UNIVERSITY OF CAPE COAST

ALTERNATIVE WATER SUPPLY SYSTEMS AND HOUSEHOLD WATER SECURITY IN THE KROWOR MUNICIPALITY OF GREATER ACCRA REGION, GHANA

ENOCH OPARE ASANTE

2024

UNIVERSITY OF CAPE COAST

ALTERNATIVE WATER SUPPLY SYSTEMS AND HOUSEHOLD WATER SECURITY IN THE KROWOR MUNICIPALITY OF GREATER ACCRA REGION, GHANA

BY

ENOCH OPARE ASANTE

Thesis submitted to the Department of Integrated Development Studies of School for Development Studies, College of Humanities and Legal Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy degree in Development Studies

MARCH, 2024

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ……………………………………Date: ……………

Name: Enoch Opare Asante

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Name: Dr. David Wellington Essaw

Signature: ……………………………………… Date: ……………

ABSTRACT

The disparity in water supply which creates household water insecurity, makes a case to highlight the usefulness of water supply systems to water security. Informed by the rational choice theory and capability approach, the study examined alternative water supply systems for household water security in the Krowor Municipality in the Greater Accra Region of Ghana. The study adopted a mixed methods approach and employed stratified and systematic random and purposive sampling procedures. A sample of 395 households and five key informants were drawn for this study. Descriptive statistics and cross-tabulation were employed for quantitative analyses, while thematic analysis was used for the qualitative analyses. The results revealed that in periods of water supply shortages for domestic water needs, households use alternative water supply systems for their household water security. The availability of reservoirs and water tanks as alternative water supply systems predominates, but the water tank (Poly tank) is the most preferred alternative water supply system for household water security. Furthermore, households' choice of alternative water supply systems is influenced by water security reasons (accessibility, availability, affordability) for their household water security. Other determinants such as household income level, location and time spent in water collection, cost of purchasing water and seasonal variations are invariably associated with households' preferred alternative water supply systems. In addition, alternative water supply systems have positively influenced water shortages, water scarcity, stress and vulnerabilities, productive activities and dependency on conventional water supply systems for household water security. The study recommends the urgent need for collective usage of the identified alternative water supply systems for household water security, while, at the household level, there should be investment in mini water storage tanks and water installations at public vantage points to store water for domestic needs in times of water insecurity in the Municipality.

Key words: Alternative Water Supply Systems, Water Supply, Water access, Household, Water security, Krowor Municipality.

ACKNOWLEDGMENTS

There is no room and space to express my indebted gratitude to every person who made this study worthwhile by contributing his or her rich quota of experience, engagement, exposure and expertise to me.

I would like to express my earnest gratitude to my supervisors Dr. David Wellington Essaw and Dr. Nana Ama Anokye, for their guidance, support, encouragement and patience in making this thesis a success.

That notwithstanding, I will mention only a few. My sincere thanks to the respondents and participants involved in the research. I also give thanks to the research assistants, especially Mr. Joseph Klu who through his co-operation aided in the combing of the materials needed for data collection.

Moreover, I extend my appreciation to my parents Mr. George Opare Asante, Mrs. Emelia Danquah Opare, my siblings Ama Adumea and Kweku Jnr. for their support, prayers and the belief they had in me to masterfully craft this work.

This work would not have been possible without the commitment of my Boss and Teacher, Dr. Albert Annang and Ennin Kweku Godfred. I gratefully appreciate your support during my lows of writing this thesis.

DEDICATION

To Ama Tiwa, Janet Ofosuwaa, and the Opare family.

TABLE OF CONTENTS

	Page
DECLARATION	ii
ABSTRACT	iii
ACKNOWLEDGMENTS	iv
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xii
LIST OF PLATE	xiii
LIST OF ABBREVIATIONS	xiv
CHAPTER ONE: INTRODUCTION	
Statement of the Problem	7
Research Objectives	9
Research Questions	10
Significance of the Study	10
Delimitation of the Study	11
Operational Definitions of Terms	11
Organisation of the Study	12
CHAPTER TWO: LITERATURE REVIEW	
Introduction	13
Theoretical Framework	13
Rational Choice Theory	13
Assumptions of Rational Choice Theory	15
Maximisation of Expected Utility	16
Consequentialism	16

Conditions of rationality 16

Application of Rational Choice Theory to the study 17

Capabilities Approach 20

Application of Capabilities Approach to the study 22

Relevance of the theories to the Study 23

Conceptual Review 24

Dimensions of Water Security 29

Global Water Security 34

Water Supply Systems 37

Alternative Water Supply Systems 38

Rainwater Harvesting 47

Reservoirs 49

Urban Water Supply in Ghana 53

Sources of Water Supply in Ghana 56

Demand and Supply of Water 60

Preferences for Alternative Water Supply Systems to Household Water Security 63

Benefits of Alternative Water Supply Systems 65

Challenges in Accessing Alternative Water Supply Systems 67

Empirical Review 70

Lessons Learnt 77

Conceptual Framework 78

CHAPTER THREE: METHODOLOGY

Introduction 81

Research Paradigm 81

Positivism and Interpretivism 82

Research Design 85

Study Area 88

Target Population 91

Sampling and Sampling Procedure 91

Samples of Household 92

Data Sources 95

Data Collection Methods and Instruments 96

Interview Schedule 96

In-depth Interview Guide 97

Data Collection Procedure 98

Pre-test of Instruments 99

Data Processing and Analysis 99

Ethical Considerations 100

Limitations of the Study 101

Chapter Summary 102

CHAPTER FOUR: RESULTS AND DISCUSSION

Introduction 103

Demographic Characteristics of Respondents 103

Age of Respondents 105

Sources of Water in Selected Communities 109

Preference of Alternative Water Supply Systems for Household Water Security 118

Benefits of Alternative Water Supply Systems for Household Water Security 134

Challenges in Accessing Alternative Water Supply Systems 145

Chapter Summary 162

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction 163

Summary 163

Conclusions 166

Recommendations 167

Suggesting Further Research 168

REFERENCES 169

APPENDIX A: INTERVIEW SCHEDULE FOR HOUSEHOLDS 212

APPENDIX B: INTERVIEW GUIDE FOR WATER VENDORS 222

LIST OF TABLES

Table		Page
1	Summary of empirical review	75
2	Sample frameworks	95
3	Age of respondents in the communities	106
4	Marital status of respondents in the communities	106
5	Household size, years of stay, and expenditure in the selected communities	108
6	Main sources of water supply for communities	111
7	Frequency of using alternative water supply systems for household water security	113
8	Domestic use of water from alternative water supply systems	115
9	Availability of alternative water supply systems in the communities	121
10	Preferred alternative water supply system to household water security	124
11	Preferred alternative water supply systems and the main reason for preference.	128
12	Selected communities and reasons for their preference	129
13	Reasons for the preferred alternative water supply systems for household water security	133
14	Communities by benefits of using alternative water supply systems	135
15	Alternative water supply systems and water shortages	136
16	AWSs and water scarcity, stress and Vulnerabilities	140

17 Alternative water supply systems and household productive activities 143

18 Alternative water supply systems and conventional water supply systems 145

19 Challenges in accessing alternative water supply systems 154

20 Recommendations on forms of alternative water supply systems 157

21 Recommendation of alternative water supply systems to household water security 158

22 Ways to improve alternative water supply systems in communities 161

LIST OF FIGURES

Figure		Page
1	Conceptual framework of alternative water supply systems and household water security	80
2	Map of Krowor Municipality showing the study town	89
3	Sex of respondents in communities	104
4	Usage and types of alternative water supply systems.	112
5	Usage of alternative water supply systems in communities	113
6	Purpose of using alternative water supply systems	116
7	Alternative water supply systems and their associated uses	117
8	Determinant reason for preferred alternative water supply systems	126
9	Ways to improve alternative water supply systems for household water security	160

LIST OF PLATE

Plate		Page
1	Several Alternative Water Supply Systems	118

LIST OF ABBREVIATIONS

AWSs	Alternative water supply systems
CEHI	Children's environmental health indicators
GLSS	Ghana Living standards Survey
GOG	Government of Ghana
GSS	Ghana Statistical Service
GWCL	Ghana Water Company Limited
GWSC	Ghana Water and Sewerage Corporation
IDI	In-depth Interview
IWA	International Water Association
JMP	Joint Monitoring Programme
MWRWH	Ministry of Water Resources, Works and Housing
NAS	National Academy of Science
NNEPA	Navajo Nation Environmental Protection Agency
RWH	Rainwater Harvesting
SD	Standard Deviation
SDG	Sustainable Development Goals
SSA	Sub-Saharan Africa
SW	Storm Water
TRW	Treated Wastewater
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UN-DESA	United Nation Department of Economic and Social Affairs
UNECA	United Nations Economic Commission for Accra
UNEP	United Nations Environment Programme

UNESCO	United Nations Educational, Scientific and Cultural Organization
UN-WATER	United Nations Water
UN-HABITAT	United Nations Human Settlements Programme
UNICEF	United Nations International Children's Emergency Fund
UN	United Nations
WHO	World Health Organization
WRC	Water Resources Commission
WSSs	Water Supply Systems

CHAPTER ONE

INTRODUCTION

Background to the Study

Water is an essential resource to life which has no alternative rival (UNICEF/WHO,2012). Access to and availability of water supply are essential for sustainable human development (Showkat & Ganaie, 2012). Water supply supports health, well-being, poverty reduction, food security, socio-economic development, and empowerment to varied degrees (Dapaah & Harris, 2017; UNDP, 2017; UNICEF/WHO, 2012). Water is a vital urban service that affects inhabitants' health and economic growth. It is crucial to maintain a balance between water supply and demand, which has been affected by political and environmental conflicts, natural disasters, and daily needs for many purposes (United Nations, 2012). Access to safe water is a fundamental right (UN, 1977). Long-term access to safe drinking water is essential to human health. The 1977 Mar del Plata Conference, one of the earliest global water conferences, called water a "basic need." This philosophy holds that "all people, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and quality equal to their basic needs." (UN, 1977 p. 29).

Proponents of the 1950s and 1970s basic needs approach to development considered drinking water a social good that governments should offer to improve social well-being (Manyire & Asingwire, 1996). This implies that every nation should recognise the right to clean, safe drinking water in adequate quantities to meet basic needs (Gleick, & Palaniappan, 2010; Mehta, Allouche, Nicol, & Walnycki, 2014; Ulman, 2019). The United Nations

General Assembly recognised that clean and safe water, especially for drinking, is a right that must be met before other rights are exercised. The UN Human Rights Council stated at the fifteenth conference that "the water right has its roots in the right to an adequate standard of living, which is inextricably linked to the right to the highest attainable standard of physical, social, religious, and mental health, as well as to the right to life and human dignity" (UN, 2010, p. 64).

Globally, water supply systems and demographics are intertwined (McDonald, Weber, Padowski, Flörke, Schneider, Green & Boucher, 2014). By 2050, more than 65% of the world's population is expected to live in cities. This phenomenon has increased most in the global south (UN-Habitat/UNECA, 2015). This implies that population growth rates and urbanisation, greater water-based industries and rising household water use due to improved living standards will require an increase in the water supply to meet growing demands (World Health Organisation, 2011; Rathnayaka, Malano & Arora, 2016). Water providers encounter challenges in numerous countries as they strive to meet increasing water demand while also mitigating the impacts of climate change. Consequently, there has been a notable rise in the adoption of alternate water supply systems globally (March & Sauri, 2017). Alternative water supply systems may potentially reduce global water resource stress and boost water efficiency (UN-DESA, 2015). Alternative water supply systems could improve and diversify water supplies, reduce stress on current sources, and increase resilience to change and shocks (Bichai, Ryan, Fitzgerald, Williams, Abdelmotef, Brotchie & Komatsu, 2015).

Alternative water supply systems reduce investment, operating and maintenance costs for long-distance water transportation for non-potable usage (Loáiciga, 2015). Agudelo-Vera, Keesman, Mels, and Rijnaarts (2013) claim that non-desalination water supply systems are cheaper and more environmentally friendly. Wilcox, Nasiri, Bell, and Rahaman (2016) argue that sustainable alternative water delivery systems can improve water security in countries with increasing water scarcity due to extraction and insufficient rainfall. For example, by irrigating public parks and green spaces, urban agriculture, backyard gardens, car washing and toilet flushing, which can account for 40–70% of urban water use, alternative water supply systems can meet non-potable urban demand with lower-quality water and reduce strain on fresh water sources (Hardy, Cubillo, Han & Li, 2015). These alternative water supply systems have increased water security such as availability, accessibility, affordability, quantity and to some extent, quality.

Water security is crucial to global water sustainability. Water security is built on ensuring reliable access to sufficient quantities of safe water for every person (at an affordable price when market mechanisms are involved) so they can live a healthy and productive life, including for future generations (Mishra, Kumar, Saraswat, Chakroborty & Gautam, 2021). The concept of water security linked to the "global water crisis" has shifted attention to long-term water management, often supply-led (Grey & Sadoff, 2005). Water security, among others, protects ecosystems and human populations by ensuring the supply and accessibility of safe water for drinking, sanitation and food production (Mukherjee, Sundberg & Schütt, 2020).

The complex world of water security affects food, energy, climate change, economic growth, national security, and human security (Falkernmark, 2013; Whittington, Sadoff & Allaire, 2013). Water security protects water quantity, quality and services for human health and development (Jespson, et al., 2017). Access to water in an adequate quantity and quality for health, livelihoods, ecosystems, and production constitutes water security (OECD, 2016). More also, the security of the water supply is essential for advancing people's health and happiness (Bartram & Cairncross, 2010). Water security is a strategy that is being strengthened to secure a sufficient water supply of appropriate quality to meet the demand of the expanding population (Bichai & Smeets, 2014). Diverse fresh water supply sources that are more resilient to climate change and population growth can ensure future water security (Bichai et al., 2015). Water security encompasses how water affects health, wellbeing, and social, cultural, and ecological concerns beyond access to better water sources (Wutich, Budds, Eichelberger, Geere, Harris, Horney & Young, 2017).

Goal 6 of the Sustainable Development Goals (SDGs) is to provide safe, affordable drinking water for all, including communities in poor countries. Similarly, SDG 6.4 requires sustainable freshwater withdrawals and supplies to address water shortages (UN-Water, 2015). UN-Water (2015) considers a population's ability to sustainably access water supplies of sufficient quantity and quality to support livelihoods, human well-being, and socioeconomic growth. Water is a core human right, a key enabler of sustainable development and economic success, and a necessity for food security, health and sanitary conditions, making SDG 6 essential for the other sustainable development goals (UN-Water, 2015).

These arguments, in theory, are underpinned by the rational choice theory and the capability approach. As explained by the rational choice theory, the choice of an alternative water supply system would increase household benefits (i.e. access to and availability of water) rather than the challenges such as safety, water disparity, water shortages, water stress, and water scarcity (Popa, 2015). The theory assumes goal-directed conduct consistent with rationality standards to explain individual actions and social results (Abraham & Voss, 2004). Within the context of this study, it is expected that given the availability of several options, i.e., alternative water supply systems, people within a given locality will make the best choice for the improvement of their welfare and water security (capabilities).

Studies have shown that alternative water systems like rainwater harvesting, stormwater, wastewater and seawater systems improve urban water security by increasing water yields and water supply resilience in industrialised countries facing climate change (Bichai et al., 2015; Clark, Gonzalez, Dillon, Charles, Cresswell, & Naumann, 2015: Dos Santos & De Farias, 2017; Lee et al., 2016). Alternative water supply systems narrow water supply gaps and increase service and resilience in underdeveloped nations. Identification of alternate water delivery systems in Lilongwe, Malawi, reduced demand on primary water supply systems. Instances like non-potable water use, alternative water supply systems lessen the water deficit, with stormwater supply exhibiting a surplus during the wet season (Jussah, 2017). In Africa, alternative water supply systems could potentially decrease water supply deficits. This enables households to prefer using alternative water supply systems (i.e rainwater) for domestic purposes as compared to stormwater and wastewater (Yahaya, 2019).

Jussah, Orabi, Sušnik, Bichai, and Zevenbergen (2020) agree that alternative water supply systems have been shown to contribute to supply augmentation and diversification by improving system resilience and service. Sušnik et al.; (2021) opine that alternative water supply systems provide chances to contribute to water supply to meet non-potable urban demand and solve water supply-demand gaps for household users. In Accra, Ghana, alternative water supply systems, such as rainwater, greywater, private informal water vendors, and sachet water, have helped informal water supply agencies close the water supply gap (Stoler, Tutu & Winslow, 2015; Ablo & Yekple, 2017; Briamah, Obeng-Nti & Owusu-Amponsah, 2018).

In the context of Ghana, Braimah, Obeng-Nti, and Owusu-Amponsah (2017) opine that alternative water supply options, particularly those provided by informal vendors, are critical to meeting the water needs of the urban poor. Alternative water supply systems have allowed households to diversify their water supply, which provides a buffer against unreliable infrastructure, especially in areas where infrastructure is lacking. A study carried out in five regions of Ghana found that more than half of households collect water from improved sources, even though they resort to many sources (e.g., boreholes and wells, standpipes) to meet their household water needs (Guzman, Brown & Khatiwada, 2016). Adonadaga (2019) concurs that the observed deficit over the period 2008-2018 was fulfilled due to the availability of alternative water supply systems. Aligning with global relevance, Gariba and Amikuzuno

(2019) opine that alternative water supply systems play a critical role in improving people's livelihoods and food security, particularly in Ghana. More so, alternative water supply systems, such as reselling water to customers, are, on the other hand, important economic activities for vendors (Nyamekye, Yarney & Oppong-Mensah, 2016). As a result, there is a need to close urban water supply with alternative water supply systems, particularly for water uses; and to improve resilience to water shocks, changes, and shortages (Bichai et al., 2015).

Statement of the Problem

Urban water supply has two main challenges. First, insufficient water availability contributes to unmet demand, and second, wealthier areas have reliable water systems, while poor urban people have limited access (Sulemana, 2019). The Joint Monitoring Programme (JMP) report found that about 844 million people, mostly in Sub-Saharan Africa (SSA), lack access to safe drinking water (WHO & UNICEF, 2015; JMP, 2018). Furthermore, urbanisation and population growth in Sub-Saharan Africa, including Ghana, also affect water demand. The need for and availability of this water supply are imbalanced, as the organisations (GWCL) responsible for providing this service have reached their maximum capacity (Brandful, Erdiaw-Kwasie & Amoateng, 2015; Gronwall, 2016).

Ghana Water Company Limited (GWCL) water extraction has put pressure on the Weija and Kpong water reservoirs to accommodate urbanisation, agriculture, industry, tourism, infrastructure developments, and domestic water demand of about 2.6 million Accra residents (GSS, 2021). Though GWCL has covered 77% of urban water supply, including household users, public standpipes and business consumers in most metropolitan regions, most municipal areas are unserved while water is rationed due to high demand and low supply (Opare, 2018; Ghana Water Company Limited, 2019). According to Ghana Water Company Limited, the water demand was 1,131,818.18m^3 (294 million gallons per day), but only 871,496m^3 (192 million gallons per day) were generated and supplied (GWCL, 2019). As a result of that, informal water suppliers such as water vendors and predominantly water tanker service delivery are used in unserved areas (MWRWH, 2014).

Conventional water supply systems have failed to meet expanding demands for water for socio-economic development, leaving Accra households, notably in Krowor Municipality, without enough access to water. Again, illegal mining and other human related activities have polluted surface water bodies, reducing their quantity and quality (Sarpong, 2013; Amankwaa, Owusu & Eshun, 2014; Owusu, Asumadu-Sarkodie & Ameyo, 2016). Water supply is limited due to pipe bursts, low treatment plant production and expensive maintenance expenses, among other problems (Twerefou et al., 2015; Oteng-Ababio, Smout & Yankson, 2017). Due to these issues, only a few households have tap connections. Public and commercial water companies often believe that installing taps in poor urban dwellings is a waste of money because the fees may not be recovered (Bakker et al., 2008).

Nungua in the Krowor Municipality in the Greater Accra Region of Ghana has everyday water demand that has been unmet by GWCL (Asenso-Boadi &Vondolia, 2013; Citifmonline.com, 2017; Adomfmonline.com, 2020). This may not be practicable if GWCL's conventional water supply is inadequate, restricted, inconsistent, or rationed. It is important to diversify potable and non-potable water delivery systems with stronger alternative or unconventional water supply systems (Loaiciga, 2015). The erratic, intermittent, and disparity in water supply in Krowor Municipality has forced households to use alternative water supply systems (i.e., rainwater collection, private water vendors, wells, sachet water, tankers, reservoirs, and storing water) and travel long distances to access water, which has socio-economic consequences (Sarpong, 2013; Stoler et al. 2015).

Empirical studies on alternative water supply systems in the literature have focused on the contributions of centralised alternative water supply systems such as rainwater harvesting, stormwater, wastewater treatment, and desalinated water at the macro level (Jussah, 2017; Bichai, Kajenthira & Murthy, 2018; Abubakar, 2018). Yet, there is paucity of literature on alternative water supply systems and household water security from a Ghanaian perspective.

Research Objectives

The purpose of this study is to examine alternative water supply systems and household water security in the Krowor Municipality.

Specifically, the study aims to;

1. establish the water sources of alternative water supply systems in pursuit of household water security in the Krowor Municipality.
2. ascertain households preferred alternative water supply systems for household water security in the Krowor Municipality.
3. examine alternative water supply systems in pursuit of household water security in the Krowor Municipality.

4. make recommendations for improving alternative water supply systems for household water security in the Krowor Municipality.

Research Questions

To achieve the objectives stipulated in the study, the following research questions were asked;

1. Where do the water sources of alternative water supply systems in pursuit of household water security in the Krowor Municipality come from?
2. Why do households prefer alternative water supply systems for their household water security in the Krowor Municipality?
3. How do alternative water supply systems affect household water security in the Krowor Municipality?
4. Which strategies should be put in place to improve alternative water supply systems for household water security in the Krowor Municipality?

