto ka ditlhotlhomiso tsa dintlha tse di bakang letlhoko metsi mo kgaolong ya Ngamiland, Botswana. Patlisiso e e tla dirisiwa hela mo go tsa thuto, kitso e o re fang e tla somarelwa. Dikakanyo tsa lona di tla sekasekwa le go gakolola badiri ba melao le ba ba fang ditirelo go tokafatsa ditirelo tsa metsi.

Date of interview: ……

Village: …….

Ward: ……

Name of the respondent: …….

Plot number: ……

Start time: .....

End time: .....

SECTION A: DEMOGRAPHIC AND SOCIO-ECONOMIC FACTORS

Question Number	Question and variable	Option	Response	
A1	**Gender** What is your gender? (*Bong*)	Male *(Rre)*	1	
		Female *(Mme)*	2	
A2	**Age** How old are you? *(Dingwaga di kae?)*	----------		
A3	**Marital status** What is your marital status? *(A o nyetswe?)*	Single *(Ga ke a nyalwa)*	1	
		Married *(Ke nyetswe)*	2	
		Widowed (*Ke tlhokafaletswe)*	3	
		Divorced *(Re kgaogane)*	4	
		Others (specify) *(Tse dingwe)* ----------	5	
A4	What is your ethnicity? *(O wa morafe ofe?)*	BaTawana	1	
		BaYei	2	
		BaHerero	3	
		BaSarwa	4	
		Hambukushu	5	
		Other (specify) ----------	6	
A5 i	**Education** What is your level of education? *(O tsene sekolo go felela kae?)*	None *(Sepe)*	1	
		Non-formal *(Thuto gaegolelwe)*	2	
		Primary *(Se se botlana)*	3	
		Secondary *(Se segolwane)*	4	
		Tertiary *(Sa ithutelo tiro)*	5	
		Other (specify) *(Tse dingwe)* ----------		

A5 ii	How many years of schooling did you have? *(O tsere dingwaga tse kae mo sekolong?)*	……..		
A6	**Employment status** Are you employed? *(A o a bereka?)*	Yes *(Ee)*	1	
		No *(Nnyaa)*	2	
A7	If **Yes** to **A6**, what is the type of employment do you have? *(O dira mofuta ofe wa tiro?)*	Civil service *(Goromente)*	1	
		Privately owned business *(Kgwebo e ikemetseng ka nosi)*	2	
		Owned business *(Kgwebo ya gago)*	3	
		Farming *(Temo-thuo)*	4	
		Retired *(Ke tlogetse tiro ka bogodi)*	5	
		Other (specify) *(Tse dingwe)* ----------	6	
A8	**Income** What is your monthly income? *(O bona bokae ka kgwedi?)*	----------		
A9i	**Household size** What is your household size? *(Lo nna lo le kae mo lwapeng?)*	----------		
A9ii	Household size group	1-5	1	
		6-10	2	
		11-15	3	
		16-20	4	
		21 and above	5	
A10	**House ownership**	Fully owned *(ke ya gago)*	1	
		Renting-private *(Ke ya mongwe/bangwe)*	2	
		Renting-public e.g. BHC or government housing *(Ntlo ya BHC or goromente)*	3	

		Other (specify) *(Tse dingwe)* ----------	4	

SECTION B: HOUSEHOLD WATER SUPPLY AND DEMAND *(Tsamaiso le letlhoko la metsi mo lwapeng)*

B1	Do your household have water connected into the house?	Yes	**1**	
		No	**2**	

B2i	Do you have alternative sources of water?	Yes *(Ee)*	1	
		No *(Nnyaa)*	2	
B2ii	If yes to **B2i**, what are they?	Public tap *(pompo ya sechaba)*	1	
		River *(Noka)*	2	
		Borehole *(Sediba)*	3	
		Neighbour's tap *(pompo ya mabapi)*	4	
		Buying water *(go reka metsi mo batho ba ba a rekisang)*	5	
		Others (Specify) *(Tse dingwe)* ----------	6	
B3	Have you ever experienced any water shortage in the past months? *(A o kile wa itemogela letlhoko la metsi mo dikgweding tse di fetileng?)*	Yes *(Ee)*	1	
		No *(Nnyaa)*	2	
B4	If yes to **B3**, how often in a month? *(Fa o le gore o rile ee ko go B2, jang?)*	Sometimes *(Ka nako dingwe)*	1	
		Always *(Ka nako tshotlhe)*	2	
		Frequently *(Kgapetsa-kgapetsa)*	3	
B5		High demand for water *(Letlhoko la metsi le ntsi)*	1	