Significance of the Study

This research examines alternative water supply systems and household water security in Krowor Municipality, Ghana. The outcome will help contribute to domestic water supply policies in the Krowor municipality. Again, the study's findings will provide valuable information regarding the significance of alternative water supply systems for household water security. The study would be valuable since it will contribute to the debate on the extent to which alternative water supply systems fill the urban water supply gap in Ghana's water sector. The research will also act as a point of reference for future researchers and will expand the theoretical, conceptual, methodological, and empirical framework it establishes.

Delimitation of the Study

The supply of water to households constitutes several factors, such as physical, social. and economic situations and available water institutions, to mention just a few. The study is confined to water from tankers, reservoirs, wells and rainwater harvesting as alternative water supply systems for household water security within the Krowor Municipality. The municipality is desired for the study because it constitutes a hot spot in the supply of water from water tankers, water storage tanks, rainwater harvesting, borehole and reservoirs to households. The study will be limited to these alternative water supply systems and household water security in the Krowor Municipality. The study will focus on a variety of issues in alternative water supply systems, but the outcome of the study will be narrowed to household water security issues.

Operational Definitions of Terms

The operational definitions generated from a thorough review of the literature will be used in the study.

Water sources: refer to water from the surface (streams, sea and rivers), ground, and rain-fed for household domestic water uses.

Water supply: refers to sources, bulk storage reservoirs, water treatment/filters, service storage reservoirs, and piped distribution to consumers or end users.

Alternative water supply systems: water supply systems that augment conventional water supply systems to reduce water scarcity, water shortage, stress and vulnerabilities, close the water supply disparity and reduce household water insecurity.

Water security: water in quantity, quality, accessible, available, affordable, and safe for household domestic water use.

Household water security: reduction in water insecurity, due to availability, accessibility, quality, quantity, affordability, safety, time spent in water collection and seasonal variations of water to enhance household wellbeing.

Organisation of the Study

The study is categorised into five chapters. The first chapter captures the study's introduction, problem statement, objectives and research questions. In addition, the first chapter shall outline the thesis's structure, define key terms and explain the study's significance. Chapter two focuses on conceptual reviews, theoretical underpinnings of the study and empirical reviews underscoring alternative water supply systems and household water security. A conceptual framework is presented to conclude the chapter.

Chapter three deals with the research methodology. These include the research paradigm, research design and study area. Further, the chapter constitutes a discussion of the target populations, the sampling procedures, the data sources, the instruments for data collection, the fieldwork, data processing, and analysis coupled with an ethical consideration of the study. Chapter four presents the results and discussion of the study. Chapter Five presents the summary, conclusions, and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter discusses the related literature on alternative water supply systems and household water security. This chapter of the study reviews literature based on the objectives, theoretical framework, conceptual reviews and empirical evidence that led to the research. The theoretical framework that underpins the study comes first, followed by conceptual reviews of alternative water supply systems and household water security. Second, the study highlights the theories' relevance and the review's contributions to urban water supply and household water security.

Theoretical Framework

The study adopts the theoretical underpinnings of rational choice theory and the capabilities approach to alternative water supply systems and household water security.

Rational Choice Theory

The rational choice theory, commonly referred to as the rational action theory or choice theory, is a theory that is frequently used to describe and understand individual and socioeconomic behaviour. It is the primary paradigm within the currently dominant microeconomics school of thinking. It is also fundamental to contemporary political science, as well as other disciplines such as philosophy and sociology. (McCarthy & Chaudhary, 2014). Gary Becker, a 1992 Nobel Memorial Prize laureate in Economics Science, was one of the first to use rational actor models more broadly and is credited with popularising the rational choice theory in the early 20th century (Becker, 1976). Elster (1989) argued that the essence of rational choice theory is that people typically choose the one they think would result in the best overall outcome when faced with multiple options.

The Rational Choice Theory argues that individual actions and their social outcomes can be explained by assuming goal-directed behaviour, which is consistent with certain rationality criteria (Abraham, 2004). Numerous scholars have discussed the irony of rational choice theory, pointing out that its premises are based on an unrealized idea or a facade (Ingram, 2016; Williams, 2018). This choice, as we typically define it, is not genuinely made voluntarily. Human decisions are influenced by the options that are accessible to them or by the information that are readily available for them to access. Scientists from a variety of disciplines have used the Rational Choice Theory, including those in the physical sciences, psychology, political science, economics, and adjudication (Oppenheimer, 2012; Ingram, 2016; Williams, 2018). The rational choice theory emerged as the standard method of behaviour analysis in the early 21st century (Oppenheimer, 2012; Williams, 2018). Rational choice theory has been at the foundation of the development of three largely separate fields: game theory, social choice theory, and decision theory. As evidence from experimental attempts to support its premises has been analysed, modifying its traditional structure, the rational choice theory's position has altered. These tests exposed fundamental problems with their underlying hypotheses, which require fundamental adjustments to the theory's core assumptions (Oppenheimer, 2012).

In simple words, the rational choice theory emboldens three aspects: thus, it is a codified logical structure that underpins a lot of political science and economics thinking, as well as a normative and empirical account of individual behaviour (Fu, 2021). It essentially establishes a link between preferences and decisions, highlighting behaviour that has a teleological or deliberate objective. Although not all rational choice theories have all three of these elements, they all support the idea that we should and do act in ways that are compatible with our values. As a result, preferences serve as a seemingly easy explanation for choice, with explanatory as well as normative assumptions and consequences (Hirschi, 2017). Although the history of rational choice theory is rather hazy, its roots may be found in the age of reason. In Thomas Hobbes' Leviathan, it was assured of its central philosophical place (Hobbes, 1961). Hobbes attempted to use people's decisions to explain how political institutions work at their most fundamental level (Schreck et al., 2020).

Assumptions of Rational Choice Theory

The psychological and individualistic nature of rational choice theory is noted by both supporters and detractors (Krsti & Pavlovi, 2020). It has some basic assumptions on which it is built: it is individualistic since it applies to the behaviour of people, as well as psychological because it begins by explaining the actors' behaviours in terms of their mental states. Only aggregates made up of individual individuals are considered to be social groupings and institutions (Krsti & Pavlovi, 2020). Also, instead of beginning with social groups or classes, rational choice theory begins with mutually independent individuals who create spending budgets that maximise their utility and available resources. This liberal system is built on egocentric actions of economic individuals with the outcomes of such actions being determined by competition (Oppenheimer, 2012). Most assessments of rational decision-making are from a methodological perspective, predominantly based on methodological individualism. In general, individual behaviours can best describe societal movements (Krsti & Pavlovi, 2020).

The main premises of rational choice theory are summarised below, with special emphasis on those that are critical to microeconomic, sociological and political analysis (Krsti & Pavlovi, 2020).

Maximisation of expected utility

The first assumption is based on the ideology that a rational person will select the option (alternative) that, in their estimation, has the highest (or maximum) predicted utility of all the actions they believe are practicable (Gordon, 2014).

Consequentialism

Any evaluation of the action (alternative) that is crucial to a person's decision-making may be reduced to an evaluation of the action's potential outcomes. The appraisal of the action result is entirely based on the following factors: (1) any potential outcomes that the individual anticipates; (2) the likelihood that they assign to these outcomes; and (3) how the individual evaluates the outcomes of the activity (Kroneberg & Kalter, 2012).

Conditions of rationality

It is often argued that people can make judgments regardless of the issue at hand, starting from the most fundamental concept that humans are free. The issue of whether it is possible to provide a straightforward logical framework within which such an understood option may be communicated arises because the choice is being understood in this context in a highly abstract manner (Kroneberg & Kalter, 2012; Gordon, 2014). In terms of philosophy, such a recognised logical structure within which the decision is made could be seen as instrumental rationality. For someone's goal to be meaningful, we must consider not what they should choose but rather what we should do in response. The axioms of preference in rational choice theory most typically define this framework (Gordon, 2014).

Application of Rational Choice Theory to the study

Taking into consideration the variables at play in the present study, the rational choice theory (RCT) may be modified or customised to suit the needs of the study. In the sense that the consequences of choosing between alternatives have encouraged people to create theories about making rational decisions, given the presently available options (Krsti & Pavlovi, 2020). The rational choice theory is essentially a simple action theory that describes how "aspects" of a social environment might impact people's decisions and behaviour. As a normative theory, it specifies the actions we should take to achieve our goals as completely as possible. It is critical to notice that this theory does not indicate the specific goals we should pursue. In contrast to moral theories, rational choice theory gives conditional imperatives based on the available means (Popa, 2015; Krsti & Pavlovi, 2020). Within the context of this study, it is expected that given the availability of several options (i.e., alternative water supply systems), people within a given locality will make the best choice for the improvement of their welfare. At the same time, challenges are inevitable; hence, there is a juxtaposition of the available options, present challenges and maximum benefits, all informing logical decisions (Popa, 2015; Krsti & Pavlovi, 2020).

Furthermore, the application of the theory to the study offers valuable insights into decision-making processes related to water supply systems. Rational choice theory, rooted in economics, posits that individuals and organisations make decisions by weighing the cost and benefits of available options to maximise their utility. When applied to alternative water supply systems, it helps us understand the decision-making processes behind choosing alternative water supply systems. Households evaluate these water supply systems by considering factors like capital cost, operating expenses, and the expected benefits, including improved water quality, safety, and reliability. They assess whether these water supply systems will ensure their benefits, taking into account the economic, environmental, and social conditions.

The rational choice theory encourages households to examine the incentives (benefits) and constraints (challenges) that influence their preference for alternative water supply systems. For instance, the government inability to supply reliable water to households, coupled with financial constraints for pipe connections or in-built water infrastructure, can play a significant role in shaping the decision-making of households to opt for alternative water supply systems for their household water security. When decision-makers perceive that choosing alternative water supply systems aligns with their utility-maximising goals while minimising their cost (access to water), they are more likely to invest in these water supply systems.

Rational choice theory emphasises the importance of information and awareness in decision-making. In the context of alternative water supply systems, households need access to accurate and comprehensive information about the technical feasibility (water supply system infrastructure), cost-effectiveness, and potential risks or challenges associated with water supply systems. Decision-makers (households) can make more rational choices when they have the necessary information to evaluate different alternatives accurately. In summary, applying rational choice theory to alternative water supply systems enables the researcher to analyse the decisions made by households about choosing alternative water supply systems for their household water security. By considering the costs, benefits, awareness and information available to the decision-makers (households), this theory provides an imperative perspective on how rational decision-making processes shape the sustainable demand for water resources and the pursuit of utility-maximising goals in the context of water supply.

Notwithstanding its applicability and merits, the rational choice theory has come under heavy criticism. The fact that the theory based on the presence of rational actors who maximise their utility is unable to explain some of the significant features of human behaviour is perhaps the most serious objection (Popa, 2015). There have been significant discussions over the idea that everything about human behaviour can be described using a single premise, which is at odds with most of what we know and observe about people (Kals & Müller, 2012; Krstić, 2022). Indeed, people frequently act logically. However, there is no factual support for the assertion that people always act in a fully logical or optimal manner (Krsti & Pavlovi, 2020).

It is also important to be aware of a few additional fundamental criticisms of rational choice theory. The four most typical of them are: 1) It is postdictive, not predictive; that is, we can only identify the causes and forces of an action after it has occurred; when misused, its logical framework can appear strikingly similar to a tautology; 2) It assumes that people only seek to maximise material possessions or financial gain; 3) It concentrates on individual action and leaves unclear the causes or forces that give rise to macro structures and processes; and 4) It assumes a type of pure logic that is not typical in actual life, where we confront confusion, decisions that change due to inconsequential diversions or whims, deeds that go against common sense, and so on (Kals & Müller, 2012; Krstić, 2022). The weakness of the theory is strengthened by the capability approach akin to household water security.

Capabilities Approach

The capability approach by Sen (1999) is a normative framework for assessing how well-being and social arrangements contribute to or detract from human flourishing and freedom, with roots in welfare economics and political philosophy. This approach describes a person's well-being in terms of beings and doings (functionings), as well as his or her ability to choose between them. That is, in terms of people's abilities to function, well-being is linked to justice: a just social arrangement supports individuals' "effective opportunities to undertake actions and activities that they want to engage in and be who they want to be" (Robyens, 2005, p. 95).

People's various ideas of the good life, as well as their capacity to achieve it, are respected in the capability approach. The tenets of the capability approach are functioning, capability and agency. A healthy body, safety, education, a good job and the ability to visit loved ones are examples of valuable activities and states that contribute to people's well-being. Although they are tied to products and income, functioning explains what a person can do or be as a result of them. When a person's basic demand for food or water (a commodity) is met, they enjoy the benefits of being well-nourished. Capabilities are ‘the alternative combinations of functioning that are feasible for a person to achieve’. Put differently, capabilities are ‘the substantive freedoms he or she enjoys to lead the kind of life he or she has reason to value’ (Sen, 1999, p. 87). Whereas, the ability of a person to pursue and achieve goals that he or she values and has reason to value is referred to as agency.

An agent is ‘someone who acts and brings about change’ (Sen, 1999, p.19). However, the capability approach was limited to individual goals and aspirations and ignored the social circumstances, structures and psychological processes that could necessitate the functioning’s capability and values of the individual(s). Jepson et al. (2017) explicitly linked water security to economist Amartya Sen’s capabilities theory, in which access to adequate water is inextricably linked to “the functioning necessary for basic human existence” (p. 109). According to their statement, society cannot progress in its functioning if people do not have access to sufficient, clean, and safe water and sanitation. This is because people's daily lives and relationships are harmed by water scarcity or stress, which prevents them from fully participating in water-related decision-making.

The capabilities approach addresses the link between water and well-being (Mehta, 2014). She makes a forceful case that the ‘‘right to water” (H2O) in its reproductive (e.g., health, bodily requirements, etc.) and productive dimensions (subsistence, maintaining livelihoods, etc.) are necessary foundations to "allow people to enjoy a host of capabilities" (Mehta, 2014, p. 66). Thus, Mehta concludes that governments, therefore, need to prioritise providing poor people with safe and affordable water which allows the poor to flourish (Mehta, 2014, p.47). In brief, the capability approach respects people's different ideas of the good life, and this is why capability is the political goal, rather than any particular outcome.

In this way, capabilities are foregrounded as the basis for individuals to make claims on society, connected to equity, recognition, participation, and democratic rights. Moreover, the capabilities approach extends beyond the individual to communities (Ibrahim, 2006; Stewart, 2006; Schlosberg & Carruthers, 2010).

Application of Capabilities Approach to the study

The application of the capability approach to household water security would provide the researcher with a broader understanding of how access to these alternative water supply systems can ensure household water security in the study area. This approach emphasises the importance of focusing on individuals' capabilities and opportunities to lead a life they value. In the context of household water security, this means going beyond the mere provision of water and looking at how access to water empowers individuals and households to lead a dignified and fulfilling life.

The capability approach directs attention to the quality and quantity of water accessible to households. It considers not only whether people have access to safe drinking water but also how that access enables them to achieve their life goals. For instance, having reliable access to safe water can enhance a person's capability to maintain good health, pursue education and engage in economic activities. Conversely, inadequate access to water can limit these capabilities, which leads to a cycle of poverty and inequality. The study will add to the knowledge gained from data collected in the Ghanaian context on the relationship between the capability approach and household water security.

The capability approach underscores the significance of participatory decision-making in addressing water security. It emphasises that individuals and communities should have a say in the management and distribution of water resources. This approach encourages policies and interventions that empower communities (households) to make key choices about water allocation based on their unique needs and aspirations, thus ensuring that household water security strategies are contextually relevant and sustainable. Moreover, the capabilities approach calls for a holistic perspective on water (household) security that considers the interconnections between water, health, education, gender equality and other dimensions of well-being. By adopting this approach, policymakers and organisations can develop comprehensive strategies that not only provide access to water for households, but also enhance people's capabilities to use it effectively, promoting a more equitable and dignified life for all. To wit, the capabilities approach provides a powerful lens through which to analyse and address household water security, emphasising the importance of enabling individuals and communities to live lives they have reason to value.

Relevance of the theories to the Study

These theories provide a pathway for understanding household maximisation of options for alternative water supply systems in the absence of unreliable water from conventional supply systems (GWCL) as well as the intricacies of these water supply systems. Their relevance cannot be overestimated, as they help develop innovative ways of supplying water from a system to enhance household water security. The theories are relevant to the study because their underlying assumptions signal how households would react when there is a limited and erratic supply of water to boost their socio-economic and wellbeing, as well as the long-run effect on water security. Hence, relying on alternative water supply systems would rationalise household water utility, identify various preferences to enhance their water security and livelihoods despite the challenges that will come with it.

The theories also create a better picture of water security and its implication on wellbeing and development since the people affected in reality, are part of the urban water security situation. Amidst the challenges of alternative water supply systems in pursuit of household water security, the theories underscore the benefits (maximisation), preferences, and access these alternative water supply systems bring to households for their water security as well as their capabilities (wellbeing and welfare).

Conceptual Review

Water Security

Understanding water security is multidimensional in nature, partly due to diversified views and attempts to integrate several conceptual indicators such as meeting human needs while sustaining ecosystem functions or describing human vulnerability to hazards (Cook & Bakker, 2012). Although many people view water security as a societal problem, the definition that is chosen will determine how the concept is operationalized and what it means for things like health, livelihoods and ecosystem production (Garrick & Hall, 2015).

Depending on the scale of measurement, the idea of water security includes several aspects, including quality, quantity, affordability and availability, that are used to fully define the situation of each community or household (Wutich et al., 2017). It has gained attention as a result of several biophysical and social factors that pose a serious threat to it, including inadequate rainfall, scarce water supplies, lack of physical water infrastructure, the slow implementation of social policies, and unchecked population growth. These factors call for international dialogue and research to develop a thorough understanding of this multi-level concept (United Nations, 2015).

Water security evolves from ensuring reliable access to enough safe water (for every person at an affordable price where market mechanisms are involved) to leading a healthy and productive life, including that of future generations (Mishra, Kumar, Saraswat, Chakraborty & Gautam, 2021). Moreover, water security was defined as access to water, its usage and sanitation that is available, affordable, safe and clean (Gerlak & Wilder, 2012). More so, Mason (2014) gave another dimension of water security, namely, water accessibility by all people, at any given time, to adequate water for an active and healthy lifestyle, such as water for basic and non-basic needs, recognises diverse dimensions of water quantity, quality and accessibility. The United Nations defines water security as "the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters and for preserving ecosystems in a climate of peace and political stability" (UN-water, 2013 p. 38).

An often-used definition of water security is where water is available in an acceptable quantity and quality for health, production, livelihoods, ecosystems and production, as well as with an acceptable level of water-related risks to people, environments and economies (Grey & Sadoff, 2007). Grey and Sadoff (2007) included water stress and risks in their definition of water security because water abstraction and pollution characterise current economic development. Economic growth can help to ensure water security, but it may not always include conservation practices that can sustain or enhance ecosystem services (Foster & McDonald, 2014). Consequently, water security is a tolerable water-related risk to society. The meaning of society differs for different people, which may lead to the privileging of some interests over others (Hope, 2012).

Calow, Ludi, and Tucker (2013) also tease out a working definition for water security as an adequate quantity and quality of water that is available with the capacity to access health, livelihoods, ecosystems and production, together with how the level of water-related risks is acceptable to people and environments and the will to manage those risks. Along these lines, Jepson et al. (2017) connected economist Amartya Sen's capabilities theory to water security, in which access to adequate water is inextricably linked to "the functioning necessary for basic human existence" (p. 109). They said that society cannot move forward if people do not have access to enough safe water and sanitation.

Water security is essential to maintaining both environmental and human health by ensuring that safe water is available and used for drinking, washing and food production (Mukherjee et al., 2020). This study focuses on water security from a human development perspective, despite the integrated definition of water security being useful in unifying and managing the trade-offs among the different water use sectors. For this study, the definition of water security by Calow et al. (2013) is adopted, which is “adequate quantity and quality of water which is available with the capacity to access for health, livelihoods, ecosystems, and production; together with how the level of water-related risks is acceptable to people and environments, and the will to manage those risks” (Calow et al., 2013). This definition was chosen because it best describes the idea in the context of the level of the research study by bringing it down to the most basic level that people can understand. The fact that this definition is broad in many ways also makes it easy to keep talking about the theoretical foundations of water security and gives enough reason to look at how the alternative water supply system affects water security in the household.

The terms "water security," and "water shortage", "water stress," and "water scarcity" which are all closely related concepts, are sometimes used interchangeably, leading to misunderstandings. To avoid ambiguously using these terms, researchers have over time clearly defined these associated ideas. This has made it easier to understand and distinguish between these terms in this study. A temporary water imbalance, such as too much use of both ground and surface water or a drop in water quality, is what is meant by the term "water shortage." This is often caused by the way land is used or by using more water than the environment can normally handle (Pereira et al., 2002). So, the term "water shortage" refers to a situation in which there is no water at all. This happens when the water supply drops so low that it is impossible to meet even the most basic needs (Pereira et al., 2002). This situation is brought on by several elements, including climate change, altered weather patterns like droughts or floods, high pollution levels, increased human demand, and above-average water use.

Water stress, on the other hand, refers to signs or proof of the direct existence and effects of either water scarcity or shortage (Pereira et al., 2002). This happens when the amount of water available is not enough to meet the current demand or when the quality of the water gets worse, making it less useful (European Environment Agency, 2018). It is often used to mean drought. "Water scarcity" which is often used as a synonym for "water security" basically means a lack of or limited access to enough water for human use and the survival of the ecosystem (Chris, 2012). On the other hand, water scarcity can also be seen as an imbalance between demand and supply within the current institutional arrangements and/or tariffs. This is shown by high consumption rates, excessive demand, and a lack of water resources (UN-Water, 2018). The primary factor leading to water scarcity in urban areas and water insecurity is rapid population growth. This places a significant strain on nearby water supplies and is made worse by the growing effects of climate change and bio-energy needs. This concept just touches on accessibility, which is one aspect of water security.