	In your opinion, what causes these shortages? *(Ka kakanyo ya gago ke eng se bakang tlhaelo ya metsi?)* (You may tick more than 1 option)	Low water supply *(Tsamaiso ya metsi e ko tlase)*	2	
		Persistent droughts (*Leuba le ntsi)*	3	
		Poor management of water infrastructures *(Go okamela mo go sa siamang ga ditlamelo tsa metsi)*	4	
		Others (Specify) *(Tse dingwe)* ----------	5	
B6	From the list of household water uses, rank them starting with the most water consuming use in your household. *(Go tswa mo ditirisong tsa metsi tse di latelang, supa ka go simolola ka tse di dirisang metsi a mantsi)*	Cooking *(Go apaya)*	1	----
		Drinking *(Go nwa)*	2	----
		Bathing/Showering *(Go tlhapha)*	3	----
		Laundry *(Go tlhatswa diaparo)*	4	----
		Washing dishes (*Ga tlhatswa dikotile)*	5	----
		Toilet flush *(Ntlo ya boiteketso e e dirisang metsi)*	6	----
		Watering plants *(Go nosetsa ditlhare)*	7	----
		Others (specify) *(Tse dingwe*) ----------	8	
B7	Do you pay for household water consumption? *(A o duela tiriso ya metsi mo lwapeng?)*	Yes *(Ee)*	1	
		No *(Nnyaa)*	2	
B8	If yes to **B7,** how often do you pay for water bills? *(Fa o dumalana mo go B6, o duela bili ya metsi jang?)*	Monthly *(Ka kgwedi)*	1	
		Yearly *(Ka ngwaga)*	2	
		Others (specify) *(Tse dingwe)*	3	
B9	How is your household charged for water consumption? *(Ba lelwapa la gago ba duedisiwa jang tiriso ya metsi?)*	Based on meter readings *(Go ya ka dipalo tsa metara)*	1	
		Flat fee *(e.g large sum included in charges or rent) (Madi a metsi a kopanngwa le dituelo tse dingwe kana tsa rente ya ntlo)*	2	
		Do not know *(Ga ke itse)*	3	
		Others *(specify*) *(Tse dingwe)*	4	

		---------- ----		
B10	On average, how much do you pay for the water monthly? (Please write) *(Ka palo ya magare, o duelela metsi bokae ka kgwedi) (Tswe-tswe kwala)*	---------- --		
B11i	Are you satisfied with the water tariffs? *(A o kgotsofalela ditlhwatlhwa tsa metsi?)*	Yes *(Ee)*	1	
		No *(Nnyaa)*	2	
B11ii	If no to **B11i,** give reasons for not being satisfied? *(Fa o sa dumalana mo go B11, fa mabaka a gore ke eng o sa kgotsofale?)*	---------- ----------		

SECTION C: PSYCHOLOGICAL FACTORS INFLUENCING RESIDENTIAL WATER DEMAND

i)Household perceptions on residential water demand

C1. Please tick if you strongly agree (SA), agree (A), neutral (N), disagree (D) and strongly disagree (SD) with the following statements.

(Tswe-tswe tshwaya fa e le gore o dumalana mo go tiileng (SD), wa dumalana (A), o le ga gare (N), o sa dumalane (D) le o sa dumalane mo go tiileng)