Even though these ideas are similar and are sometimes used interchangeably with the term "water security," they do not fully describe the concept because they only talk about one part of water security. However, these concepts could be very helpful in figuring out what causes people to not have enough water. So, it is important to tell the difference when choosing a topic for this study. From what we have seen so far, it is clear that there is no one definition of "water security". Instead, scholars have often defined it in terms of their areas of expertise, like human rights, agriculture or economic development. Other literature defines water security in different ways, depending on how it is used, from a global to a household level (Howard, 2017).

Dimensions of Water Security

Several studies have recognised and examined various aspects of water security (Siwar & Ahmed, 2014). While Global Water Partnerships (2012) identifies the three factors that affect water security: economic, environmental and social factors, it was expanded to encompass five major categories of national water security, with a measuring emphasis on preserving lives and livelihoods, eradicating poverty and improving governance (Asian Water Development Outlook, 2013). Several studies have also emphasised various aspects of water security to provide further context. The three components of water security that were deemed crucial for a person to live a healthy, clean and productive life while guaranteeing environmental sustainability are water availability, water safety and water affordability (Bizikova et al., 2013; Global Water Partnerships, 2000). Given the different dimensions of national water security presented above, the study, therefore, focuses on examining alternative water supply systems to household water security.

The subsequent paragraphs will discuss the concept used for the study.

Household Water Security

Household water security, in contrast to food security, is a developing concept in the literature on water demand management for both developed and developing countries. The growing study on household water security is important to understand the needs of the urban poor people which may not be covered by water security evaluations at the national or sub-national level because of how data is collected (Zeitoun et al., 2016). At the household level, water security means having adequate, safe, accessible and inexpensive water to promote health and well-being (Jepson et al., 2017). Water insecurity is a result of threats to these water security dimensions.

Access to better drinking water sources like piped water, public taps or standpipes, tube wells or boreholes, protected wells or springs or rainwater collection is the most common way to define domestic or household water security (UNESCO, 2006; Asian Development Bank, 2013). The scope of this study is the household, and it looks into how different types of water supply systems impact household water security. The study adopts a definition of water security derived from Jepson (2014, p. 109): "One can identify three dimensions of household water security by:

1. water access: the capacity to access water for consumptive purposes, including physical access, affordability and reliability
2. Water quality acceptability: the broad range of biophysical characteristics of water quality (taste, colour, smell, biochemical, etc.) that influence water usage and health/well-being.
3. Water effect: the emotional, cultural, and subjective experiences of water."

In contrast to the conventional perspective employed by policymakers and practitioners, this concept of household water security goes beyond viewing water as only a "technical" issue (Lahiri-Dutt, 2015). For instance, monitoring the Water Sanitation and Hygiene (WASH) sector's progress and SDG objectives 6.1 and 6.2 by the WHO/UNICEF Joint Monitoring Programme is now concentrated on access to infrastructure, such as the provision of clean drinking water and sanitary facilities. This material offers a simplistic picture of home water security, ignoring the significance of social, cultural and ecological factors (Gimelli, Bos & Rogers, 2018; Wutich et al., 2017). Household water security broadens the notion of wellbeing to encompass aspects like health and livelihoods, moving away from a narrow focus on WASH services for public health outcomes (Gimelli et al., 2018).

Trevett (2003) defined household water security as the uninterrupted availability of potable water for domestic use. Moreover, Ariyabandu (2001) defined household water security simply as the ratio of water supply to water demand. If the water demands are higher than the water supply, then there would be a water deficit, while the opposite situation would be water surplus, in which it could be theoretically assumed that household water security is satisfied. He offered the holistic definition of household water security as the timely, reliable and easy accessibility of sufficient safe water to meet basic human needs. Other literature expands the definition to include the health benefit, thus, defining household water security as safeguarding a household water supply of adequate quality and quantity to sustain the health of the household members (Chenoweth et al., 2013).

In general, these definitions show the complexity of household water security. Assefa et al. (2019) defined domestic water security, which is similar to that of household water security, as the capability of a population to ensure sustainable access to sufficient quantities of and tolerable quality water for basic household essentials such as drinking, sanitation and hygiene. Hence, for this study, household and domestic water security are considered to be the same concept. The global Water Partnership (2014) asserts that household water security is an important part of water security, which looks at the availability and use of water for a healthy home life that improves personal, family, livelihood and human health.

Jepson (2014) argues that the household water security approach captures both the objective and subjective experiences of water security. Good deficits in any of these three dimensions contribute to water insecurity as they impact human wellbeing. The study's definition of household water security draws from the first dimension of Jepson's household water security, namely, water access: the capacity to access water for consumptive purposes, including physical access, affordability and reliability. In a study done in the Bolivian city of Cochabamba, researchers found that the city's insufficient and unreliable water supply system made people worried, which made water insecurity in some parts of the city even worse. Those who lived in the informal settlements on the southern edge of the city felt this effect even more. This had even more serious consequences (Wutich & Jepson, 2019). Large populations may experience water insecurity since many developing nations may struggle to maintain adequate water supplies required for human fundamental needs at the household level as well as for national economic and social progress (Boretti & Rosa, 2019).

Although it is anticipated that measures to increase household water security will benefit inhabitants equally, there have been several instances when divergent and uneven effects have been recorded in places where access to services has improved. This may be the consequence of a variety of social, economic, or institutional hurdles, such as the fact that impoverished households are nevertheless forced to use services that are of poor quality and convenient (Cole et al., 2017; Nicol, Metha & Arulingam, 2018; Carrard et al., 2019). Aleixo et al. (2019) indicate that some households kept consuming water from filthy sources following a piped rural water supply intervention in North-East Brazil because they disliked chlorinated water and preferred already-existing sources, such as public taps and rainwater reservoirs.

The predictions of how much water will be available in the future to meet the growing needs of cities for growing crops to feed the world's growing population and for drinking and non-drinking uses in cities around the world are in danger. Future water security can only be achieved if many different sources of freshwater are more resilient to climate change and population growth (Bichai et al., 2015). To reduce risk and maximise advantages for economic players in towns and cities, water is considered a resource that must be captured, regulated, distributed and drained (Hoeskstra et al., 2018). Majuru et al. (2016) did a systematic review and found a wide range of ways to deal with the problem. These included building storage tanks, storing water in buckets and bottles, drilling wells, installing hand pumps, and buying water. This systematic review showed how to deal with water insecurity, but it focused on the reliability of existing water supply infrastructure (piped connections), which is only one part of water insecurity.

To generate a consistent understanding of the term, as it is used frequently in this study, it is crucial to define a household as a unit of study. The basic definition of the household was adopted from GSS (2021, p. 24), which defines a household as a unit consisting of “a person or a group of two or more persons (related or unrelated) who live together, share housekeeping arrangements (eating and sleeping), and recognise one person as the head.”

Global Water Security

It is impossible to overstate the value of water as a resource for enhancing a nation's growth and its citizens' social well-being. Because of this, the type and quantity of water provided to a community play a critical role in defining its degree of growth, standard of life and health (Falkenmark et al, 1990). The inclusion of water supply, sanitation and hygiene among the Sustainable Development Goals shows that the United Nations has acknowledged water quality and availability in communities as a tool for development. The Ghana Water Company Limited (GWCL) established in 1999 by the Ghana Water and Sewerage Corporation (GWSC), is in charge of providing potable water for urban use. To fulfil its duties to numerous metropolitan populations, GWCL has encountered challenges. Feachem et al. (1978) noted that several factors, including a lack of funding for capital projects, improper political influence, poor management, subpar designs, a lack of skilled personnel, a lack of appropriate technology and poor logistics, may contribute to these challenges in developing nations.

One of the Sustainable Development Goals is to reduce the number of people without access to drinkable water by half by the year 2015 in acknowledgment of the need for increased access to water supplies in developing countries (United Nations, 2016; Carter & Danert, 2003; Malley et al., 2009). Since the start of the global campaign to reach the Millennium Development Goals, about 1.6 billion more people have had access to safe water. But statistics about how much of the world's population has access to "improved water sources" are disputed because the criteria for what is considered an "improved water source" are not clear. But the United Nations says that a big part of the world's population still needs safe drinking water very badly (United Nations, 2015).

Many methods, such as the development of wells and boreholes, the use of tankers and reservoirs, and the extension of urban water delivery infrastructure, have been used to enhance access to potable water supply in developing nations. Utilising alternative water sources in addition to established or dominant ones is another tactic (Opare, 2012). Rainwater harvesting (RWH), which has been used in places where traditional water supply systems have not been enough to meet people's needs, is being pushed as a way to deal with the lack of water in some cities in the developing world (Mati et al., 2006). Taking into account the factors that affect the use of alternative water sources, up to 70% of urban water use does not require drinking-quality water (Agudelo-Vera et al., 2013).

These applications offer AWSs the chance to contribute to the security of the water supply by supplying additional water that can be utilised for non-potable purposes in addition to drinking-quality water. Population centres have always been connected to extensive water supply networks throughout history (Baumann et al., 1998). Water is an essential resource for business, agriculture, and daily living in modern countries. Water delivery to residences in urbanised regions is mostly dependent on water distribution networks. Ghana has a high rate of rural-urban migration, which has led to a sharp increase in the sizes and populations of major cities and increased pressure on water supplies. Unfortunately, the growth and extension of the distribution systems have not kept up with the increase in demand, leaving many areas with severe water shortages (Ahiablame, 2012).

A nation's infrastructure directly influences its development and level of modernity. Some of the most crucial infrastructures are often those set up for wastewater treatment, urban drainage and water supply (Cabrera & Espert, 1992). In developed nations, the majority of design work done on distribution systems includes increasing supplies to specific locations, renovating existing networks and adding new sub-networks to service smaller new housing and industrial areas. However, in developing nations, the current supplies are occasionally insufficient, necessitating the building of whole new systems (Walters & Cembrowicz, 1992). This is a situation that applies to Ghana as well. There has not been any significant expansion to new locations in the areas served by the distribution system during the planning of the cities. This is the primary reason for the severe water shortages at newly developed residential and commercial locations in the metropolitan regions, which has led to a water crisis and forced these communities to rely on alternative sources of water supply.

Water Supply Systems

Water supply has long been regarded as a service that is necessary for every settlement, especially in urban areas, to survive. Water supply is typically based on a city's geophysical features, socioeconomic factors, and institutional, technical and administrative setups (Saleth & Dinar, 2000). By 2035, about 3 billion people will reportedly reside in countries with inadequate water supplies (UNEP, 2002). Water supply systems consist of several parts, such as pipes, pumps, reservoir tanks and hydraulic control elements, which work together to serve all clients with the necessary amounts of water at an adequate pressure. A water supply system is one in which water is created from a source and pushed to homes via municipal systems. It is then delivered to the ultimate users' residences through a network of pipes and accessories (reservoirs, valves, bends, and metres), which are referred to as the distribution systems (Brooke, et al., 2013).

Water comes from a variety of sources, which can be a sizable regulated reservoir or surface water, among other, depending on the treatment method and approach. The water is moved from the production and treatment centre to other stations for distribution to the various communities through the transmission system, which is made up of very big pipes (Shannon et al., 2008). Nyarko and Franceys (2008) argued that the structure and nature of the water supply system is influenced by some interrelated elements. Among the key influences are the geographic location, particularly the topography, the availability of water sources and the capability of the institution(s) in charge of the water supply.

Water Supply Systems (WSSs) are intricate systems created to consistently and adequately handle, store and provide potable water to users at all times (Walski et al., 2003; Farmani, Walters, & Savic, 2005). According to UNICEF/WHO (2014), water supply is defined as an enhanced drinking-water source as one that is shielded from outside pollution, in particular from contamination of faeces, either naturally or by intentional action. However, in different places, how a combination of modes is used has changed based on how things are in those places. Singh (2003) explained the case of India that even though 85% of the urban population had access to some source of water supply, only 20% of this value was found to be drinkable. Some cities also used traditional methods, like collecting rainwater. Komives et.al. (2002) confirmed from their study that households without access to a tap or piped connection obtained water through multiple modes. There were a few ways to get water: direct access to unimproved sources (rivers, streams, etc.), community taps or yard taps (provided by the city), different kinds of wells, vendors, and collecting rainwater. The study showed that about 2.4 percent of households resorted to water vending as their routine arrangement for water supply.

Alternative Water Supply Systems

Rapid urbanisation is happening, and by 2050, 66% of the world's people are expected to live in cities, up from 54% now (UN-DESA, 2015). The growing numbers of people living in cities are putting pressure on water services as shown by the fact that many water providers are having trouble keeping up with the growing demand (Chidya et al., 2016). Many cities have trouble getting enough water for their residents (Loáiciga, 2014; McDonald et al., 2014). Urban areas could need up to 92% more water than they do now because of population growth and changes in social and economic conditions (World Bank, 2009; Dzidic & Green, 2012). On the other hand, changes in rainfall patterns, the need to make sure ecosystems have enough water, and competition among users all have an effect on freshwater supply. Because traditional water sources are getting more and more used, many countries are investing in other ways to get water to supplement traditional systems. Commonly used alternative systems in Ghana are tanker supply, wells, water storage tanks, reservoirs and rainwater harvesting systems.

Alternative water supply systems are defined as water supply systems that augment and diversify water supply options by reducing vulnerability to potential water shortages (Agudelo-Vera et al., 2013). Alternative water supplies are safe ways to get water that comes from surface water or groundwater and indirectly through rainfall. Cook et al. (2009) defined alternative water supplies as systems that are not linked to the town's main water supply but work on the same premise as a centralised system. That is, houses have plumbed pipes connecting to the water system, which itself is located away from the point of use. Furthermore, alternative water supplies can be defined as reliable, long-lasting sources of water for irrigation and other potable and non-potable uses that are not directly derived from surface water or groundwater (WHO, 2007). For this study, based on the varied definitions and categorisations, alternative water supply systems are the systems that augment water supply from conventional water supply systems to areas with limited water supply for water uses.

Existing studies indicate that two main approaches to alternative water supply systems (i.e., centralised and decentralised) are developed at different scales depending on the location (Domenech, 2011; Marlow et al., 2013; Sharma et al., 2013). In centralised systems, large infrastructure- buried pipes that convey water to users have generally been observed to generate high water losses in the system. The centralised system can also lead to ‘lock-in’, where future development relies largely on existing infrastructure, which may not always be fit for purpose; and is often hard to improve or retrofit (Sapkota et al., 2015). They sometimes require replacement due to ageing or meet the increasing demand for water supply (Marlow et al., 2013).

Alternative water supply systems such as shallow or deep wells are created by the community which are either used collectively or privately. Moreover, Bell and Aitken (2008) posited that, with the aim of improving water supply provision, the global change in the provision of water to urban areas has undergone different processes and setups of organisations due to the involvement of the private sector in water provision. As some of these alternative systems are developed under the local circumstances that suit them, many variations of alternative water delivery systems are adopted globally. According to McDonald et al. (2014), for water-scarce regions to meet their present and future water demand, emerging middle- and low-income economies will need to make critical investments in alternative water systems.

The burden on existing sources can be lessened, and the supply-demand gap can be closed with the help of alternative water sources (Agudelo-Vera et al., 2013). AWSS can be treated to quality drinking despite the social and cultural stigma they experience when it comes to drinking for health reasons. They play a significant part in non-potable uses of water that do not call for high quality, like irrigation of public parks, open spaces and urban agriculture (Hardy et al., 2015). These alternative water supply systems are either centralised or decentralised. The centralised alternative systems face the same challenges as traditional water supply systems, from water boards to water losses in the system (IWA, 2015).

Decentralised systems are becoming increasingly popular because of the potential for more inventive water supply systems, inexpensive implementation costs, fewer energy losses that cut operational expenses as well as decreased water loss in pipeline conveyance (Sharma et al.,2013). Decentralised water delivery systems can address these problems, which the centralised system runs through more frequently. For applications that do not necessitate high-quality water, alternative water delivery systems might occasionally be less expensive than traditional systems (Libralato, et al., 2012).

Bichai et al. (2015) argued that one way that urban folks today and tomorrow might accomplish sustainable growth in the face of the uncertainties of climate change is an investment in alternative water supply systems to increase yields and resilience with urban water supply. These alternative water sources have the potential to significantly supplement the natural supply sources that are now under stress due to climatic change and human activity (Qadir et al., 2007; Wilcox et al., 2016). To buttress the arguments above, Sitzenfrei and Rauch (2014) posited that investments in decentralised infrastructure enable greater flexibility and manipulation in the face of climate change and unpredictable weather patterns related to rainfall and drought.

Significantly, using the alternatives will inevitably make potable water available for the majority of the required needs. Several factors, including the quantity and quality of water given, as well as the temporal and spatial availability, are taken into account while evaluating alternative sources (Leduc et al., 2009; Panagopoulos et al, 2012; Bichai et al., 2015). In addition, social and cultural acceptance difficulties, the technical and financial viability of various systems, hydrological and climatological considerations, storage, treatment and distribution possibilities, and customer affordability are taken into account when evaluating alternative water supply systems (Sturm et al., 2009).

One of the primary factors driving the development of AWSs is water scarcity in arid or semi-arid regions; these systems have the potential to bridge the gap between rising water demand and water supply in these regions (Qadir et al., 2007). Several different kinds of AWSs can support urban water security in areas with limited water supplies. Regarding geography, population and other parameters that determine which of the AWSs are most suitable, these non-traditional water resources can be used (Loáiciga, 2014; Qadir et al., 2007).

Rainwater harvesting is advised in areas with comparatively greater and more severe precipitation, as well as in areas that are susceptible to heavy rainfall and seasonal flooding. In places where traditional water resources are exceedingly low, these sources can potentially be employed as supplemental water sources to address water scarcity issues (Qadir et al., 2007). The alternative water supply systems option that can be best developed to support urban water delivery systems is determined by costs and benefits. Utilising alternate water sources can result in benefits for the environment, economy and society (Bichai et al., 2015). Reducing water consumption and the amount of untreated wastewater discharged into the environment eases pressure on the existing traditional water sources from an environmental standpoint (OECD, 2007).

Even though Ghana Water Company Limited (GWCL) is required by law to provide water to the country's citizens, this goal has yet to be met. Water from GWCL is typically only provided to particular metropolitan populations at specific times of the day or on specific days of the week. This may be mostly related to Ghana's rapidly developing metropolitan communities' sluggish expansion of water distribution networks to newly created communities. Due to the water crisis, many communities are now forced to pick other water supply sources. For their water demands, the majority of these communities have turned to tankers, water storage tanks, reservoirs, wells and boreholes among others.

Water Tankers

Water supply is a lifeline activity that must remain functional even if a disaster occurs. An elevated water tank is a water storage container constructed to hold a water supply at a height sufficient to pressurise a water distribution system. Water tankers have become a ubiquitous feature of domestic water supply systems across the Global South. Much attention has been paid to the neo-liberal-inspired privatisation of water utilities as well as to the hybrid formal and informal water access strategies of the urban poor (Bakker, 2005; Loftus, 2005; Ahlers et al., 2014). In major cities, the main supply scheme is augmented by the individual supply systems of institutions and industrial estates of which elevated tanks are an integral part (Falguni & Vanza, 2012).

According to the policy, the Ghana Water Company Limited (GWCL) is responsible for providing water to urban areas in Ghana; however, in practice, even some areas of the country's two largest cities, Accra and Kumasi, either do not receive any water at all from the GWCL mains or receive intermittent supplies with very low flows (National Water Policy, 2007). As a result, residents in these locations have decided to rely on water tanker services to meet their water needs. In reality, the operation of these water tankers complements the work of GWCL and saves lives for the locals in these locations. According to history, water tanker services in Accra date back to the time before independence, while GWCL is reported to have launched water tanker services in Kumasi in 1976 (National Water Policy, 2007).

Tanker services were already in place before the founding of GWCL as a way to supply water to urban areas that were previously cut off from the main distribution network. The water tanker services were also designed to bring water to the city's hilly areas, which were having trouble getting water because of distribution system head losses and a lack of booster stations to increase the supply to those areas (Songsore, 2008). Between the late 1980s and the early 1990s, water tanker service activity in Accra dramatically increased. These were primarily utilised to provide water for home and construction needs in Accra's newly developed neighbourhoods. The tankers, unlawfully and without paying any fees, drew water from GWCL hydrants (MRWH, 2014).

The GWCL and the operators decided that the owners of the tanker should organise associations to whom the GWCL will assign hydrants for their activities to reduce this trend. The Private Water Tanker Owners Association (PWTOA) was established as a result in 1992. The Kwashieman, the Odorkor and the Lashibi Associations are the three that are now in operation in Accra. In February 2001, the fourth association in Teshie, which had been founded in 1997, ceased operations. When GWCL constructed a depot in a suburb called Aboabo to fulfil the rising demand, the services of water tankers in Kumasi became more functional in 1990. To accommodate consumer demand, GWCL conducted the service with just three tankers. However, starting in 1998, the need for water tanker services expanded significantly during the dry seasons, to the point where GWCL alone was unable to satisfy consumer demand. As a result, GWCL asked private water tanker operators to participate in water tanker service operations in Kumasi.

Urban water supply systems are becoming more stressed due to growing water demand as a result of population growth, economic development, and recently, climate change (McDonald et al., 2011). In general, surface water is collected and supplied through a public water delivery network which in the event of water scarcity or decline in water quality may be supplemented by groundwater extraction, water tankers, and bottled water provision**.** For instance, water tankers, usually referred to as cisterns, are a typical method of delivering water from springs or wells to communities without infrastructure or access to water sources (World Health Organisation (WHO) and United Nations Children's Fund (UNICEF, 2006).

Both established and developing towns use tankers to transport water, usually in response to water shortages or during emergencies.

In developed countries, water tankers, in particular, also known as cisterns, are a common means of transporting water from wells or springs to communities lacking infrastructure or deprived of water sources (WHO & UNICEF, 2006; National Academy of Sciences, 2008). Tanker service is therefore emerging in low-income urban settlements as a preferred alternative to conventional water supply, usually patronised by sections of middle-to-high-class residents who are not covered by conventional systems. Nevertheless, in developed economies where pipe-borne water supply is readily available, water supply by tankers is largely regarded as an emergency option (WHO, 2005). Initially used as an emergency measure, tanker water supply has become a common practice of water provisioning in Accra since the late 1980s (Yeboah, 2006; Bohman, 2010).