Statement	**SA**	**A**	**N**	**D**	**SD**
	(1)	(2)	(3)	(4)	(5)
i) People should have the right to as much water as they want. *(Batho ba tshwanetse go nna le tshwanelo ya selekanyo sa metsi a ba a batlang)*					
ii) The government should not place restrictions on the amount of water a household can use. *(Goromente ga a tshwanela go fa selekanyo sa metsi a lelwapa le ka a dirisang)*					
iii) The water supply of Ngamiland District is adequate to meet the needs of its residents for many years to come. *(Tsamaiso/kabo ya metsi mo kgaolong ya Ngamiland e tla kgona go fitlhelela botlhoki jwa banni mo dingwageng tse dintsi tse di latelang)*					
iv) I do not believe that over-use of water diminishes the (water) resources available for use. *(Ga ke dumele gore tiriso-phetelela ya metsi e fokotsa metswedi e leng teng go ka dirisiwa)*					
v) I do not have any moral obligation to conserve water. *(Ga ke na maikarabelo ape a go somarela metsi)*					
vi) Wastewater cannot be effectively treated and used for flushing, watering plants and other outdoor uses. *(Metsi a berekileng ga a kgone go tsenngwa mo khemikhaleng a bo a diriwa go phepafatsa ntlo ya boiteketso e e dirisang metsi, go nosetsa ditlhare le ditiro tse dingwe tsa kwa ntle ga lelwapa)*					
vii) Wastewater cannot be effectively treated to the standard suitable for drinking. *(Ga go kgonegale gore metsi a berekileng a ka tsengwa dikhemikhale go bewa mo seemong se siametsing go ka nowa)*					
vii) I use much water for personal hygiene during summer season. *(Ke dirisa metsi a mantsi go ephephafatsa ka paka ya selemo.*					
ix) I also use much water during winter season. *(Gape ke dirisa metsi a mantsi ka paka ya mariga.)*					

ii) Household awareness on water conservation

C2	Are you aware of water conservation? *(A o itse ka tshomarelo ya metsi?)*	Yes *(Ee)*	1	
		No *(Nnya)*	2	
C3	If yes to C2, where did you hear about it?	Media e.g radio, TV (by water providers)	1	
		Family and friends	2	
		Others *(specify)*	3	

C4. Perceptions on water conservation

Please tick if you **strongly agree (SA), agree (A), neutral (N), disagree (D) and strongly disagree (SD)** with the following statements.

(Tswe-tswe tshwaya fa e le gore o dumalana mo go tiileng (SD), o dumalana (A), o le ga gare (N), o sa dumalana (D) le go sa dumela mo go tiileng

Statement	**SA** (5)	**A** (4)	**N** 3	**D** (2)	**SD** (1)
i)In Ngamiland District water demand exceeds supply, so water needs to be well conserved. *(Mo kgaolong ya Ngamiland letlhoko la metsi le feta kabo ya metsi, ka jalo metsi a tshwanetse go somarelwa)*					
ii)The household has a responsibility of contributing to Ngamiland District water demand management by reducing water consumption. *(Lelwapa le na le boikarabelo jwa go thusa mo go tsa tshomarelo metsi mo kgaolong ya Ngamiland ka go fokotsa tiriso ya metsi)*					
iii) If each household reduces the amount of water it uses by just a little, it will make a big difference for the public *(Fa lelwapa lengwe le lengwe le ka*					

fokotsa metsi a le a dirising ka bonnye fela, go ka dira pharologano mo kgaolong)					
iv) Households' willingness to pay for water contribute to water conservation. *(Go batla go duelela metsi ga lelwapa go thusa ka tsa tshomarelo metsi).*					
v) Water Utilities Corporation and the community is jointly responsible for ensuring that there is enough water supply Ngamiland District. *(Ba kompone ya metsi le sechaba ba na le boikarabelo jwa go tlhomamisa gore go na le metsi a a lekaneng mo kgaolong ya Ngamiland).*					
vi) I am aware of environmental pollution *(ke itse ka kgothelesego ya tikologo)*					
vii) My neighbors and friends always practice water conservation *(Ba mabapi le ditsala ba dirisa metsi ka kelotlhoko ka nako tsotlhe)*					
viii) I always check the water bill regularly *(ke nna ke cheka dituelo tsa metsi kgapetsa-kgapetsa)*					
ix) It is important to always conserve water to prevent water shortages *(Go botlhokwa go somarela metsi go kganela tlhaelo ya metsi)*					
x) Making an effort to save water is an indication of good upbringing and culture (*Go dira maiteko a go somarela metsi go supa kgodiso le ngwao e siaming)*					

C5. What is the degree of your knowledge about the following water issues?

(O dumela gore o itse go le kae ka dikgang tsa metsi tse di latelang)

i) Where your household water comes from. *(Kwa metsi a mo lwapeng a tswang teng)*	A lot of knowledge *(Kitso e ntsi)*	3	
	Little knowledge (*Kitso e potlana)*	2	
	No knowledge at all *(Ga ke na kitso gotlhelele)*	1	
ii) The water pricing tariffs of your area. *(Mokgwa wa ditlhwatlhwa tsa metsi mo kgaolong ya Ngamiland)*	A lot of knowledge *(Kitso e ntsi)*	3	
	Little knowledge (*Kitso e potlana)*	2	
	No knowledge at all *(Ga ke na kitso gotlhelele)*	1	

iii) The re-use of grey water in your household. *(Tiriso ya metsi a berekileng mo lwapeng la gago)*	A lot of knowledge *(Kitso e ntsi)*	3	
	Little knowledge (*Kitso e potlana)*	2	
	No knowledge at all *(Ga kena kitso gotlhelele)*	1	

iii) Household attitude towards water conservation

C6i	Have you taken any actions to reduce your household water consumption in the past 6 months? **(If yes go to question C6ii and C6iii), if no go to C7)** *(A o kile wa tsaya kgato go fokotsa tiriso ya metsi mo lwapeng kgwedi tse thatharo tse di fitileng?)*	Yes *(Ee)*	1	
		No *(Nnya)*	2	

C6ii. If **yes** to question **C6i**, please tick the actions you have taken and indicate by ticking how frequently **(usually, sometimes, occasionally, never or not sure)** you undertook that action(s) to reduce water consumption? (*Fa o rile ee mo potso ya C6i, tswe-tswe tshwaya kgato e o e tsereng ka go kaya gore o dira go le kae (ka tlwaelo, nako ding we, ka sewelo, gotlhelele kana ga ke tlhomamise) go fokotsa tiriso ya metsi.*

Actions	**Frequency**			
	Usually *(Ka tlwaelo)*	Sometimes *(Nako dingwe)*	Occasionally *(Ka sewelo)*	Not at all *(Ga nke ke dira jalo gotlhelele)*
	4	3	2	1
i)Turn off water while brushing teeth *(Go tima metsi fa o tlhapha meno)*				
ii)Have short showers or do not fill the bath tab *(Go tsaya nako e khutshwan mo shawareng kgotsa go sa tlatsa bata e tlhapelang)*				

iii) Use small bucket instead of a bigger bucket when bathing *(ke dirisa emere e nnye fa ke thapa mo sekoteleng)*				
iv)Fix leaking taps and leaking toilets whenever and wherever applicable *(Go baakanya dipompo le matlo a boiteketso a dutlang)*				
v)Use sink/basin plug more often *(Go dirisa sethibo sa sekotlele gantsi)*				
vi) Use minimal amount of water whilst washing the dishes/ clothes in a washing basin *(Go dirisa metsi a a lekanetseng go thatswa dijana or diaparo mo sekoteleleng)*				
vii) Do laundry or dishes only when there is full load be it using machines or doing manually *(Go tlhatswa dilwana le diaparo hela fa di tletse)*				
viii)Reuse water (flower watering, toilet flushing) *(Go dirisa metsi a berekileng, go nosetsa ditlhare, phephafatsa ntlo ya boiteketso)*				
ix)Replace old appliances with water-saving appliances *(Go chencha didirisiwa tsa metsi tsa bogologolo ka tse disha)*				
x)Water garden/plants during the coolest part of the day *(Go nosetsa tshingwana kgotsa ditlhare go se mogote)*				

C6iii. If yes to question C6i, please indicate what led you to use less water (You can tick more than one factor).

(Fa o rile ee mo potso C6i, tswe-tswe supa ka go tshwaya ntlha e dirileng gore o dirise metsi a mannyennyane. O ka tshwaya go feta bongwe).

i) Influence by other people e.g. family/children/friends *(thotoetso ya batho ba bangwe sekai, ba lelwapa/bana/ditsala)*	1	
ii)Water use restrictions by WUC *(Kganelo tiriso ya metsi)*	2	
iii) General environmental knowledge/awareness. *(Kitso/temogo ya tirologo ka kakaretso)*	3	
iv)Religious/spiritual belief *(Tumelo)*	4	
v)Water scarcity *(Letlhoko la metsi)*	5	
vi)The need to save money *(Go somarela metsi)*	6	
vii)Upbringing/habit/common sense *(Kgodiso/mokgwa/tlhaoganyo)*	7	
viii)Educated about water saving *(Thutego ka go somarela metsi)*	8	
ix)Influenced through advertisements e.g. media *(Thutuetso ka tsa papatso, dikae; pampiri ya dikgang, kgaso)*	9	
x) Other (specify) *(Tse dingwe)* ----------	10	

C7	Are you willing to change your water use practices in the near future to conserve water? *(A o etleêtsêga go fetola ka fa o dirisang metsi ka teng mo bogautshwaneng a somarela?)*	Yes *(Ee)*	1	
		No *(Nnya)*	2	
C8	What prompted you to think about conserving water? *(O gwethilwe ke eng gore o somarele metsi?)*	…….		