In Ghana, the water tanker delivery industry is experiencing tremendous growth, particularly in Accra, where many residents reside in areas that are not yet included on the Ghana Water Company's supply map. Companies that provide water by water tanker provide services including providing clean pipe water, providing water for building roads, filling swimming pools, filling subterranean storage, watering expansive gardens, filling fishponds, etc. Additionally, they provide water to a variety of institutions, including schools, churches, organisations, businesses, and homes. Tanker drivers supply water to those who can pay for it: domestic users who are not connected to networked infrastructure and those residents who, despite living in areas served by the utility (Ghana Water Company Limited (GWCL)), experience water shortages (Oteng-Ababio et al., 2017).

Water tanker supply is important for retailers that buy water in bulk from drivers and then resell it to end-users (often neighbours) in buckets. Water tankers are also supplied to construction companies that need large amounts of water for building purposes. Tanker water supply is explained as contributing to processes of water commodification and forms of endogenous privatisation of urban water supply as compared with multinational companies (Bartels, Bruns, & Alba, 2018). Water conveyance using tankers occurs in both developed and developing communities, largely in response to water shortages or during emergencies. In developed economies, water transport tends to be of a short-term nature and relied upon in response to emergency cases such as water pipes freezing or being used to supply isolated rural communities (Arasmith, 2011; NNEPA, 2010).

Rainwater Harvesting

Rainwater harvesting can be utilised to supplement piped water. In reality, rainwater harvesting has the potential to give underprivileged populations access to affordable water. There may be rainwater available to improve the water security of households if torrential rainfall occurs between April and June and September and October in most of southern Ghana. UNEP (2006) states that a threshold of 200 millimetres of rainfall is regarded as the minimum rainfall arrival to start a successful program for gathering rainwater. Rainfall in the case study locations is between 1000 and 1400 millimetres, while it varies between 800 and 2000 millimetres in Ghana. Thus, rainwater harvesting is possible throughout the entire nation. In underprivileged areas, rainwater collected in storage tanks can replace the water used all year.

RWH is essentially the practice of collecting and storing rainwater for a variety of uses, and the technology is adaptable and versatile in the local environment (CEHI, 2009; Yannopoulos et al., 2019). The usual practice is to collect rainwater directly from rooftops and store it for home consumption in cement reservoirs that have been built or other storage tanks (Owusu & Teye, 2015; Andoh et al., 2018). RWH began at the household level in Ghana, where small containers were used to collect and store rainwater during storms, but it has since expanded to include the construction of sizable concrete reservoirs for the community, schools, health centres and churches (Barnes, 2009). Given the limited availability of a public water supply, rainwater is a particularly good choice for rural populations to obtain potable water for domestic usage. It is widely encouraged for people to help ameliorate water supply issues because rainwater itself is free and the method of harvesting just needs basic tools or supplies (UNEP, 1998; Yannopoulos et al., 2019).

The advantages of RWH range from lowering the demand on the public water supply to lowering the risk of flooding (Barron, 2009; Rahman et al., 2014). According to Owusu & Teye (2015), locals primarily use rainwater for bathing and cooking, with only 9% of people consuming it. Other documented uses of rainwater include washing automobiles, watering gardens, and flushing toilets (Zuberi et al., 2013; Owusu & Teye, 2015). Even though rainwater is mostly safe to use, contamination can nonetheless happen from several sources. These include environmental contaminants like dust and ash, as well as roof materials that might increase the number of heavy metals in the water (Mosley, 2005; Zakaria, 2011). Inorganic pollutants or bacteria found in rainwater contained in storage tanks are additional dangers that could have detrimental effects on the user (Mosley, 2005; Rahman et al., 2014).

In Ghana, as a result of water scarcity and climate change, interest in RWH is rapidly increasing, with governments and investors taking the lead in most cases. RWH programs that are large are frequently funded and conducted by local governments and non-governmental organisations (NGOs) in Ghana and other western donors (Barnes, 2009). Rainwater harvesting has also become common and has great potential to increase water availability in certain localised areas (Alim et al., 2020). A broader understanding of the technology's potential is required to scale up the adoption of RWH, nevertheless (Balogun et al., 2016). The capital or investment cost and worries about the quality of rainfall are further barriers to RWH implementation that need to be properly addressed (Opare, 2012; Balogun et al., 2016; Oke & Oyebola, 2015).

Reservoirs

The ability to store water is a significant tool for mitigating the effects of temporal fluctuations in water supply and demand (Ackermann et al., 2009). Slavik, Keila, Peter, and Wolfgang (2020) opined that domestic storage tanks are necessary since water supplies are often inadequate. Decentralised storage devices, most commonly residential storage tanks, are needed to make up for the scarcity of available water. Not only that, but water scarcity has led to the elimination of centralised water treatment in most areas.

Domestic drinking water storage tanks are commonplace in both low-density and high-density communities. Consequently, they can be used in both cold and warm areas. The specifics of the local water supply have a substantial impact on how they are built and used. Buildings in the Arctic often have water storage tanks because of the great distances that must be travelled from the water source to the treatment facility and finally to the user. Moreover, the population density in these areas is exceptionally low, which is another distinguishing feature of these places. As a direct consequence of this, the water demand is relatively modest and highly fluctuating. In addition, the extended low temperatures that prevail in such regions make it difficult or even impossible to use pipes and locations that are outdoors (Guyer, 2013, Daley et al.,2018).

Building new reservoirs to store water may seem like an obvious option to deal with droughts and water shortages, but this approach is strongly contested in many locations across the world (Shevah, 2015). Others point out the contradiction that a larger water supply from reservoirs can lead to higher demand and subsequently outweigh the initial gains, while some claim that reservoirs are becoming more and more vital in maintaining water security and facilitating drought management. It is necessary to use caution when making assumptions about reservoirs' potential effects on water security. The encounters are far more challenging than they initially seem. In addition to the presence or lack of a reservoir, other factors, such as rules governing the usage and distribution of water, as well as political and economic interests, must be taken into account. Water scarcity may be lessened by reservoirs, but only if fair access to and responsible use of the water are ensured.

Reservoirs or dams and impoundments have been created for water supply, irrigation, hydroelectric power generation, and ecosystem support

(WRC, Ghana, 2015). The main idea of water supply systems is to transmit water from a reservoir to demand. A reservoir is a natural or artificial place where water is collected and stored. Dams, lakes and groundwater aquifers are examples of reservoirs (Young & Esau, 2013). According to UNCTAD (2011), water storage has perhaps the greatest potential to deliver improvements in water management. This is old technology and one that has been exploited throughout history. Water storage is often associated with dams that have environmental and social problems. Over 45,000 large dams have been built for storage across the world, and some 40 percent are used for irrigation purposes, but dams are just one means of storage.

Ethiopia is one of the countries in Sub-Saharan Africa with the fewest people who have access to clean water (UNICEF/WHO, 2015). But since 1990, half as many people in the country do not have access to clean water. Even though Ethiopia has made a lot of progress, more than 48 million people do not have access to better water sources, and most health centres do not have safe water (UNICEF/WHO, 2015). Even though some people have access to clean water, the supply is inconsistent or not enough, whereas the connected water supply works only sometimes. So, people often use holding tanks to make sure there is enough water for short-term or long-term use. If water storage tanks aren't treated properly, like by using clean tools and sealing or covering them, they can affect the quality of the water. Inappropriate hygiene practices, such as the use of dirty utensils and not properly closing or covering the water storage tank, can harm water quality.

McCartney and Smakhtin (2010) stated that surface storage includes natural wetlands and reservoirs and subsurface storage consists of groundwater aquifers and soil water storage that can be accessed by plant roots, tanks, and ponds. Storage makes more water available by capturing water when it is in abundance and making it available for use when there are shortages. In Ghana, the storage story is mixed. Some reservoirs have led to more reliable water supplies and have enabled farmers to diversify their crops and have a more stable income. But other reservoirs nearby, under similar conditions, have failed to bring about any significant change (McCartney and Smakhtin, 2010).

To meet the diverse water needs of the people who share a shared river basin, they must have the ability to foresee and deal with socioeconomic changes as well as the effects of climate change. Building reservoirs and irrigation systems is a lucrative sector that uses lobbying to affect political decisions. Regulating demand and distribution are ignored while governance procedures and government spending continue to be heavily geared towards supply-side solutions like reservoirs. This can have unforeseen consequences. There are, however, effective examples of the complementary nature of supply- and demand-side rules being integrated.

Wells

Traditional sources of water for these rural communities' needs have included dug-wells, ponds, dug-outs, streams, springs and rainwater collection from rooftops. The majority of these sources, especially those that rely on surface water supplies, are contaminated and are the principal causes of the water-borne illnesses that are so prevalent in rural regions. Therefore, it would seem that the key to solving the issues with current rural water delivery systems is to effectively utilise groundwater and manage aquifers, hand-dug wells, and boreholes. Due to the dispersed structure of rural settlements, groundwater is not only practical but also the most cost-effective source of drinkable water. Currently, groundwater sources provide access to drinking water for around 52% of rural residents. By 2020, complete rural coverage will require a significant capital investment of roughly $1 billion. When available, groundwater resources will serve as the main foundation for the majority of these rural water supply systems. Throughout the country, more than 10,000 boreholes have been drilled as a result of the numerous groundwater development schemes (Webber, 2016).

Urban Water Supply in Ghana

Urban water supply in cities is typically managed by an institution that is partially or entirely governed by the state. Though many countries are privatising urban water supplies, the treatment and supply of water have some type of statutory or legal backing to make them formal institutions which are recognized by the public as such (Martson, 2014; Misra, 2014). On the contrary, water supply has become a monopoly in developing countries, with a single operator frequently providing sub-optimal quality and quantity of water services (Tecco, 2008). Consequently, the "informal" settlements remain unserved. In most cities in developing countries, only 40–70% of the population is provided with water by the institutional agencies responsible for water distribution. The remainder typically obtains their water from informal water suppliers (Ahlers et al., 2014).

To replace Ghana Water and Sewerage Corporation (GWSC), an independent public corporation called GWCL was established in 1999. The government of Ghana's (GOG) initiative to restructure the water sector included creating GWCL. The GWCL was reorganised in part to boost efficiency and effectiveness and to put it in a position to promote private sector involvement in the water industry. The primary goals of GWCL are:

i. planning and development of water supply systems in urban communities in Ghana;
ii. provision and maintenance of acceptable levels of service to consumers in respect of water quantity and quality;
iii. preparation of long-term water supply plans in consultation with the appropriate coordinating authority established by the president;
iv. conducting water supply-related research;

Ministry of Water Works and Housing, which has supervisory authority over the sectoral policies in the water sector, providing overall guidance to GWCL. In urban regions all around the nation, 86 pipe water systems are run by GWCL. The overall installed capacity of the water systems managed by GWCL is 737,000 m per day, which is insufficient given the expected urban demand of 939,070 m per day. Even though GWCL can produce 737,000 m per day, administrative and distributional inefficiencies limit actual delivery to 551,451 m per day, which exacerbates water supply issues (MWRWH, 2014). Majority of the shortfalls in the urban water supply to consumers inside the GWCL piped network are caused by inefficiencies in GWCL. The majority of the issues GWCL faces were carried over from GWSC. GWSC was a public business that, for a sizable amount of time, was subject to political orders. At the time it functioned, there was no independent regulating body to keep an eye on its operations. Water supply and resource management, as well as supply and regulation, were all roles played by GWSC.

Ghana's water supply is organised and essentially divided into two types; the water supply in urban and rural areas. According to the Ghana Statistical Service (2010), an area is regarded to be rural if its population is under 5,000 and urban if it is over 5,000. However, the scope of this study is restricted to the urban water supply. Ghana Water Company Limited (GWCL) is the only institution responsible for urban water supply (National Water Policy, 2007). An adequate supply of water to consumers in most urban areas in Ghana requires that water is captured through reservoirs and or diversion in sufficient quantity, transported and treated and finally distributed to areas of economic need (Ainuson, 2010; Mcdonald, et al., 2011). However, GWCL is unable to meet the water demand for several reasons, including rapid development, a rise in population and an inadequate budget. As a result, the majority of urban areas are not connected to the national grid. Additionally, water production cannot keep up with daily demand. It is viewed that while the current city water demand is around 150 million gallons per day, Accra's total water production is 93 million gallons per day. This results in a shortage in the drinking water supply of 57 million gallons (GWCL, 2016). Consequently, there is perpetually a daily supply shortfall. As a result, the majority of the time, GWCL follows a water rationing schedule that directs water flows to specific areas of the city on particular days (Adank et al., 2011).

This is done to ensure that the water is distributed evenly to the various communities on time. Some regions are claimed to only receive water once a week or not at all, whilst others may be serviced as frequently as seven days a week (Stoler et al., 2012a; Morinville, 2012). Although both higher and lower-income homes are plagued with unpredictable water flow, the former can typically afford to purchase and install poly tanks to store water. The urban poor rely on informal vendors, community standpipes and surface water sources more significantly, storing water in smaller containers and buying water daily (Ainuson, 2010; Songsore, 2008). The case study site -- Adenta Municipality - is an example of a peri-urban area where many low-income residents do not have direct access to water from the GWCL network (Stoler et al.,2012a; Adank et al., 2011).

In many developing cities, informal community-based water provision predominates, with households purchasing water from small-scale vendors. While the use of surface water and groundwater is socially rooted in communities, during the privatisation phase, neoliberal rationalities generated a stigma against informal supply, claiming that informal supply was inferior to the idealised formal supply piped network (Kooy, 2014; Misra, 2014). This stigma has been worsened by the MDGs' definition of “clean water”, which does not classify collecting water from carts, tanks or surface water as an improved method of accessing water (UNDP, 2013). Hence, McDonald et al. (2014) and Ainusion (2010) argue that the infrastructure required from the point of capture to the delivery requires substantial capital investment which goes beyond governments’ resources.

Sources of Water Supply in Ghana

Water is necessary for all living forms and must be present in sufficient quantities and quality to support it. With a present population of over seven billion people and the development of technology, the world's growing human population necessitates that human society pays more attention to the preservation of adequate water supplies (Owusu, Asumadu-Sarkodie & Ameyo, 2016). Water resource degradation has long been a problem of human society (Nwokoro & Chima, 2017). In Ghana, water consumption, irrigation and livestock watering are the three main consumptive uses of water resources. Most of the water used for domestic and industrial purposes in cities comes from surface water that is either redirected by levees in rivers or locked behind minor dams. However, the majority of the water used in rural regions comes from groundwater sources.

Ghana’s water supplies are split between surface water and groundwater, although there are also impoundments or reservoirs. Three river systems—the Coastal, South-West, and Volta rivers—are the source of Ghana's surface water resources (Yeliere, Cobbina, & Duwiejuah, 2018). The three main traditional river releases in Ghana—the Volta, South-West, and Coastal Rivers—provide the majority of the country's surface water supply. The Volta River systems are made up of the Red, Black, and White Rivers as well as the Oti River. The South-West River systems consist of the Bia Tano, Ankobra, and Pra rivers. The Tordzie/Aka, Densu, Ayensu, Ochi-Nakwa, and Ochi-Amissah make up the coastline network. (Yidana, 2009).

Ghana's groundwater resources are made up of three geological formations, which are, respectively, the Cenozoic and Mesozoic sedimentary rocks, the consolidated sedimentary formations and the basement complex (metamorphic rocks and crystalline igneous) (Williams et al., 2012). The emergence of groundwater in the basement complex is linked to the growth of secondary porosity, which causes a fracture, joining, shaving and weathering. The yields from the aquifers, which typically had depths between 10 and 60 metres, were only about 6 metres cubic per hour (Williams et al., 2012). The extreme southeast and west of Ghana typically have Cenozoic and Mesozoic formations, which are limestone aquifers with a depth range of 120 to 300 m. The typical yield of the calcareous aquifers is about 184 cubic metres per hour (Williams et al., 2012).

The water source has also been categorised as improved or unimproved. The improved source of drinking water consists of piped water into dwellings or homes, public tap and standpipes, boreholes, protected dug wells, protected springs and rainwater collection (GSS, 2009; JMP, 2008). However, the unimproved sources are unprotected dug wells, unprotected springs, tankers, surface water (river, dam pond) sachet and bottled water. Non-consumptive or in situ water use, in contrast to consumptive water use, is associated with activities that do not necessitate the extraction of water from its primary source. The main non-consumptive uses of water are for ecosystem support, freshwater fishing, hydropower generation, tourism, and recreational activities like waterfalls.

In Ghana, 27.3 percent of households have access to piped water; 28.5 percent utilise well water; and 8 percent get their drinking water from natural sources. With 35% of households using bottled and sachet water, the remaining 36.1 percent of households have access to other sources such as water vendors and tanker services. Approximately 68.4% of urban dwellings have access to pipe-borne water, however the source is typically outside the home (GLSS, 2017). A domestic water supply can be obtained from a variety of sources, including a spring, stream, hand-dug well, borehole with hand pump, rainwater collection system, piped water supply with tap-stand or house connection, water vendors, or sachet water (Reed et al., 2013).

Similarly, Guzman, Brown, and Khatiwada (2016) argued that in places with unstable infrastructure, it makes sense for households to diversify their water sources to protect themselves from fluctuations in water supply. More than half of Ghanaian households gather water from upgraded sources, according to recent research conducted across five regions of the country. 76 percent of households rely on rainwater collection during the rainy season, while 24 percent use community water sources, 43 percent utilise boreholes, and 6 percent use bottled water. Since all water sources, apart from rain, are commercialised, 46% of homes were found to be making some sort of payment for their water supply.

The current report on water and sanitation by the Ghana statistical Service (2021) indicates that the three main sources of drinking water for households are sachet water 37.4 percent and pipe-borne water 31.7 percent while 17.7 percent of the water sources for drinking come from borehole or tubewells. The two main water sources in the urban areas are sachet water (51.5%) and pipe-borne/tube well (33.6%) respectively. Conversely, Engel et al. (2005) cited in Eguavoen (2008), argued that many households in Ghana's diverse regions are forced to choose which source of water is most potable for household consumption because they must acquire water from multiple sources. This makes water user groups dynamic, offering households options to choose from while minimising risks, particularly during the dry season.

Demand and Supply of Water

The world's supply of potable water is constantly declining, despite the fact that having access to water is essential to maintaining human wellbeing (MacDonald, 2014). Even though the proportion of the world's population with access to potable water increased from 79% in 1990 to 82% in 2000 and then to 89% in 2010 (WHO/UNICEF, 2000, 2012), a lot of people in underdeveloped parts of the world are still experiencing water shortages (Cosgrove & Rijsberman, 2014). By the middle of this century, it is estimated that about 2 billion people will lack access to potable water if current trends are not reversed (Parmar, 2003). With only 61% of its population having access to better water sources, Sub-Saharan Africa has the lowest water supply coverage (WHO/UNICEF, 2012). According to estimates by Malley, Taeb, Matsumoto, and Takeya (2009), water stress will affect 50% of Africa's population by 2025. Some cities in the developing world are currently dealing with severe water stress, while historically, the issue of insufficient water supply has been more severe in rural areas than in urban centres (Efe, 2006). Water shortages in some cities in the developing world have been brought on by poor management, a lack of financial resources to expand water supply infrastructure, and a rapid increase in urban population (Handia, Tembo, & Mwiindwa, 2003).

Ghana is one of the nations were government representatives and development partners have recently placed considerable emphasis on the utilisation of rainwater. This is because the country's water supply status has been inadequate for a very long time (Gyampoh, Idinoba, & Amisah, 2008). Ghanaians in rural areas still get their domestic water from surface streams, lakes, wells, and boreholes. Furthermore, there are two pressing issues with urban water supply systems. First, there is an unmet demand due to inadequate supply. Second, demand is unbalanced: while the poor and those living in peri-urban areas have very little access, the more affluent metropolitan areas have a consistent water supply. For instance, in Accra, the inner city and affluent residential neighbourhoods enjoy a steady supply of drinkable water, but peri-urban areas do not (Sulemana, 2019). The main cause of Accra's deficient per-urban water supply is a lack of funding for the government to build water facilities for the surrounding areas. Since the primary water provider, Ghana Water Company Limited, lacks the resources required to guarantee a sustainable water supply in peri-urban villages, they are now forced to deal with the problem of a water crisis. Dos et al. (2017) report that the total daily demand for potable water in Ghana is 967,744 m^3. Ghana Water Company Limited (GWCL) provides 605,469.69 m^3 per day, which is equivalent to 62% of the total demand. Consequently, there are significant coverage gaps. 90% of the urban 50% of Ghana's population has access to potable water sources, according to estimates. It is essential to note, however, that only about 30% of this population has access to potable water, which is typically supplied intermittently. The remaining sixty percent rely on alternative water sources such as standpipes, protected dug wells, protected springs, and rainwater collection.

The majority of urban residents rely on basic water services (Vásquez and Adams, 2019). Ghana Water Company Limited (GWCL), the public water utility, rations water to various urban areas in response to rising demand (Peloso and Morinville, 2014; Tutu and Stoler, 2016). Consequently, people utilise any available water source whose quality cannot be guaranteed. This practice also has its health consequences. This discussion reflects the situation in which the water supply corporation in the municipality of Krowor currently finds itself.

Conversely, over the past several decades, the major use of water has switched from being for home consumption to being for consumption in the industrial, energy, and agricultural sectors. Even though Connor (2015) validates this trend, it does not indicate that people's need for water resources will decrease; rather, it merely indicates that there will be an increase in demand for services related to energy, agriculture, and industry. Since that is the primary subject of this study, the following is a narrative that discusses water consumption in homes.

Domestic water consumption varies depending on factors such as household income, the number of people living there, the number of children, the average age, and the level of education. Shaban and Sharma (2007) opined that the majority of household water usage goes towards domestic tasks, including bathing, dishwashing, laundry, and utensil washing. Taking longer showers and baths is one way in which our modern way of life contributes to water waste (Bello-Dambatta, 2014). Fotuè (2013) contends that urban households are more likely to use enhanced water sources for both drinking and other domestic purposes. Further, water shortages and deteriorating water quality are among the issues that require more attention and action. Due to inadequate infrastructure and rapid population growth, the disparity between water supply and demand continues to widen (Dos et al., 2017).

Preferences for Alternative Water Supply Systems to Household Water Security

One of the most crucial prerequisites for sustainable development is having access to safe drinking water (Odonkor, 2017). It is impossible to overstate the significance of having access to clean and safe water, as it is used for many purposes, including household chores, drinking, and non-domestic purposes. Even if access to drinking water is becoming more prevalent globally, for many developing and less developed nations, the main worry remains the safety of the water supply (Vásquez, Mozumder, Hernández-Arce, & Berrens, 2009). Generally, a range of infrastructure systems coexist, each with its own characteristics and service levels, and each based on a separate source of water supply. Water can be obtained from a variety of locations, including local streams, water vendors, and private or public wells. However, piped water systems are frequently the most preferred method of delivery in urban water supply since they are frequently linked to higher standards of safety and dependability (Mitlin, Beard, Satterthwaite, & Du, 2019).

There are many considerations when deciding which water supply to use. Studies have shown that a variety of socioeconomic and geographical factors, including income level, level of education, location and distance to the water source, preferences, knowledge, and perceptions about the quality of water, and cultural norms, all play a role in determining which water is chosen for domestic use. These considerations affect households' water source choices (Adjakloe, 2014; Osei-Akoto, 2014; Nketiah Amponsah, Woedem & Senadza, 2019). Cameroon and Fotuè (2013) found that household size, wealth quintile, dwelling area, and gender of the household head strongly influence the household choice of water source. However, the household's health status and the number of children under five have little impact on their water source choice for domestic use. Once more, the availability of water or access to specific sources may demand certain characteristics based on the intended use. Households in the developing world use different water sources for different purposes. Notably, Hope (2015) discovered in Kenya that households in rural areas have higher preferences for water points under community-based management compared to public or private management. Rahut et al. (2015) found that affordability influences people's choices and actions, and that wealthier households have better access to and can afford the installation and monthly costs of piped water than poorer households. Furthermore, affordability, quantity, and continuity are determinants when selecting a form of water supply. Water is available when needed; and water consumption depends on availability and purpose. The socioeconomic position of users, whether and how they pay for water, whether it is easy to access, and whether it is utilised for special activities all affect water use (Kundzewicz and Stakhiv, 2010). Moreover, in Vermavor's (2017) study, households prioritise factors including water source quality, availability, cost, and accessibility when purchasing water for domestic use.

It was assumed that the number of years spent in a community affected an individual's perception of potable water. Adjakloe (2010) found that individuals who had lived in a community longer tended to define water quality based on its taste and colour. Younger people, on the other hand, were more concerned with the colour of the water, which they used to determine whether or not it was potable. Household size is directly proportional to water consumption (Gaudin, 2006). Households with children consume more water than those without. However, research indicates that family size has no bearing on water consumption at home (Guhathakurta and Gober, 2007). Water consumption is greater in a large family because of the use of higher-frequency appliances. Water use and household size are both positively correlated with the age of the head of the household, according to numerous studies (Arouna and Dabbert, 2010; Syme et al., 2004).

Users' attitudes and beliefs significantly impact how and where individuals obtain their water. Risk perception, attitudes towards chemical content, acquaintance with certain water qualities, trust in suppliers, history of difficulties related to water quality, and information provided by the media and other interpersonal sources are all known to have a role in this (Doria, 2010). Engel et al. (2005) add that in Ghana, people's views, preferences, and availability all play a role in deciding where they get their water.

Benefits of Alternative Water Supply Systems

UN-HABITAT (2016) estimated that 1.3 billion people do not have access to sufficient water supplies. Urban water insecurity has recently been demonstrated in a sample of 12 megacities where water demand is higher than the formal supply that is available (Ahmadi et al., 2020). In 2050, US$73 billion will be invested in water delivery infrastructure, including water reservoirs, desalination, tankers, and rainfall harvesting, to meet the increasing home and industrial water demand around the world (Ward et al., 2010). Alternative Water Supply Systems (AWSs) have been cited as having a significant impact on diversifying and enhancing water supply sources, lowering stress on current sources, and boosting resilience in times of scarcity

(Agudelo-Vera et al., 2013; Bichai et al., 2015). AWSs are more frequently used to help meet non-potable urban demand, which can make up between 40% and 80% of urban water usage (Mitchell et al., 2002). Examples of this include irrigating municipal parks and green spaces and urban agriculture (Hardy et al., 2015). As a result, AWSs presents a substantial opportunity to enhance water efficiency and free up conventional sources for potable supply. This is essential because urbanisation strains water supplies and makes it more difficult to ensure a universal and equitable water supply (Loáiciga 2014). Mehta et al. (2007) reported that governments in many developing countries view tanker water (and other small water providers) as a practical way of serving low-income households and dispersed populations in rural and peri-urban areas. This is even though WHO and UNICEF (2006) have classified tanker-supplied water as 'unimproved' and consider it to be unsafe for drinking purposes. Lowe et al. (2019) highlighted better health, time savings, expenditure savings, empowerment, community capacity, food security, improved nutrition, school attendance, and productivity, and income as potential implications of improved water on livelihoods. Further, having access to safe water close to settlements frees up time for women to focus on other aspects of strengthening livelihood resilience (Abanyie et al., 2021).

Alternative water supply systems could potentially decrease water supply deficits and enable households to prefer using rainwater for domestic purposes as compared with stormwater and wastewater (Yahaya, 2019). Jussah, Orabi, Sušnik, Bichai, and Zevenbergen (2020) agree that alternative water supply systems have been shown to contribute to supply augmentation and diversification by improving system resilience and service.

Sušnik et al. (2021) opined that alternative water supply systems provide chances to contribute to water supply to meet non-potable urban demand and solve water supply-demand gaps for household users. Again, Wilcox, Nasiri, Bell, and Rahaman (2016) posit that alternative water supply systems are sustainable systems of water that can contribute significantly to increasing water supply security in regions experiencing increasing water scarcity through extraction and low rainfall. Jepson et al. (2017) argued water security is the capacity to access water without stress and to benefit from reliable, affordable, sufficient, and safe water for healthy lives and well-being.

Challenges in Accessing Alternative Water Supply Systems

Notwithstanding the recent improvements in water service coverage in developing countries, vast numbers of people still lack reliable water. AWSs are valuable for places with limited water resources. Even though integration and execution are hindered by some difficulties (Helmreich & Horn, 2019). In many cases, the technology is either unaffordable or does not offer sufficient capabilities to meet the needs of the area. There are times when users exhibit a lack of acceptance, lack of motivation, and lack of involvement. In addition, homes that utilise a certain AWSs are confronted with several challenges, including those regarding maintenance and safety. Borehole/well drilling takes experience. Water contains chemicals that erode metal well casings. Therefore, households need professional water well contractors to choose a water-safe casing material to prevent corrosion. Singh (2020) suggests contractors utilise plastic casing liners and stainless-steel well screens for corrosive water. Sulphate-reducing bacteria induce rusting. Shock chlorination controls these microorganisms. Products, contractor services, and procedures may be expensive. This support the findings of Peloso and Morinville's (2014) study, which found that when asked if the prices being charged by vendors were reasonable or good, most respondents indicated that it was manageable but also made it clear that they were powerless to change the price; vendors set the price of water.

Maintenance of the water supply is another difficulty with AWSs. Lack of maintenance of water facilities and an insufficient electrical supply for pumping water into overhead tanks are two other water supply problems (Olukanni et al., 2014). In Ikeja, residents have complained about a lack of power, which makes it impossible to pump water into the overhead tanks. In Olukanni's survey, 67% of the people viewed the price of water as high, while 33% thought it reasonable. This is not dissimilar from the routine maintenance required for water tankers and reservoirs. Poor maintenance of borehole pumps, reservoirs, and street pipelines causes water supply issues, and pipe leaks cause water loss during distribution (Mema & Mothetha, 2013). For instance, an RWH system is a source of high-quality water and can differ in complexity from a simple water tank to a complexly designed and constructed system. It provides an economically sustainable solution and a consistent water supply for families. Inadequate maintenance of rainwater tanks can result in health hazards for individual users and the general public through the spread of water-borne diseases and potentially expensive health impacts (Mankad et al., 2014).

Safety is a major worry when it comes to how people use alternative water supply systems. According to Alhassan et al. (2014), "accessibility, reliability, and timely availability of adequate safe water to satisfy the basic human need" are the three qualities that define water security. In what sense are the AWSs safe? When a well is drilled and pumped, the process increases the concentration of oxygen and nutrients in both the well and the aquifer that is located nearby. It's possible that certain bacteria, such as iron bacteria, will thrive under these conditions. They are capable of producing a slime or biofilm that has the consistency of a gel and can bond to chemicals, minerals, and other abrasive materials such as sand, clay, and silt. For instance, iron will oxidise, and then it will become trapped in the biofilm. The phenomenon known as "biofouling" occurs when the accumulation of biofilms becomes big enough to inhibit the flow of water. This may result in a lower well yield and poorer water quality (Poehls, 2016). Maintenance problems with water facilities have also made it harder to get water. The water infrastructure in Lusaka, Zambia, was built in the 1960s and 1970s, but it has not changed much and isn't enough to meet the needs of the present population (Hubbard, Meltzer, Kim., et al., 2020). A study done in Nima, an urban informal settlement in Accra, by Adams and Vásquez (2019) found that residents are sceptical about water quality, connection fees, and monthly water expenditures. The findings provide policymakers and water utilities with vital information for evaluating the feasibility and cost-effectiveness of extending household taps to poor urban settlements.

AWSs may have an impact on municipal water supply economics and public health (OECD, 2007). If the water is not treated properly for the application it is intended for or if it is used improperly, negative effects may result. In the event of suitable treatment, the effects are avoided or reduced. Therefore, a thorough cost-benefit analysis must be considered when creating

AWSs, along with a determination of the end user and the necessary treatments.

Empirical Review

Scores of studies have been conducted to enunciate the present dilemma of water security, the efforts of various fronts including the United Nations, private organisations, governmental institutions, and civil society organisations (Mekonnen & Hoekstra, 2016; Gerlak et al., 2018; Hartley et al., 2018; Jensen & Wu, 2018). Water security is a major concern in urban dwellings in most of the world due to rapid population growth, economic development, and lifestyle changes. Abubakar (2018), in his study of two dwellings of varying socioeconomic status; Nima and New Achimota, Accra, Ghana. The study assesses the potential contribution of alternative water supply systems (AWSs), rooftop rainwater harvesting (RWH), decentralised stormwater (SW), and treated wastewater (TRW) in two urban dwellings. Using a mixed-method approach, administered questionnaires, and 20 interviews coupled with QGIS spatial analysis, results indicate that though the contribution of the AWS to that from GWCL would increase supply, the current and projected water demand in the two urban dwellings will not be met with pronounced deficits in New Achimota due to high per capita water use. Additionally, in the case of the household interview, the results of the 20 households indicated the preference for rainwater over both stormwater and treated wastewater in the study areas, and as such, residents were willing to implement RWH at the household level.

Public water companies in many countries in the global south struggle to meet the water needs of their growing urban population, especially the urban poor. A study by Braimah, Obeng Nti, and Owusu Amponsah (2017) investigated the persistence of the poverty penalty associated with water supply to the urban poor in Ghana from unregulated water vendors. The study implored a mixed-methods approach with survey and interview methods used to solicit data from a total of 78 water vendors, made up of 53 fixed-point water vendors (including borehole water vendors, public stand-pipe water vendors, and vendors of water from reservoirs) and 25 mobile water vendors (comprising cart water suppliers and truck water suppliers) from two water-stressed poor urban communities and one poor urban settlement with water supply from the state utility provider.

Quantitative data were analysed with SPSS, while content analysis was also used for the analysis of the qualitative data. Results indicate that informal water vendors play a very important role in meeting the water needs of the urban poor. However, it was observed that urban poor households paid a high-poverty premium for relying on these unregulated water vendors for their water needs.

Another empirical study on growing water demand poses a challenge to supply. A poor understanding of alternative sources can hamper the plan in terms of addressing water scarcity and supply resilience. Jussah et al., (2020) conducted a study on the assessment of the potential contribution of alternative water supply systems in two contrasting locations: Lilongwe, Malawi, and Sharm El-Sheikh, Egypt using a fast, data -light assessment approach as well as mixed-method approach.

The results indicate that alternative water supply systems are shown to potentially contribute to supply augmentation/diversification, improving supply systems resilience. There are considerable seasonal variations to consider, especially regarding the storage of water. Social preferences could limit the uptake/demand for alternative water. One important conclusion is the value of addressing public perceptions of alternative systems and assessing water end use to site systems appropriately.

In Nigeria, Abubakar (2018) in his study on the strategies for coping with inadequate domestic water supply, explores household strategies for coping with an inadequate domestic water supply and the factors that affect strategy choice. Through the qualitative method, data were collected from in-depth interviews with 60 household heads or their spouses while grounded analysis was used to analyse the data collected. The results found that water storage (90%), bottled and sachet water (82%), water vendors (78%), and fetching water from neighbours (60%) were preferred for coping with inadequate water supply over water conservation and recycling (38%), boreholes (23%), home water treatment (15%), and surface water (10%). The necessity of water, the cost of coping strategies, housing characteristics, socio-economic factors, and planning regulations influenced the household choice of strategies.

Moreover, in Dar es, Salaam, Tanzania, the work of Mapunda, Chen, and Yu (2018) on the role of informal small-scale water supply systems in resolving drinking water shortages in per-urban was established. Mixed methods along with surveys and interviews were used to ascertain the role of these informal suppliers. Findings show that informal small-scale providers account for 100% of drinking water in Peri-urban settlements, but water infrastructure is in a dire state as its investment is carried out without adequate professional guidance. Furthermore, over 64.1% of the communities acknowledged the importance of water providers increasing water access.

In other studies, Owusu and Teye (2014) examined the challenges associated with rainwater harvesting and usage in peri-urban Accra. The study relied on a mixed methods approach with survey and interview methods being chosen for the study. Again, chi-square was used for quantitative analysis and content analysis for the qualitative data. Data obtained from 357 heads of households reveal that rainwater harvesting has the potential to supplement existing water sources in peri-urban Accra. Contrarily, high investment costs for rainwater harvesting facilities, short-term tenancy arrangements, the perception that rainwater is not clean, and the unique dry climate of the Accra Plains emerge as key challenges limiting the domestic use of rainwater. Public education for house owners to invest in rainwater harvesting facilities and governmental support will be needed to increase investment in rainwater harvesting, purification, and usage.

Furthermore, household water source choices in Dodowa and Doryumu, Shai-Osudoku District, were studied by Vormawor (2017). The research used sampling techniques in a systematic and stratified fashion. The research involved a sample of 300 houses, four sets of focus group discussions with six participants each, and five key informants. The Water Poverty Index and logistic and multinomial regression models were used to conduct the statistical analyses in the study.

The findings showed that quality, availability, cost, and accessibility of water sources are prioritised by households for usage in the home. The study indicated that there is a favourable correlation between the selection of upgraded water sources and age, education level, and daily household expenditures. Married people also tend to use fewer tanker deliveries and boreholes. However, using rainwater is favourably correlated with a lower reliance ratio than using tanker services. Upper Dodowa has the greatest water poverty index (0.053minsk-1) of any community in the world. Water from the mains is the standard in most American homes. A sizable fraction of homes, however, cannot afford the installation fees.

Table 1: Summary of empirical review

Author Year	Aim of the study	Research approach	Research method	Key findings	Unexplored research gaps
Abubakar (2018)	The potential contribution of alternative water supply systems on urban water security	Mixed methods	Survey and Interview	Results indicate that the contribution of the AWS to the GWCL would increase supply to meet water demand in two urban dwellings (Nima and Achimota)	Water from wells, tankers, and reservoirs were not looked at. Preference for Alternative water supply systems was not captured. Household water security was unexplored.
Braimah, Obeng Nti and Owusu Amponsah (2017)	Investigated poverty penalty associated with water supply to the urban poor in Ghana from unregulated water vendors	Mixed method	Survey and interview	Results indicate that informal water vendors play a very important role in meeting the water needs of the urban poor.	Water security not explored, Social and health issues were narrowed, Preference/Choice of AWSs,
Jussah et al (2020)	Assessment of alternative water supply systems	Mixed method	Survey and interview	results indicate that alternative water supply systems are shown to potentially contribute to supply augmentation/diversification, improving supply systems resilience	Tankers, wells, and reservoirs were unexplored. Social preference of alternative water supply systems, Challenges were limited.
Abubakar (2018)	explores household strategies for coping with an inadequate domestic water supply and the factors that affect strategy choice	Qualitative	Interview	The necessity of water, the cost of coping strategies, housing characteristics, socio-economic factors, and planning regulations influenced the household choice of strategies.	Benefits of these alternative water supply systems, Challenges of alternative water supply systems

Mapunda et al. (2018)	The role of informal small-scale water supply systems in resolving drinking water shortages in per-urban was established	Mixed method	Survey and interview	Findings show that informal small-scale providers account for 100% of drinking water in peri-urban settlements	Socio-economic characteristics of households influencing alternative water supply systems, Choice and preference of water supply systems
Owusu and Teye (2014)	examined the challenges associated with rainwater harvesting and usage in peri-urban Accra	Mixed method	Survey and interview	households reveal that rainwater harvesting has the potential to supplement existing water sources in peri-urban Accra.	Water from tankers, wells Reservoirs, Socio-economic Dimensions, Choice and social preference of Alternative water supply systems

Lessons Learnt

The review of the relevant theories, concepts, and empirical studies reveals that rational choice theory dwells on the maximisation of the utility, benefits, and cost for the household to choose from various alternative water supply systems, which have the potential to contribute to household water security in the absence of conventional water supply systems. It was also evident that household water security is built on the tenet of Sen's capabilities approach (functionality and well-being), which explains the roles of functionality and well-being in household water security for socio-economic development.

Operationalising the terms, it was learned that water security is referred to as water that is of good quality, accessible, available, affordable, and safe to improve livelihood and well-being. Alternative water supply systems have been operationalised as water supply systems that augment conventional water supply systems for household water needs. Household water security was referred to as improving water security, stress, and vulnerabilities due to the availability, accessibility, quality, quantity, and safety of water to enhance household well-being.

In terms of the lessons learned from the methodology, except for one researcher who utilised a qualitative research strategy, the majority of the works that were used were mixed-method approaches, with survey design being the preferred option. To obtain primary data from households, a stratified and systematic random sampling approach was utilised, and the tools of questionnaires and interview guides were used. Household water security indicators such as quality, quantity, availability, affordability, accessibility, and safety were measured on an ordinal scale of measurement. Empirical studies have shown that alternative water supply systems contribute to meeting the growing water demands of households and ensuring household water security. A conceptual framework is inferred from the lessons for this study.

Conceptual Framework

The conceptual framework below is inferred from the review of the literature on alternative water supply systems and household water security in this study. Figure 1 illustrates the links between alternative water supply systems and household water security. The water supply from the GWCL is described as the primary or conventional water supply, which is mainly served through centralised systems to consumers. Water supplied to consumers and households can be used for potable and non-potable purposes. Potable and non-potable water uses both constitute the water demand. The sources of water supply include rainwater, surface water, and groundwater, but water from GWCL is mainly from surface water resources. However, conventional water supply systems are under stress as a result of increasing population growth and the development of socio-economic activities. This necessitates a lot of stress on the existing supply systems to meet the increasing demand of users. Due to the limited water supply from conventional water systems, households would opt for alternatives such as wells, reservoirs, tankers, and harvesting rain to meet their water demand and security.

Alternative water supply systems such as water tankers, wells, rainfall harvesting systems, poly tanks, and reservoirs can also be used for domestic water needs, depending on the households' preferences and the benefits derived. Households' preference for alternative water supply systems for household water security is influenced by the quantity, quality, availability, accessibility, affordability, safety, income level, time spent, seasonal changes, and cost of water from these alternative water supply systems. This, then, results in the outcome of household water demand, including water for domestic water uses, enhancing well-being, decreasing vulnerabilities and stress, and increasing productivity among households. It is ascertained that the intermittent supply of water from conventional water supply systems to households in the study area will be augmented by the reliability of alternative water supply systems to improve household water security as well as increase system resilience and diversify water supply.