C8. Do you think the following strategies would make it easier for you to conserve water? Please tick if you **strongly agree (SA), agree (A), neutral (N), disagree (D) and strongly disagree (SD)** with the following statements.

(A o akanya gore maano a latelang a ka dira gore go nne motlhofo go somarela metsi. Tswe-tswe tshwaya fa e le gore o dumalana mo go tiileng (SD), o dumalana (A), o le ga gare (N), o sa dumalana (D) le go sa dumela mo go tiileng)

Strategies	**SA** (5)	**A** (4)	**N** (3)	**D** (2)	**SD** (1)
i) Incentives to save water (e.g. financial incentives, vouchers). *(Kgothatso ya go somarela metsi, dikai; kgothatso ka madi, pampitshana e ka ananngwang le dithoto)*					
ii)Improved water supply by WUC *(Tokafatso ya kabo ya metsi)*					
iii) Being assured that recycled water is safe. *(Go rurifaletswa gore metsi a berekileng a sireletsegile*					
iv) Availability of cheaper water saving facilities. *(Go nna teng ga didirisiwa tse di bolokang metsi)*					
v) Provision of more information on methods of conserving water. *(Go fiwa kitso e ntsi ya mefuta ya go somarela metsi)*					
vi) Public demonstrations of water saving techniques. *(Tshupegetso ya mekgwa ya go somarela metsi)*					

iv) Challenges to reduce household water consumption

(Dikgwetlho tsa go fokotsa tiriso ya metsi mo lwapeng)

C9. What do you think are the challenges to reduce water consumption? (You can tick more than one factor)

(O akanya gore dikgwetlho tsa go fokotsa tiriso ya metsi ke dife. O ka tshwaya ntlha tse di fetang bongwe).

i) Lack of information on methods of water conservation. *(Go tlhoka kitso ka metlhale ya go somarela metsi)*	1	
ii)Limited access to water saving devices *(Tlhaelo ya didirisiwa tse di somarelang metsi)*	2	
iii)Economic reasons (e.g. water saving appliances cost money) *(Mabaka a tsa itsholelo, sekai; didirisiwa tse di bolokang metsii di a tura)*	3	
iv) Water conservation is a low priority compared to other issues. *(Tshomarelo ya metsi e lekanyediwa kwa tlase fa e tshwantshwanngwa le dikgang tse dingwe)*	4	
v) Need of adequate water to maintain high living standard of life. *(Letlhoko la metsi a mantsi go tshela botshelo jwa boleng jo bo kwa godimo).*	5	
vi) Difficult to change water use behaviours that developed over time. *(Go thata go fetola boitshwaro jwa tiriso ya metsi e tlwaelesegileng)*	6	
vii) Personal factors (e.g. forgetfulness, laziness, not thoughtful about effective water use). *(Mabaka a motho, dikae; botshwakga, ga sa akanya ka tiriso ya metsi e siaming).*	7	
viii)Other (specify) *(Tse dingwe)* ----------	8	

SECTION D: WATER USE BEHAVIOUR

(*Mokgwa wa tiriso ya metsi)*

D1	Please indicated the number of the following facilities in your household *(Tswe-tswe supa palo ya didirisiwa tse di latelang mo lwapeng la gago)*	
	i)Dishwasher *(Motshine o tlhatswang dijana)*	-------
	ii)Washing machine *(Motshine o tlhatswana diaparo)*	-------
	iii)Single flush toilet *(Ntlo ya boiteketso e dirisang*	-------

	konopo e nngwe go phepafatsa)	
	iv)Double flush toilet *(Ntlo ya boiteketso e dirisang konopo tse pedi go phepafatsa)*	-------
	v)Bathtub (*Bata e tlhapelang)*	-------
	vi)Shower *(Shawara)*	-------
	vii) Bathing basin (*Bata/sekotele se se thapelang)*	------