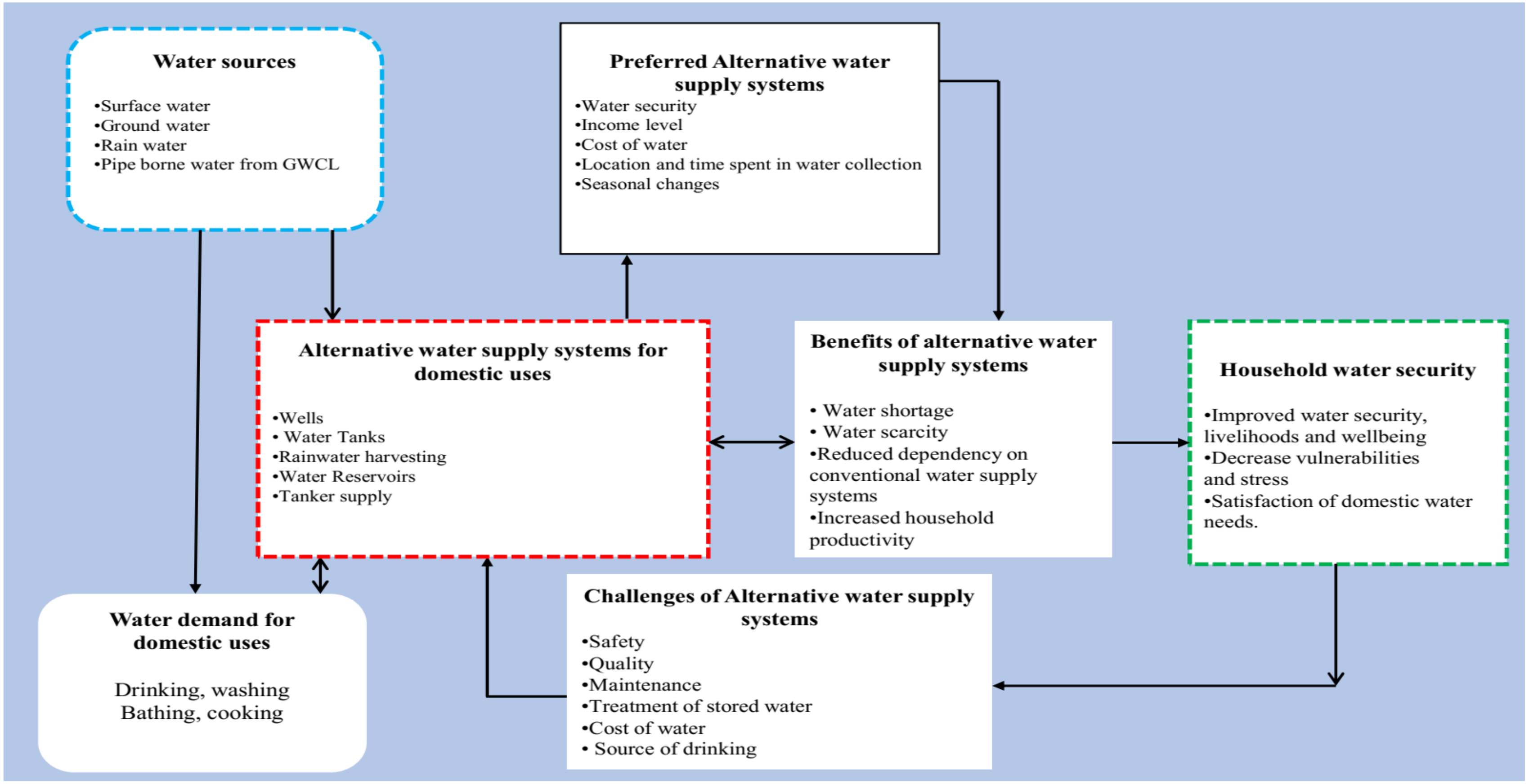


Figure 1: Conceptual Framework of Alternative Water Supply Systems and Household Water Security
Source: Author's Construct (2023) based on relevant literature reviewed.

CHAPTER THREE

METHODOLOGY

Introduction

The methodology chapter in a research study enables the reader to essentially assess the universal validity and reliability of the study (Kumar, 2018). Sarantakos (2012) said that the methodology offers a broad strategy for connecting the conceptual problems at the root of the research problem to the pertinent empirical techniques. This chapter was important because it describes the scientific methods used to produce results that are accurate, valid, and reliable. This chapter discussed the research methodology for the study, which started with the research paradigm and research design, followed by a description of the study area. The subsequent paragraphs in this chapter were followed by a discussion of the target population, sampling procedure, data collection instruments, data collection procedure, ethics, data processing, and analysis.

Research Paradigm

The three major social science research paradigms offer distinct approaches to seeing, measuring, and comprehending social reality. These are positivism, interpretivism/constructivism, and pragmatism (Creswell, 2009; Scotland, 2012). These research paradigms are being adopted by researchers to shape their ontological and epistemological positions, which lead to the choice of their research approaches (i.e., qualitative, quantitative, or mixed-method approaches). Neuman (2011) and Sarantakos (2012) are of the view that each paradigm deals with beliefs that are influenced by social theories and diverse research techniques to systematically examine and establish truth and reality as a philosophical foundation in a research process. The subsequent paragraphs discussed the paradigms.

Positivism and Interpretivism

The positivist tradition promoted an ontological assumption of objective reality, suggesting that reality is both objective and external to the human. It views truth as something that is independent of human consciousness and that every member of society can experience in the same way (Oppong, 2014). In this study, the measurability of variables is motivated by the philosophical perspective of positivism. The aspect of the quantitative approach is closely linked to it (Creswell, 2009). Sarantakos (2005) concurred that within positivist epistemology, knowledge is only obtainable via sensory experiences and that positivism holds an empiricist epistemology, thus reality is objective.

Further, Sarantakos (2013) observed that research in a positivist paradigm uses a quantitative approach. This implies that the only way to learn anything is to observe things quantitatively. This research's epistemological viewpoint outlines the instruments used for gathering, analysing, and interpreting data. Studying deterministic and functional relationships under the premise that there is a cause for every outcome is made easier by the positivist paradigm. Reductionism, the foundation of positivism, holds that concepts may be reduced to discrete, limited groups of concepts (or variables) that can be tested. Moreover, Bhattacherjee (2012) concurs that the positivist perspective expresses variables in numbers and frequencies using statistical methods, including parametric and non-parametric, to unravel significance for a better conclusion.

Scientific research through a positivist orientation emphasises theory, rejecting or supporting the theory based on the collected data, and revising the theory where necessary before extra tests are made, which will lead to generalisations of the results postulated by Mason and Lee (2013). Additionally, social science research studies with a positivist orientation can be replicated, and the findings are value-free (Neuman, 2007; Sarantakos, 2005). However, positivist assumptions have been criticised for the use of rigid natural laws that cannot adequately predict human behaviour. Also, Sarantakos (2005) posited that it fails to distinguish between the appearance and the essence of social events.

The interpretive ontological position, on the other hand, is focused on the relativist paradigm, where reality is individually constructed, leading to multiple realities (Villiers, 2005; Scotland, 2012). Leitch, Hill, and Harrison (2010) observed that under this paradigm, the epistemic orientation is subjectivism, which is derived from real-world phenomena. The contention of epistemic interpretivism states that "no external reality exists independent of our beliefs and understanding and that reality is only knowable through socially constructed meanings and the human mind" (Ritchie, Lewis, Nicholls, & Ormston, 2013, p. 16). Knowledge emerges through social constructions such as language, consciousness, and shared meanings (Klein and Myers, 1999; Rowlands, 2005).

Under the interpretivism paradigm, some studies utilised include case studies, phenomenology, hermeneutics, and ethnography (Leitch et al., 2010). For data collection methods, interpretivism normally employs interviews, focus group discussions, and observations (De Villiers, 2005; Leitch et al., 2010). Data analysis usually involves the researchers making their agenda and value system explicit from the outset (Leitch et al. 2010). Interpretivism uses the qualitative research approach when conducting research. Babbie and Mouton (2001) and Charmaz (2006) assert that this allows for a deeper interrogation of assumptions, questions, and the logic of theoretical perspectives, as well as the fact that people continuously construct, develop, and change their everyday interpretations of their world.

According to Chowdhury (2014), constructivist epistemology affords flexibility and sensitivity to contextual elements, the capacity to examine symbolic dimensions and social meaning, and heightened possibilities for the development of novel, empirically supported ideas and theories. However, a major weakness of interpretivism is the lack of mechanisms to discourage the researcher's bias towards the determination of reality. Another concern, as Mack (2010) affirms, is its inability to generalise including its use of subjective data.

Mutsiwa (2016) argued that under the pragmatic philosophy of social science research, knowledge is learned through acts, situations, and consequences rather than antecedent conditions. Further, the pragmatic epistemic principles allowed the research to focus on outcomes by combining approaches that best address the problem (Onwuegbuzie et al., 2009). The ontological position is eclectic; thus, reality is seen as what is practical and works. The pragmatists, therefore, reject any form of dualism (Johnson & Onwuegbuzie, 2004). They believed in an external world independent of and embedded in the mind. Patton (2014) suggests that a pragmatic approach is a means of encouraging methodological appropriateness that allows researchers to increase both methodological adaptability and flexibility.

Morgan (2014) and Creswell (2009) have argued that some of the benefits of employing a pragmatic stance are that it is not limited to any epistemic or ontological paradigm. Thus, it can be adapted to any philosophical viewpoint. Consequently, it allows researchers to employ both quantitative and qualitative standpoints in accomplishing their target goal. This implies that pragmatism allows the researchers some measure of flexibility in the choice of methods, procedures, and techniques of research that best suit their objectives and necessities. This paradigm allows for the use of statistical methods and statistical tools in analysis (Johnson& Onwuegbuzie, 2004), whereas the former sanctions generalisation of findings. As discussed, based on the three philosophical orientations of social research, this study seems to incline itself towards the assumptions of pragmatism. A reason for the choice of pragmatism is that this study will require the concurrent collection of qualitative and quantitative data on issues relating to households' preference for alternative water supply systems, the contributions of alternative water supply systems, and challenges faced by households with regard to household water security. The pragmatists' school of thought provides the right avenue to adequately address these salient issues in the study.

Research Design

Research design is an essential part of the research process. A major purpose of the research design is that "it offers a guide that directs the research actions and helps to rationalise the time involved, resources used, and reduced costs"

(Sarantakos, 2013, p.121). An empirical method that connects data collecting to the study objectives and identifies solutions to meet them is further considered to be a research design. Research methodologies that support the elements of good social research, provide justification for conducting research, link research to attributes, and direct moral behaviour serve as the basis for research designs (Kruger & Neuman, 2006).

This study adopted a mixed-methods research approach. The mixed method as Creswell (2014) observed, is an inquiry involving gathering qualitative and quantitative data, integrating the two classes of data, and using different designs. The main assumption behind this form of investigation is that a blend of qualitative and quantitative approaches will offer a more comprehensive understanding of the research problem than either approach in isolation. The study, therefore, finds the mixed-method favourable since it allows both quantitative and qualitative measures in data collection and analysis. Creswell (2009) proposed that mixed methods permit the study to be conducted from a broader survey to generalise results to the population and at the same time use qualitative methods to collect views from participants in the survey. Particularly, this study adopted a concurrent mixed-method design. Creswell (2009) argues that the concurrent mixed methods design is primarily because it permits the combination of quantitative and qualitative data collection at the same time to provide a detailed analysis of the research problem. The mixing of methods in particular could improve the validity and reliability of the data and their explanation (Zohrabi, 2013).

Concerning the choice of study design, Creswell (2009) suggests that for any research approach adopted, be it a qualitative, quantitative, or mixed method, there are several strategies of inquiry from which the researcher will select. Saunders et al. (2011) and Sekaran and Bougie (2013) opined that these 'strategies of inquiry' provide a blueprint constructed out of the research question and objectives, focusing on transforming the research question and objectives into a researchable project. Therefore, the study employed a descriptive survey design. A survey design was used because it gathers information deemed appropriate for studies of either large or small samples selected from a given population or an object. It is used to explain what is in existence concerning the conditions or variables that are on a given instrument. Moreover, the design is good and convenient because it helps the researcher describe the existing situation by asking respondents to respond to questions, gather data, and draw a successful conclusion. This design was preferred because it is anchored on many factors that are essential to the goal of the objectives and provides in-depth analysis as an excellent vehicle for measuring the characteristics of a population (Vaske, 2019). The focus of the research was on the disparity in water supply bridged by alternative water supply systems for household water security.

Descriptive studies may be cross-sectional studies, which involve a one-time interaction with groups of people, or longitudinal studies, which interact with individuals over a period of time. A descriptive study enables the researcher to interact with respondents or participants through a survey or interviews to collect the necessary information. This study specifically employed the cross-sectional descriptive method, where there was the administration of interviews with a one-time interaction with a selected sample of various households across the municipality.

The strength of the descriptive research design was that it gave a voice to the household to ensure that the findings were grounded in the experiences of the users. It also helps in understanding the contradictions between quantitative results and the qualitative findings of the research objectives. The research objective cannot be solely explained or discussed by the quantitative or qualitative approach. The mixed method helps the study overcome the weakness of the quantitative design with the strength of the qualitative aspect and vice versa (Morse, 2016).

Study Area

This section presents the physical, demographic, and socio-economic characteristics of the study area.

Krowor Municipality is among the newly created municipalities in the Greater Accra Region. The municipality was formerly part of the Ledzokuku-Krowor Municipal Assembly, which was separated in 2017 to create Ledzokuku Municipality and Krowor Municipality respectively. It was carved out of the former Ledzokuku-Krowor Municipal Assembly in the year 2018 with Legislative Instrument 2318 of 2017 (GSS, 2017). The municipality is located in the central part of the Greater Accra Region and has Nungua as its capital town. The municipality covers an area of approximately 16 km^2 (8.37 sq. mi) (GSS, 2021). It is along the sea, which lies between Teshie on the west and Sakumono-Tema on the east side of the Atlantic Ocean. It is sandwiched administratively between Tema West Municipal Assembly to the east and Ledzokuku Municipal Assembly to the west with Latitude: 5° 35' 59.99" N and Longitude: 0° 03' 60.00" E (Figure 2).

Krowor, located in the Coastal Grassland Zone, has two peak wet periods each year. It rains about 730 millimetres per year on average in Ghana, mostly during the country's two monsoon seasons. A secondary, less intense rainy season occurs in October, although the main rainy season runs from April to about the middle of July. Short, intense downpours are more common and lead to floods in low-lying areas when drainage systems are clogged (GSS, 2018).

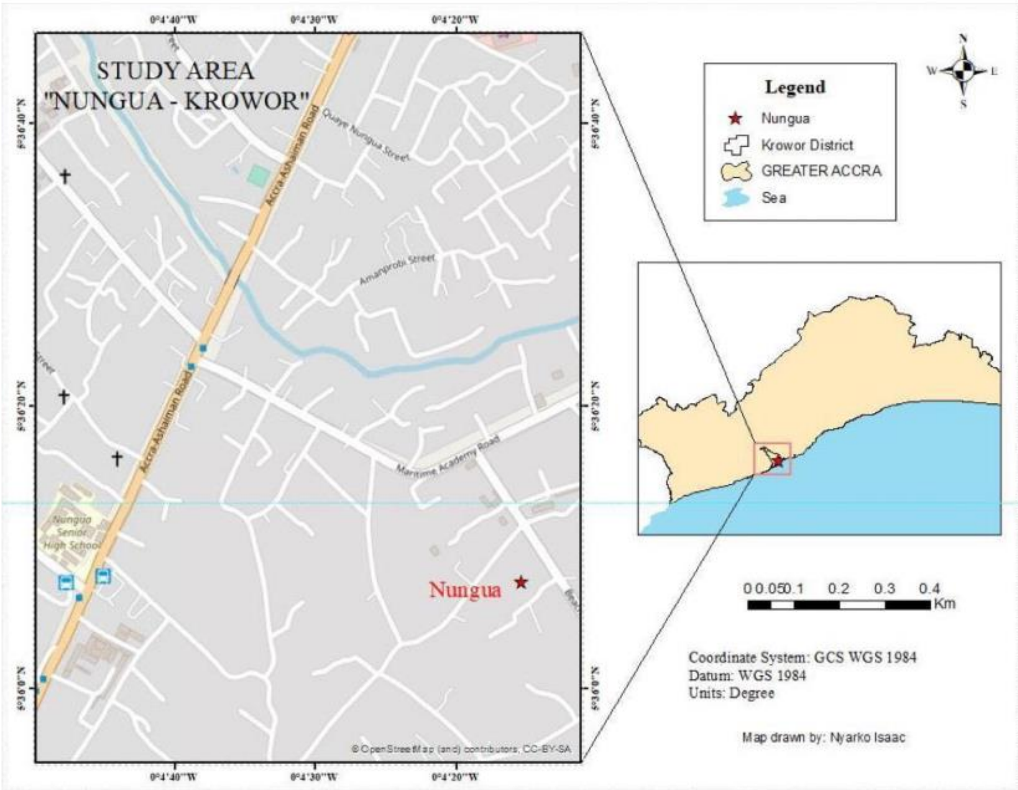


Figure 2: Map of Krowor Municipality showing the study town
Source: Nyarko (2022).

The national population and housing census in 2021 estimate the municipality's population at 143,012 with a growth of 3.2 percent. The projected population for the year 2010 is estimated at 102,059. This consists of a female population of 52.1% and a male population of 47.9%. The population density for the municipality is 4915 per km^2. The youth population in the area is estimated to be 49.5% (24 years of age and older). The growth of the population is mainly due to urbanisation (GSS, 2017). The 2021 population census figure yields a density of 9.183.4 persons per square kilometre much higher than the regional density of 1,300 persons per square Kilometre (GSS, 2021). This indicates the great pressure of the population on land and resources in the Municipal. In terms of economic activities, the major economic activity in Krowor is commerce, which is about 42.5%, followed by manufacturing 15.8%, and agriculture 10.1%. The majority of the people living in the municipality are middle-income earners, while 28% are high-income earners, leaving 19% of the localities as low-income earners (Figure 2).

The temperature varies very little during the year. The average annual temperature is 27.6 °C (81.7 °F), with the coldest month being August, when average temperatures drop to 25.9 °C (78.6 °F), and the warmest month being March, when average temperatures soar to 29.6 °C (85.3 °F). In general, the "colder" months are more humid than the "hot" ones. Therefore, the area receives a breezy "dry heat" during the warmer months, especially during the windy harmattan season, which is less heated than the "cooler" but more humid rainy season (GSS, 2018). This makes them more likely to use rainwater as a source of water during the rainy season, but they have to use other water supply systems during the dry season. Therefore, the choice of the study area is influenced by the presence of many alternative water supply systems due to perennial water insecurity in the municipality. These alternative water supply systems provide water to households and residents in low-income parts of the city. Hence, the study area is a desired physical location for the study.

Target Population

A study population is defined as all of the research subjects or units that are the focus of the research (Jennings, 2001). Rubin and Babbie (2007) defined population in research as the aggregation of elements from which a sample is taken. The defined population for the study included all households in Krowor Municipality. The target population is the household heads and other members of the households, either male or female, above the age of 18 in the Krowor Municipality. Household members between the ages of 18 and above were included in the target population to provide options for respondents from households whose heads were not present during the time of data collection within the category across Amanfa, Buade, Asanko and Sokpoti operational sections. The primary criterion used in selecting the respondents was that such persons must have been residents of the study area for at least a year, since this would give them a better appreciation of the water supply situation as well as a sound contribution to the study.

For the in-depth interview, the target population included water tankers, water vendors of water storage tanks, and reservoir operators. The key targets were selected because of their fair knowledge of the activities, operations, and constraints of water insecurity and their contribution to the urban water supply.

Sampling and Sampling Procedure

Sampling can be referred to as a selected proportion of the population under study. A sample is defined as elements chosen to learn something about the whole population from which they are drawn (Mouton, 1996). The objective of the research and the characteristics of the populations have a significant impact on the sample's accuracy (Merriam & Grenier, 2019). Sampling is important in situations where there is limited finance or time to capture the entire population; thus, a reasonable size based on the available resources was selected. Probability and non-probability sampling methods were used in the selection of respondents and participants for the study.

Samples of Household

A household is any individual or group of two or more people (related or not) who share living quarters, eat and sleep together, and acknowledge one person as the head of the household (GSS, 2021). The study was conducted in selected sections in Nungua, the municipal capital. From the 2021 population and housing census, Nungua was ranked the most populated settlement with an estimated population of 84,119, accounting for 59% of the total population in the municipality. At an average household size of 3.0 for the municipality, Nungua had a total of 28,039 households. Therefore, due to the size and heterogeneous nature of the population under study, the study adopted Yamane's (1968, p. 886) method of representative sample, which assumes a 95 percent confidence level as presented in equation 1 to estimate the ideal sample for the study. For the study's household sample, a sample of 395 households was generated with the assistance of Yamane's estimate.

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

Where n=Sample size

N= population size

e= error (0.05) reliability level 95%

Using the above, the total number of households selected for the study is derived as;

$$N = \frac{28{,}039}{1 + (0.05)^2 \times 28{,}039} = 394.915$$

Therefore, a total of 400, thus, 395 household respondents and 5 key informants' participants were used for the study. This calculated sample (395) out of 28,039 was proportionately distributed across the four operational sections of the municipality.

The stratified and the systematic sampling technique were employed to select the participants for this study. Stratified sampling is a sampling procedure that can be used concurrently with either random or systematic sampling. The systematic random sampling method was used for selecting houses of households to be involved in the study. The use of the systematic random method ensured that each household was given an equal, calculable, and non-zero probability chance for selection for the study. The reason was to obtain a representative sample across households and different categories of household sizes. The stratified sampling procedures enabled the division of the Municipality into subsets before the sampling was done. This procedure was employed when the population or the sampling frame was made up of subsets of definite size. The subsets make up different proportions, and hence sampling is stratified to ensure that the outcomes are equal and representative of the whole.

The Krowor Municipality was divided into four sections comprising Amanfa, Asanko, Sokpoti, and Buade, based on the demarcation by the municipal assembly.

The next stage of the sampling procedure was systematic random sampling. At this stage, the household's house sample was selected systematically. This technique was to cover the household heads from each of the four stratums. This was employed because it allowed for equal representation of household heads from each operational section respectively. A sample factor was obtained from each of the four strata by dividing the population by the sample size (28,039/395=4.5) that was approximated to five to serve the purpose. By selecting a starting landmark, the fifth house was chosen systematically. This was done so that the selected houses were far from each other and not too close together. The sampling factor and its corresponding codes were recorded up to the level the sample sizes from the four operational sections were exhausted (Table 2).

In addition to the above, the non-probability sampling method, specifically the purposive sampling technique, was used to select the key informants to solicit vital information. The study adopted purposive sampling because it involves strategies in which the researcher exercises his or her judgement about who will provide the best perspective on the phenomenon of interest and then intentionally invites those specific perspectives into the study (Kumar & Phrommathed, 2005). Moreover, to facilitate a thorough comprehension of the main issue, purposive sampling involves choosing units with specific features (Ritchie, Lewis, Nicholls, & Ormston,2013). The study purposefully selected five water vendors and operators of alternative water supply systems as participants for the in-depth interview. The rationale for adopting purposive sampling was that participants fitted into the issue under investigation. The inclusion criterion was to be used to select these water vendors based on the fact that only five water vendors were chosen to participate in this study. Even though there are operational sections for the study, at a point in time, the study purposely selected an additional participant with two or more alternative water supply systems in the one of the operational sections to share their experiences to enable the researcher examine the alternative water supply systems for household water security from different perspectives.

In all, a total of 400 participants were involved in the study. The disaggregated sample units are presented in Table 2.

Table 2: Sample frameworks

Units	No of household	Sample Size	Male	Female
Asanko	6,957	98	45	53
Buade	6,886	97	38	59
Sokpoti	7,098	100	39	61
Amanfa	7,098	100	20	80
Water Vendors		5	5	0
Total	28,039	400	147	253

Source: Field Data, Asante (2023)

Data Sources

To address the objectives of the study, primary data was sought from households and key persons. The households' data showed water security in terms of availability, accessibility, quality, quantity, safety, and sustainability, as well as the challenges they face in accessing alternative water supply systems. The data from the water vendors focused on the sources of water supply, preferred alternative water supply systems, benefits of alternative water supply systems to household water security, and challenges in accessing alternative water supply systems for households. The data from the key persons focused on the water supply, operations, delivery, and maintenance of the alternative water supply systems. However, apart from the target participants, the study sought data from other published and unpublished research articles, such as online and print journals, articles, memos, and gazettes. Other sources of materials were derived from various news portals and books in either soft, or hard copies, or both.

Data Collection Methods and Instruments

To address the objectives of the study, primary quantitative and qualitative data were collected through survey and interview methods. Kumar (2019) argued that data collection may be done with measurement methods, extensive; interviews, and observation. Data collection methods are the strategies used to collect data in a research study. Data collection instruments are the specific tools or materials utilised within those methods to gather data. The selection of appropriate instruments should align with the chosen data collection method and the research objectives to ensure the quality and reliability of the collected data. The study used a semi-structured interview schedule and an in-depth interview guide for the data collection, respectively. These instruments for data collection were preferred for their flexibility in terms of information gathering and ability to produce an accurate and high proportion of responses.

Interview Schedule

Interview schedule is an instrument used for collecting quantitative data. Interview schedule is easy to analyse, whereas most statistical analysis software can easily process them. The study used the interview schedule due to its known advantages of building a good rapport and creating a healthy atmosphere where respondents easily cooperate, answer questions, and clear doubt about any side of a study (Kumekpor, 2002). The interview schedules were given to the household respondents and contained both closed-ended and open-ended questions. The closed-ended questions were to solicit direct answers from household respondents, while the open-ended questions captured information that was not obtained by the closed-ended questions.

The interview schedule had 44 items, divided into 5 sections (A--F). Section A consisted of the demographic characteristics of the respondents. Section B covered sources of water supply for household water supply systems. Section C aligned itself with the preferred alternative water supply systems for household water security, whereas Section D focused on alternative water supply systems for household water security. Section E covered the challenges households face when accessing alternative water supply systems, and finally, Section F drew on the recommendations to improve alternative water supply systems for household water security.

In-depth Interview Guide

The in-depth interview guide (IDI) was another instrument used for the study. This guide was used for the in-depth interviews conducted with the water vendors and operators of the alternative water supply systems. The semi-structured interview guide was appropriate because it serves the purpose of triangulating findings. The semi-structured interview guide had open-ended questions in five sections. The first section of the guide looked at the demographic characteristics of the participants regarding the study’s objective.

Section two of the guide covered the sources and benefits of alternative water supply systems for household water security, whereas Section three explored why households preferred alternative water supply systems for their household water security. Section four of the guide contained the challenges of alternative water supply systems for household water security, and the final section of the guide looked at ways to improve alternative water supply systems for household water security.

The interview guide was considered appropriate because it served the purpose of triangulating and authenticating the findings from the household survey. To make sure that there was validity and reliability, the responses provided by the interviewees were repeated by the interviewers for the participants to confirm or otherwise. This ensured that the participants understood the issues well and their responses were not misrepresented by the interviewers or the recorders.

Data Collection Procedure

The researcher divided the study area into four sections (Buade, Sokpoti, Amanfa and Asanko for the data collection. The researcher together with three field assistants who were fluent in English Language, Ghanaian Languages such as Ga and Asante Twi were selected to interview household heads in the houses chosen through systematic random sampling. The field assistants got extensive training to grasp the study's aims, instrument items and content, practice in using the instrument, skill development exercises on interviewing and interpersonal communication, and discussions on ethical problems. The training took place in the second week of June 2023. The researcher's identity was introduced, and the purpose of the data collection was explained to the household heads who voluntarily consented to be part of the study. The data collection involving the interview schedule was done four weeks after approval from UCCIRB. The duration of time for the household survey was 10 minutes minimum and 15 minutes maximum, depending on the household's understanding of the questions. One-on-one interviews were conducted with the use of a semi-structured in-depth interview guide for key informants like water vendors and operators of alternative water supply systems. The interviews with a duration of 45 minutes, were done concurrently with the administration of the interview schedule after clearance was given. The interviews, with the consent of the participants, were recorded on a recording device for subsequent transcription.

Pre-test of instruments

The research instruments were pre-tested at Teshie within the Ledzokuku district to allow for the necessary modifications and effectiveness of the instruments in the field before the main data collection. The pre-test for this study was done using 15 randomly sampled households and two key informants at Teshie, a 7-minute drive away from Krowor, to guarantee the consistency of the instruments. The area was chosen due to its proximity to Krowor as well as the homogeneity of the water situation to that of the actual study area. The pre-test enabled the researcher to update the research instruments that were difficult to appreciate in the local Ghanaian languages.

Data Processing and Analysis

The data that contain both quantitative and qualitative information were scrutinised for legibility, completeness, and consistency. The quantitative data was coded and keyed into the Statistical Product and Services Solution

(SPSS) version 23 for data analysis. Statistical techniques, including descriptive statistics such as frequencies, percentages, charts, and cross-tabulations, were used for detailed analysis. However, the qualitative data collected were manually transcribed and coded. Thematic analysis was used to interpret and analyse the transcribed data.

The first objective of the study, which sought to investigate sources of water supply for household water security, was measured using descriptive statistics with the assistance of SPSS. The responses from the households were compared with those of the key informants as a benchmark for the validity of the data analysis. The second objective concerned preferred alternative water supply systems for household water security and employed descriptive statistics (mean, frequencies, SD), and cross-tabulations to arrive at the analysis. Concerning the third and fourth objectives, which sought to ascertain the benefits and challenges of alternative water supply systems to household water security, descriptive statistics and cross-tabulations were used to arrive at the analysis

Ethical Considerations

Social scientists generally have a responsibility not only for their profession in its search for knowledge and quest for truth but also for the subjects they depend on for their work (Saunders & Lewis, 2009). Therefore, the study conformed to ethical standards in order not to violate research ethics, and the study's methodology was subjected to official ethical considerations. Participants were duly informed about what the research was about and were asked whether they were interested in participating in the research while being assured of confidentiality. Also, anonymity was ensured, including the use of pseudonyms, and any sensitive data or reports analysis were masked. Details were kept private, while data was recorded anonymously. Before data collection began, participants were briefed on the study's relevance. Informed consent for key informants was sought through a letter of consent. The respondents' rights to participate in the study were guaranteed and protected if they agreed to participate.

Limitations of the Study

Data collected for the study was done from June 5th to July 7th ,2023. The researcher had limitations in the field. One of them was that some of the scheduled interviews could not be taken because some of the participants decided not to partake due to some level of anger. This was because the data collection was done during a conflict in the study area. However, the aim of the research, which was only for academics, was explained to them and the majority (90 percent) of them gave their consent to participate in the research due to the importance of the study to the municipality.

Another limitation was the unwillingness of respondents to partake in the survey. Some of the questions were not completed because the respondents complained of the time duration and could not read or write. The problem was, however, minimised by making sure that both the researcher and field assistants were fluent in at least three languages (English, Akan, and Ga), which were the most common languages among the indigenes and settlers. These limitations did not render the results of the study biassed or unscientific.

Chapter Summary

The study adopted a mixed-methods approach, consisting of a survey of 395 households and five key informants. Stratified and systematic sample techniques were used to sample households across four operational sections in the Krowor Municipality of the Greater Accra Region. An interview schedule and an in-depth interview guide were used to collect data from households and key informants, respectively. Analytical tools such as descriptive statistics were used in SPSS to analyse the quantitative data, whereas the interview with the key informants was transcribed and analysed thematically. Chapter four presents the results and discussion.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter presents the results and discussion of the survey and interview data collected on alternative water supply systems for household water security in the Krowor Municipality of the Greater Accra Region. A sample of 395 households was surveyed across Asanko Buade, Sokpoti, and Amanfa, the operational sections of the study area. Based on the objectives, this chapter is organised under the following themes: demographic characteristics of respondents, water supply sources for household water security, preferred alternative water supply systems for household water security, benefits of alternative water supply systems, challenges of alternative water supply systems, and ways to improve alternative water supply systems for households.

Demographic Characteristics of Respondents

This section covers the demographic characteristics of the respondents from Nungua in the Krowor Municipality. The analysis of the respondent's characteristics gives a clear understanding of other extraneous variables that may account for respondents' reasons for a particular component, therefore the need to explain this in the discussion.

Sex of respondents in the communities

The sex of respondents who participated in the study was discussed in Figure 3.

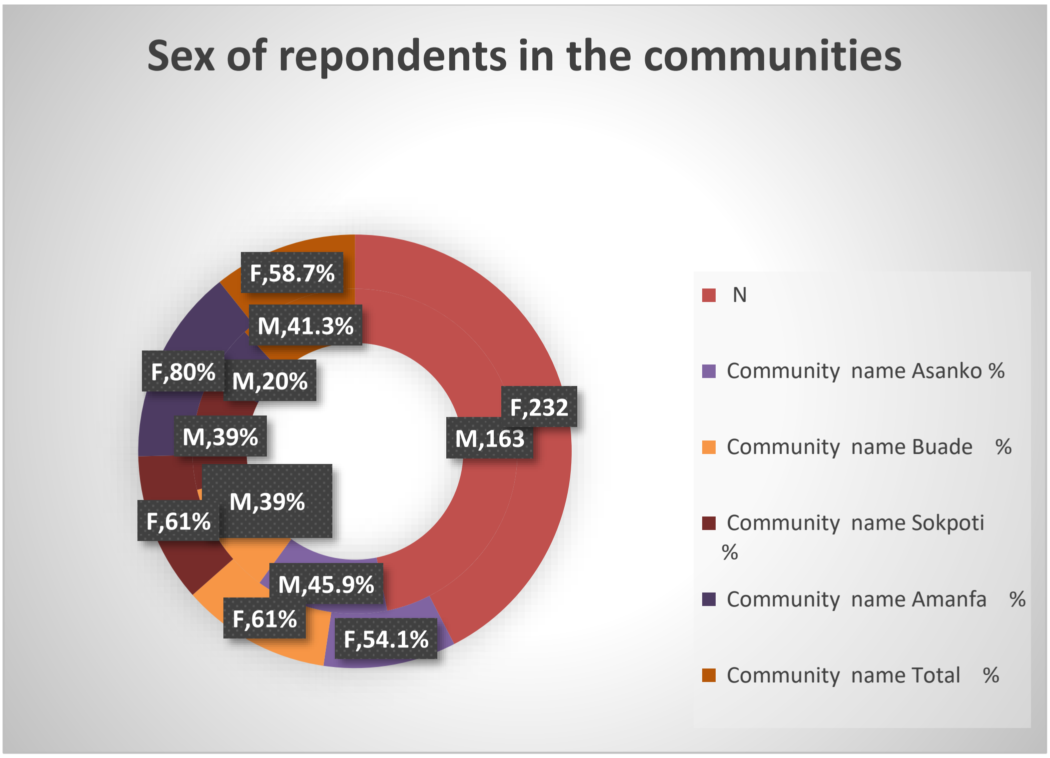


Figure 3: Sex of Respondents in Communities
Source: Field Data, Asante (2023)

The sex distribution of respondents in the communities indicated that for total male respondents, Asanko had 60.8 percent, followed by Buade constituting 45.9 percent, while Nungua had 39.0 percent, and Seawater had the least at 20.0 percent (Figure 3). The number of females who participated in the survey at sea water was 80.0 percent of the total respondents, followed by Nungua (61.0 percent), Buade (54.1 percent), and Asanko (39.2 percent). The data collected showed that there was more female participation (58.7 percent) as compared to 41.3 percent participation from men. This corroborates the findings of the Population and Housing Census by the Ghana Statistical Service (2021), which indicate the municipality has a higher female population of 52.1 percent and a male population of 47.9 percent. This shows the gender perspective of AWSs usage, their preference for alternative water supply systems, as well as the cost and challenges associated with alternative water supply systems (See Figure 3).

Age of Respondents

The age distribution may not paint a true reflection of the respondent's decision, but it can give a fair signal of influence in their water decision-making. Table 3 below shows the age of respondents who participated in the study.

Table 3 shows that the median age of respondents in the Krowor Municipality was 34.5years (skewness=1.222, mean= 35.5) with a quartile deviation of 7.00, while the minimum age in the study area was 18 years and the maximum age was 86 years in the study area. The findings of the study replicate the Ghana Statistical Service (2017) district report that concluded that the age of the respondents falls within the youthful age range (18-35).

Furthermore, observing the intra-communities in the study area, it was observed that the median age of respondents in Asanko was 35 years (skewness= 0.863, mean = 36.18) with a quartile deviation of 9.0. In total, the lowest age was 18 years, while the highest age was 70 years in Asanko. Conversely, the median age of respondents in Buade was 32 years (skewness = 1.069, mean = 35) with a quartile deviation of 10.0. On the whole, the lowest age was 18 years, and 79 years was the highest in Buade. Further, Sokpoti had a median age of 34 years (skewness = 1.069, mean =35) with a quartile deviation of 11.0. The minimum age was 18 years, while the maximum age was 86 years in Sokpoti. In Amanfa, the median age was 35 years (skewness = 1.845, mean = 36) with a quartile deviation of 11.0, while 20 years was the lowest age and the highest age was 86 years. The age distribution of respondents in the study is positively skewed (skewness = 1.222) indicating that the age of the majority of the respondents in the study is less than the mean age of 36.00 years.

Table 3: Age of respondents in the communities

Community	Mean Years	Median	SK	SD	QD	N
Asanko	36.18	35.00	0.863	12.016	9.0	98
Buade	34.57	32.00	1.321	14.108	10.0	97
Sokpoti	35.13	33.50	1.069	12.796	11.0	100
Amanfa	35.96	34.00	1.845	11.320	11.0	100
TOTAL	35.46	34.00	1.222	12.562	7.0	395

Source: Field data, Asante (2023).

Marital status of respondents

To better comprehend respondents' decisions about water management, usage, and preference, marital status highlights a better demographic point of view in analysing the issues of water usage and preference. Table 4 presents the distribution of marital status in the communities.

Table 4: Marital status of respondents in the communities

		Marital	Status				
Communities	Single (%)	Married (%)	Separated (%)	Divorced (%)	Widowed (%)	Total	N
Asanko	32.7	56.1	6.1	1.0	4.1	100	98
Buade	48.5	45.4	2.1	0.0	4.1	100	97
Sokpoti	43.0	49.0	2.0	3.0	3.0	100	100
Amanfa	41.0	56.0	1.0	0.0	2.0	100	100
Total	41.3	51.6	2.8	1.0	3.3	100	395

Source: Field data, Asante (2023).

Analysis in Table 4 shows that out of the total respondents (395), 51.6 percent represent respondents who are married, while 41.3 percent account for respondents with single status, followed by respondents who are widowed, 3.3

percent and 2.8 percent represent respondents with separated status. Further decomposition of the data shows that Asanko and Amanfa accounted for 56.1 percent and 56.0 percent, respectively, for respondents with the marital status of married, followed by Sokpoti at 49.0 percent, and Buade, (45.4 percent). Other marital statuses observed in the study covered respondents who were single, separated, divorced, or widowed. The single group in Buade, Sokpoti, Amanfa, and Asanko accounted for 48.5 percent, 43.0 percent, 41.0 percent, and 32.7 percent, respectively. This finding re-echoed the Population and Housing Census by the Ghana Statistical Service (2021) report that there are more registered married persons in urban areas than in rural areas, of which the study area is no exception.

Household size, expenditure on water, and years of stay in the communities

Another socio-economic determinant of water supply systems for households is the number of individuals in the household and the years of stay in the community. These offer a clear indication of how families will depend on water supply systems and the level of financial burden they go through in accessing water in the study area. From Table 5, the mean household size in the study area was 4 (median =4, skewness = 0.154) with a standard deviation of 1.623. Overall, the lowest household size was 1, while the highest household size was 9. This finding confirms literature that argues that household size, wealth quintile, dwelling area, and household head gender strongly influence the household choice of water sources (Fotuè, 2013). However, the average household size (4.00) contradicts the finding of the municipality's average household size. The municipality's average household size from the Population and Housing Census was 3.0 (GSS, 2021). The discrepancy between the study findings and that of the municipality figures may be underscored by the sampling approach. Since the municipal exercise covered the population in its entirety, whereas the study only assessed a fraction of one community in the municipality.

Table 5: Household size, years of stay, and expenditure in the selected communities

VARIABLES	Mean	Median	SK	SD	QD	MIN	MAX
Household size	4.00	4.00	0.154	1.623	1.00	1.00	9.00
Years of stay	13.07	9.00	2.002	12.750	7.00	1	75.00
Monthly Expenditure	106.7	90.0	1.279	55.185	30.0	20	300

Source: Field data, Asante (2023)

From the study, the median number of years lived in the selected communities was 9 years (mean = 13.07 years, skewness = 2.002) with a quartile deviation of 7. In total, the least number of years lived was 1 year, while the most lived number of years in the community was 75 years in the study areas. This signifies that all respondents have spent a useful part of their stay in Krowor. This, then, justifies the respondents' ability to convey to the author their varied views and experiences on the water situation over the years in the study area. This finding re-echoed the work of Adjakloe (2010), which explained that individuals who had lived in a community longer tended to define water quality based on its taste and colour. Younger people, on the other hand, were more concerned with the colour of the water, which they used to determine whether or not it was potable.

The study also investigated the monthly expenditure on water. It can be observed from Table 5 that the mean expenditure spent on the water in the individual communities was GHC 106.70 pesewas (Median = 90, Skewness =

1.2) with a standard deviation of 55. 185. In total, the maximum amount spent a month on water was GHC 300, while the minimum amount spent a month on water was GHC 20. This finding confirms Barbara and Ali’s (2015) finding that the amount of money spent on water offers some direction on what fraction of an individual's income is spent on water. In this case, areas that experience water shortages have a higher demand for water services as compared to those with constant water supply from Ghana Water Company Limited.

Sources of Water in Selected Communities

To address the first objective of the study, respondents in the selected communities in the Krowor Municipality identified the main sources of water supply for household water security. The sources of water for the individual communities in Krowor do not vary from the general picture. Table 6 shows the main sources of water supply for households in the selected communities in the Krowor Municipality.

From the analysis in Table 6, the study found that there are multiple sources of water supply for household water security in the Krowor Municipality. The availability of many sources of water supply gives the respondents several water supply sources to combine to meet domestic water needs. This included water from pipe-borne by Ghana Water Company Limited (99.5 percent) and harvested rainwater (0.5 percent). It is observed that the main source of water supply for respondents in Asanko (24.8 percent), Buade (24.1 percent), Sokpoti (25.3 percent), and Amanfa (25.3 percent) is pipe-borne water. However, except for Asanko (0.5 percent), rainwater, groundwater, and river and stream as alternative water sources were not recognised as water sources for the people in Buade, Sokpoti, and Amanfa, respectively. In this view, an overwhelming majority of the respondents (95.5 percent) who accessed water from pipe-borne water by GWCL were from Sokpoti, Asanko, and Amanfa (Table 6). Even though few people harvested rainwater for use over a time interval in Buade, it was supplemented with other sources, such as water from a pipe borne through Ghana Water Company. This finding corroborates the Ghana Living Statistical Survey (2017) conclusions that in urban areas, about 68.4 percent of households have access to pipe-borne water, but in most cases, the source is from outside the house. This finding also replicates Reed et al.'s (2013) arguments that domestic water supply can take different forms, such as a stream, a spring, a hand-dug well, a borehole with a hand pump, a rainwater collection system, a piped water supply with a tap-stand or house connection, sachet water, and via water vendors.

This finding was further confirmed by the water vendors in the communities. A 34-year-old male water vendor revealed during an in-depth interview that:

Initially, the source of water was from Akosombo, but currently, we are now using seawater; it was directly from Akosombo, and now it is seawater. It's from Ghana Water on the main line that has been laid.

Another participant said:

'*The source is from the Ghana Water Company Limited but since the Sea Water started operating, we do not take water from the Akosombo which was cut off due to the availability of the Seawater.'* (47-year-old Key informant I)

Table 6: Main sources of water supply for communities

Community	**Main Sources**					
	Pipe borne	Rainwater	Ground water	Rivers/Streams	Total	N
Asanko	24.8	0.5	0.00	0.00	25.3	98
Amanfa	25.3	0.00	0.00	0.00	25.3	100
Sokpoti	25.3	0.00	0.00	0.00	25.3	100
Buade	24.1	0.00	0.00	0.00	24.1	97
Total	99.5	0.5	0.00	0.00	100	395

Source: Field data, Asante (2023)

Usage and types of alternative water supply systems

In accounting for respondents' usage and types of alternative water supply systems for their household water security, the study found that 92.7 percent of respondents use alternative water supply systems for their household water security while the remaining 7.3 percent did not use alternative water supply systems for their household water security. Out of the 7.3 percent who do not use alternative water supply systems for their household water security, 7 percent have water directly accessed from the standpipe to their household, while the remaining 0.3 percent use tanker supplies for their household water security.