D2	From the facilities in question D1 above, what is the most water consuming appliances? *(Go tswa mo dirisienga tsa metsi mo go D1, ke sedirisiwa sefe se dirisang metsi a mantsi go feta tse dingwe?)*	----------		
D3	For personal hygiene which of the following do household member use? *(Ka tsa bophepha ba lelwapa la gago ba dirisa eng thata?)* **(You may tick more than 1)**	Shower *(Shawara)*	1	
		Bathtub *(Bata)*	2	
		Bath container (*Selwana se tlhapelang)*	3	
		Other (specify) ----------	4	
D4	Indicate the frequencies for the following water use habits in your household. *(Supa dinako tse ba lelwapa la gago ba dirisang metsi)* i)On average how long does each shower? *(Ka palo ya magare motho a le mongwe o dirisa shawara lobaka lo kae?)*	Less than 10 minutes		
		11 to 20 minutes	2	
		21 to 30 minutes	3	
		31 minutes and above	4	
		Once a day	1	

	ii)What is the average bathing/showering frequency? *(Palo ya magare ya go tlhapha ke bokae?)*	Twice a day*)*	2	
		Three times a day	3	
		More than three times a day	4	
	iii)In a week, what is the frequency of doing laundry in your household? *(Ka beke ba lelwapa la gago ba tlhatswa a kae?)*	Every day *(Malatsi otlhe)*	1	
		Once in three days *(Gangwe mo malatsing a mararo*)	2	
		Once a week *(Gangwe ka beke)*	3	
		Other (specify) *(Tse dingwe)* ----------	4	

SECTION E: HOUSEHOLD WATER DEMAND

(Letlhoko la metsi a dirisiwang mo lwapeng)

E1	How much water does your household currently consume on average per day (answer in the number of 20 litre containers)? *(Lelwapa la gago le tlhoka selekanyo sa metsi se le kae)? (araba ka selelekanyo sa palo ya lithara tse di masome a mabedi)*	----------
E2	In the past months, how much water did your household consume on average per day? (answer in the number of 20litre containers)	----------

E3	In your household which age group uses more water? Provide a tick. *(Mo lwapeng la gago ke setlhopha sefe se dirisang metsi a mantsi)? Tshwaya karabo*	Old age (60 years and above) *(Bagodi)*	1	
		Adults (36 to 59 years*)* *(Bagolo)*	2	
		Youth (20-35 years) *(Banana)*	3	
		Teenagers (13-19 years) *(Banana)*	4	
		Children (Under 12 years) *(Bana)*	5	

APPENDIX 2: Research permit

PRIVATE BAG 00434
GABORONE
BOTSWANA

Republic of Botswana

TELEPHONE: + (267) 3682000
FAX: + (267) 3911591/3913055

MINISTRY OF LAND MANAGEMENT, WATER & SANITATION SERVICES

CMLWS 1/ 17 /4 II (38)

10 December, 2018

Okavango Research Institute
Private Bag 285
Maun

(Attention: Miss. Manga Motho)

RE: APPLICATION FOR RESEARCH PERMIT BY MANGA MOTHO TITLED, "DETERMINATES OF RESIDENTIAL WATER DEMAND IN NGAMILAND DISTRICT, BOTSWANA".

The above subject matter refers.

- Permission is being granted to conduct research titled **"Determinates of Residential Water Demand in Ngamiland District, Botswana".**
- We trust the research programme will be conducted in accordance with local and international ethical norms and as per research guidelines of July 2004 issued by the Office of the President attached herewith.
- We request an oral presentation on the findings to the Senior Management and the final copy to be submitted to the ministry.

- The focal person for the ministry is head of research Mr. Khawulani Ace Bachobeli.
- The following personnel will be involved in the research:

  i. **Manga Motho** (Principal Investigator)
  ii. **Prof. Kolawole** (Main Supervisor)
  iii. **Dr. Motsholapheko** (Core Supervisor)
  iv. **Mrs Mogomotsi** (Core Supervisor)

- Any changes on the research personnel should be communicated to this Ministry.

- The research will be undertaken in the following areas:

  i. **Maun**
  ii. **Gumare**

The research permit will last for a period of **One Year (1)**, commencing from **10 December 2018** to **10 December 2019.**

Yours Faithfully,

Khawulani Ace Bachobeli
Principal Research Officer
+267 71576661