The study also finds out that, 31.6 percent of respondents agreed to use water tanks (poly tanks) for their household water security, followed by 1.8 percent who accessed water from wells for their household water security, 2.3 percent harvested rainwater as a type of alternative water supply systems, and 7.3 percent used a public standpipe for their household water security. Similarly, nearly over half (57.0 %) accessed water from reservoirs as their type of alternative water supply system for their household water security

(Figure 4). It is evident that the overwhelming number indicate the usage of alternative water supply systems for their household water security. This finding replicates the views of Guzman et al. (2016) and Eguavoen (2008), who argued that many households in the various regions of Ghana are faced with having to decide which source of water is more potable for household consumption because they must access water from different sources. This makes water user groups dynamic, giving households options to choose from, bearing in mind the minimisation of risks, especially during the dry season.

Figure 4 shows the usage and types of alternative water supply systems for household water security in the municipality.

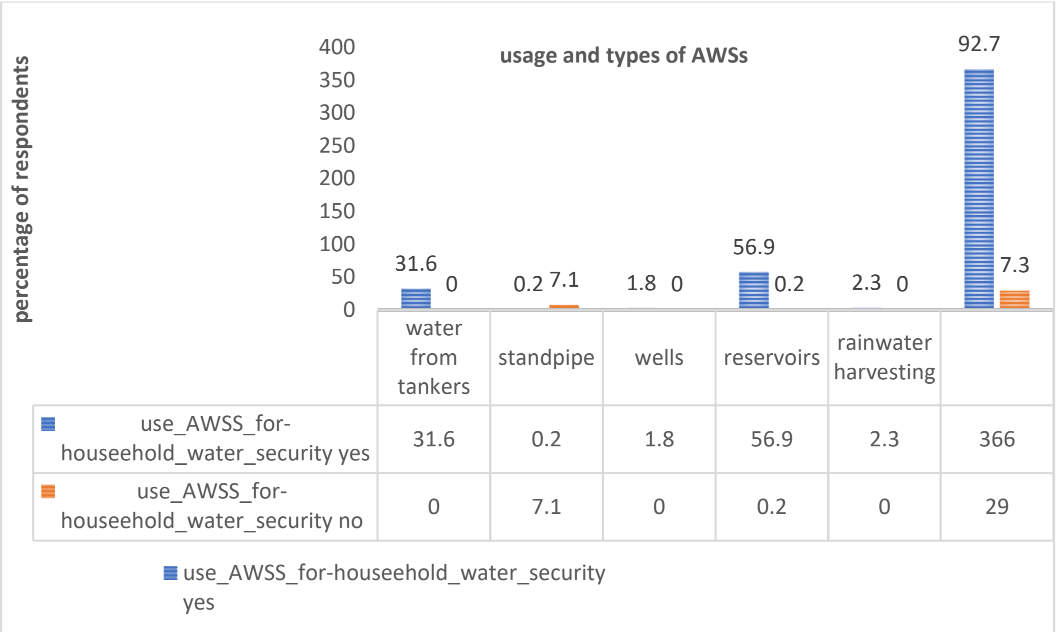


Figure 4: Usage and Types of Alternative Water Supply Systems.
Source: Field Data, Asante (2023)

Disaggregating the data further to understand the usage dynamics in the communities, it is observed from Figure 4 that people in Asanko, Buade, and Sokpoti used reservoirs for their household water security, accounting for 19.2 percent, 14.2 percent, and 13.2 percent, respectively. Conversely, people in Amanfa (11.1 %) and Sokpoti (10.4 %) accessed their water through water tanks (poly tanks). Only 1.8 percent in Buade harvested rainwater for their household water security, while 3.8 percent used a public standpipe as an alternative water supply system for their household water needs (see Figure 5).

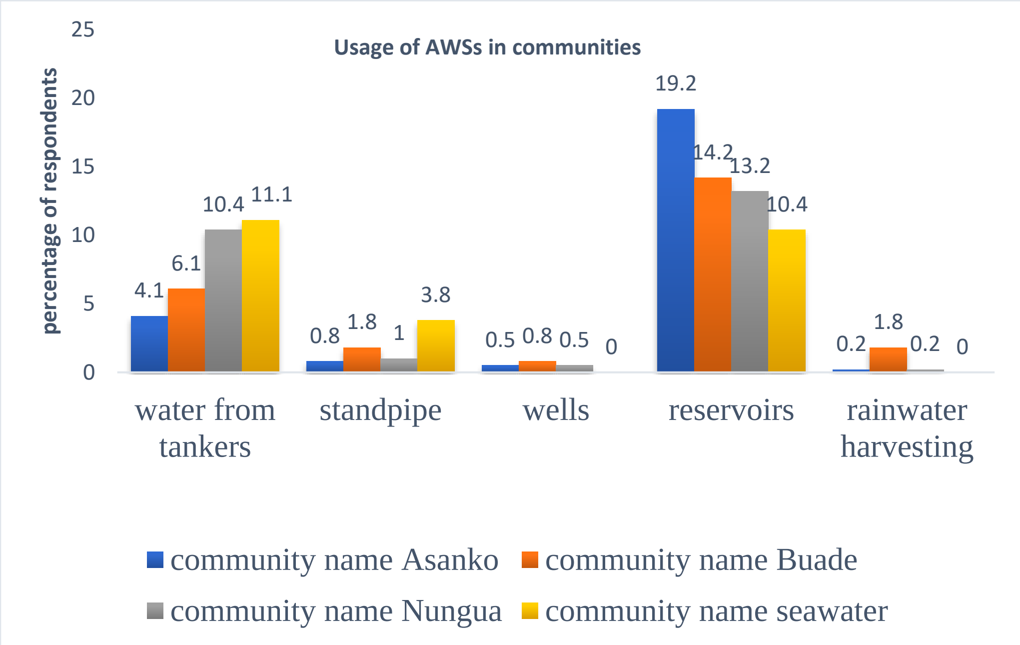


Figure 5: Usage of alternative water supply systems in communities
Source: Field Data, Asante (2023)

Table 7: Frequency of using alternative water supply systems for household water security

Frequency of alternative water supply systems use	Frequency	Percent
Daily	111	28.1
Weekly	189	47.8
Monthly	87	22.0
Other	8	2.0
Total	395	100

Source: Field Data, Asante (2023)

In the communities, the study identified the frequency of alternative water supply system usage. It is observed that 47.8 percent of respondents use alternative water supply systems weekly for their household water security, while about a quarter (28.1 %) of respondents use alternative water supply systems daily for their household needs. The remaining 22.0 percent used alternative water supply systems monthly, and 2 percent used alternative water supply systems once in a while and during periods of water shortages for their household water security (Table 7). The finding agrees with Vormowor (2017), who claimed that 43.8% of the household collect water three or more times within a week. while about a quarter (24.2%) of them collect water daily. This was confirmed during an in-depth interview when a 54-year-old male water vendor participant in Baude concurred that;

Households fetch water from the alternative water supply system every week. Do you know something? We store water in small water tanks, normally called 'Kufuor' gallons. People buy them in bulk to store the water accessed from these water supply systems. When you are going to fetch the water, you have to fetch all of them so that they will spend about three or four days before buying another bottle.

Another participant noted that:

'*Well, it is daily. Some also come monthly as well, especially those close to us; they do it monthly, but then those that are far away come to purchase it daily. That is how we operate*.' (34-year-old Key informant II)

Uses of alternative water supply systems for household water security

The study showed that respondents use alternative water supply systems for their household water security needs. Some of the respondents confirmed that they combine sachet water, bottled water, and alternative water supply systems for their various domestic water needs. As shown in Table 8, 32.7 percent of respondents used water from alternative water supply systems for washing purposes, followed by bathing at 32.6 percent, and 29.5 percent depended on alternative water supply systems for cooking purposes. Subsequently, respondents used alternative water supply systems for drinking purposes at 4.5 percent, whereas the remaining 0.7 percent used alternative water supply systems for other purposes, such as flushing toilets. However, it can be seen from Table 8 that most of the respondents considered alternative water supply systems for drinking purposes; instead, they used sachet water or bottled water with the presumption of being clean or well-treated for drinking. It was therefore apparent that most respondents in the municipality made use of water from alternative water supply systems. This finding from this study is in tandem with the views of Yahaya (2019) and Ghana Statistical Service (2021), who opined that alternative water systems increase water supply, which enables households to use it for domestic purposes, while the main source of drinking water for households in the Greater Accra region is sachet water. The predominance of sachet water in the region is a result of the heterogeneity of the inadequate water supply in the region.

Table 8: Domestic use of water from alternative water supply systems

Domestic Use	N	Percent
Drinking	51	4.5
Bathing	373	32.6
Cooking	338	29.5
Washing	374	32.7
Others	8	0.7
Total	1144	100.0

Source: Field Data, Asante (2023)

Furthermore, the study sought to find out in the communities on the purpose of using alternative water supply systems for their household water security. From the analysis in Figure 6, water from alternative water supply systems is predominantly used for washing, cooking, and bathing in all communities. In Asanko, 8.4 percent, 7.4 percent, and 8.1 percent, as well as Buade, 7.5 percent, 6.6 percent, and 8.1 percent, used water from alternative water supply systems for bathing, cooking, and washing, respectively, while 0.9 percent and 1.5 percent used it for drinking purposes. Similarly, in Sokpoti and Amanfa, respondents used alternative water supply systems for bathing, cooking, and washing, accounting for 8.1 percent, 7.8 percent, 8.0 percent in Sokpoti while Amanfa accounted for 8.6 percent, 7.7 percent, 8.7 percent, respectively. The use of alternative water supply systems for domestic water needs such as bathing, cooking, and washing dominates in three communities thus: Asanka, Sokpoti, and Amanfa (Figure 6).

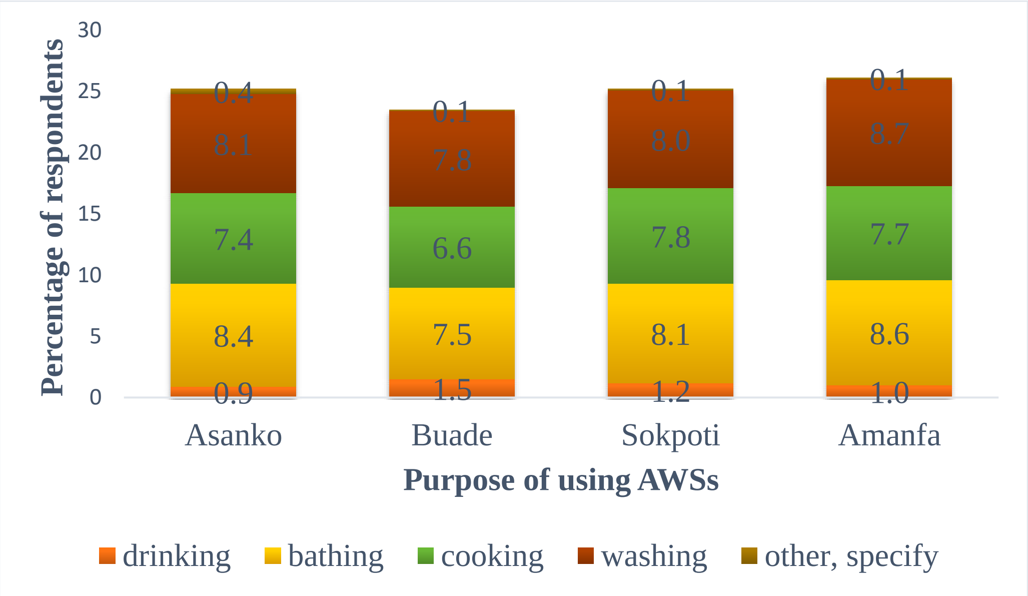
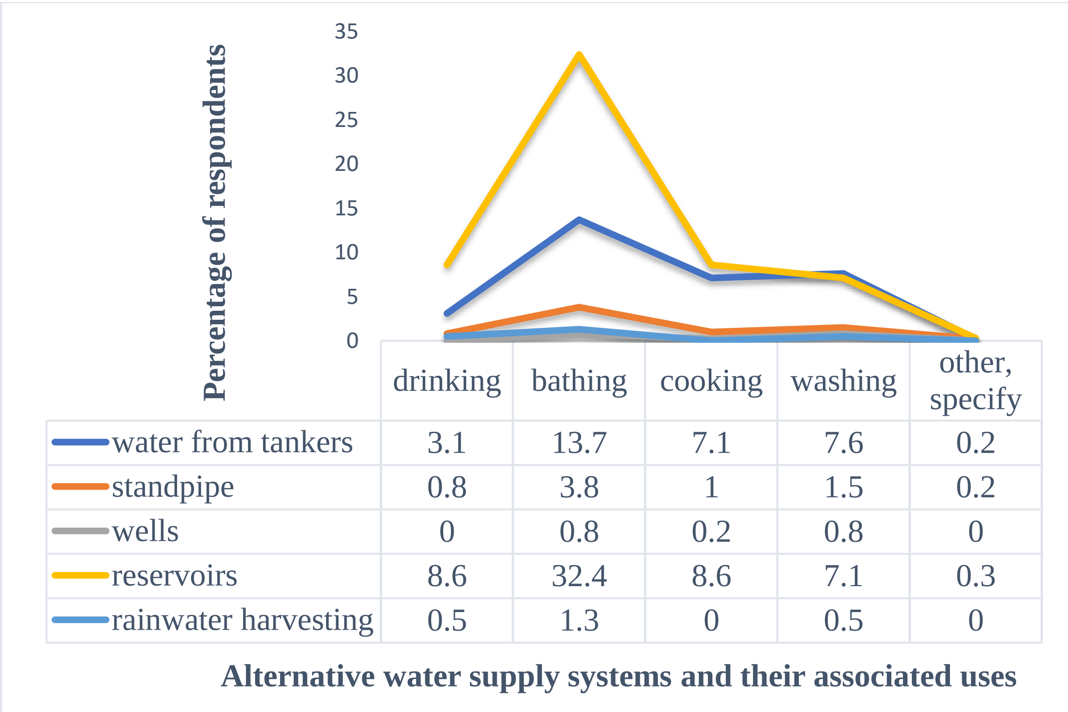


Figure 6: Purpose of using alternative water supply systems
Source: Field Data, Asante (2023)

Some of the respondents indicated that they tend to complement two or more types of alternative water supply systems to meet their domestic water needs. In Figure 7, 3.0 percent of respondents used water tanks for drinking, while 8.6 percent used water from reservoirs for drinking purposes. Further, for bathing purposes, 32.4 percent used water reservoirs the most, followed by water tanks (13.7%). For cooking purposes, moreover, water reservoirs top with 8.6%, followed by water tanks (poly tank, 7.1%), standpipes (1.0%), and wells (0.2%). Again, in terms of washing purposes, water tanks (poly tanks) lead with 7.6 percent, followed by water reservoirs (7.1%), standpipes (1.5%), wells (0.8%), and rainwater harvesting (0.5%). In contrast, wells were never used for drinking purposes due to the perceived salinity of the groundwater. The finding re-echoed the view of Leduc et al. (2009), who argued that using the alternative water supply systems will inevitably make potable water available for the majority of required water needs.



	drinking	bathing	cooking	washing	other, specify
water from tankers	3.1	13.7	7.1	7.6	0.2
standpipe	0.8	3.8	1	1.5	0.2
wells	0	0.8	0.2	0.8	0
reservoirs	8.6	32.4	8.6	7.1	0.3
rainwater harvesting	0.5	1.3	0	0.5	0

Figure 7: Alternative water supply systems and their associated uses
Source: Field Data, Asante (2023)

The plates show some identified water supply systems in the communities captured by camera during field observation.

Panel A: Water Reservoir

Panel B: Water Tank

Panel C: Water Reservoir

Panel D: Well

Plate 1: Several alternative water supply systems
Source: Field Data, Asante (2023)

Preference of Alternative Water Supply Systems for Household Water Security.

Availability of Alternative Water Supply Systems in Selected Communities.

The study further attempted to establish the households' preferred alternative water supply systems for household water security in Krowor. Due to the many types of alternative water supply systems available for use in the communities, respondents were presented with the opportunity to express their preference. Respondents' ability to choose from the available alternative water supply systems is influenced by the benefits or reasons that determine the choice of individual communities' alternative water supply systems for their household water security. These preferences, however, cut across all four communities, affecting the entire municipality rather than individual communities. Studies such as Bichai et al. (2015) and Sturm et al. (2009) found that several factors, including the quantity and quality of water given, temporal and spatial availability, social and cultural acceptance, storage, treatment, and distribution possibilities, as well as customer affordability, are considered while evaluating alternative water supply systems.

The study found that the rationale for using a particular alternative water supply system was determined by a multiplicity of reasons, such as the socioeconomic, geographic, and demographic characteristics of households. For household water security needs, individual communities use the availability of several alternative water supply systems to meet these household water demands. Table 9 provides results on the views of respondents on the availability of alternative water supply systems for their household water security in Krowor. The study reveals that 51.6 percent of respondents indicated that reservoirs are the most available alternative water supply systems for their household water security in Krowor, followed by water tanks (41.5 %). Again, 3.8 percent of respondents indicated wells as an alternative water supply system for their water needs, while the remaining 3.0 percent indicated that rainwater harvesting was an alternative water supply system available for household water security. Reservoirs are noted as a major source of alternative water supply systems available for household water security in Krowor. The finding of this study corroborates the views of UNCTAD (2011) and Slavik et al. (2020), who opined that water storage (reservoirs) has perhaps the greatest potential to deliver improvements in water management, while the constrained or scarce amount of water available is the primary factor that contributes to the necessity of utilising domestic water storage tanks, respectively. The conceptual framework (Figure 1) describes that unreliable water supply is expected to increase the use of alternative water supply by households for their household water needs.

An interview held with a male water vendor in the community further gave insights into the availability of these water supply systems in Krowor. According to a water vendor in Sokpoti, there are multiple alternative water supply systems for household water needs in the community. He said that;

'*Well, to me, I think two or three. I have seen the pipe and poly tank but I have not seen the well because the well is not effective. The 'bula' (reservoir) is different from the pipe because it is a pipe-borne transfer into the reservoir. Therefore, I think the reservoir is better and even okay than the well.*' (34-year-old Key informant II)

Subsequently, another participant during the interview affirmed that:

I can say that it is only the 'bula' (reservoir) and poly tank that are available here. When water is flowing, they fetch it from the pipe tap but when the pipe stops flowing, it is the 'bula' (reservoir) and poly tank that are available to access water; There are no wells, it's only the 'bula' (reservoir) and the poly tanks which are available.' (54-year-old key informant III)

Table 9: Availability of Alternative Water Supply Systems in the Communities

Name of Communities	Water tanks	**Availability of AWSs for Household water security (%)** Wells	Reservoirs	Rainwater harvesting	Total	N
Asanko	4.8	0.5	19.1	0.5	24.8	98
Buade	10.1	1.3	11.4	1.8	24.6	97
Sokpoti	14.4	1.5	8.6	0.8	25.3	100
Amanfa	12.2	0.5	12.6	0	25.3	100
Total	41.5	3.8	51.6	3.0	100	395

Source: Field Data, Asante (2023)

These indications dovetail with the views of people in the individual communities that reservoirs are the most available alternative water supply systems for household water security in Krowor. The study included a cross-tabulation between the communities and the available alternative water supply systems. The results, as shown in Table 9, clearly show the community's views were varied except for people in Amanfa, where all respondents indicated that rainwater harvesting is the least available alternative water supply system. In Asanko, respondents could not agree on the available alternative water supply systems for household water security, as 4.8 percent of respondents indicated water tanks (poly tanks), wells (0.5 %), reservoirs (19.1 %), and 0.5 percent for rainwater harvesting as their available alternative water supply systems for household water security.

Furthermore, in Buade, most respondents confirmed that reservoirs and water tanks were the available alternative water supply systems, accounting for 11.4 percent and 10.1 percent, respectively, while wells (1.3 %) and 1.8 percent for rainwater harvesting were accounted for as available alternative water supply systems for household water security. Again, in Sokpoti, most respondents claimed that water tanks (14.4 percent) are the most available alternative water supply systems, followed by reservoirs (8.6 percent), wells (1.5 percent), and rainwater harvesting (0.8 percent). A similar trend of responses was reported in Amanfa, but rainwater harvesting was not a recognised alternative water supply system in Amanfa (see Table 9). Among the two available alternative water supply systems in Krowor, reservoirs were more available in Asanko than in the other individual communities, while water tanks (poly tanks) were more prevalent in Sokpoti as compared to the other individual communities. The conceptual framework showed that the availability of alternative water supply systems will influence households to use them during periods of water scarcity (Figure 1).

Preferred Alternative Water Supply Systems for Household Water Security

As indicated in the previous discussion, households in the communities tend to combine many water supply systems to meet their domestic water needs. Despite the availability and combination of various water supply systems for water security, respondents tend to prefer a specific water supply system among the various water supply systems. Therefore, there is a need to identify the most preferred alternative water supply system among the lot as well as the determinant reasons that influence such preferences for the selected communities. From Table 10, the most preferred alternative water supply system for household water security is water tanks known as ‘poly tanks’ (48.6 percent), followed by reservoirs (43.0 percent). From the community’s perspective, the results as shown in Table 10 reveal different variations on the most preferred alternative water supply system in Krowor. The majority of the respondents in three of the four communities confirmed their views that water tanks (poly tanks) are the most preferred alternative water supply system for their household water security, accounting for 13.7 percent, 17.2 percent, and 14.2 percent in Buade, Sokpoti, and Amanfa respectively. However, the use of reservoirs as the preferred alternative water supply system appears highest in Asanko (20.0 percent), followed by Amanfa (10.4 percent), and least preferred in Buade (6.3 percent) and Sokpoti (6.3 percent). These findings confirm the finding of McCartney and Smakhtin (2010), who argued that water storage makes more water available by capturing water when it is in abundance and making it available for use when there are shortages.

The study, therefore, sought to find out the reason why most households preferred a specific alternative water supply system among the many. During an in-depth interview session with water vendors, one water vendor participant in Asanko revealed that;

'*They prefer the poly tank most at times. The reason why they prefer the poly tank is that, to them, they do not have access to what is within the tank. When there is dirt, you do not see it, but for the reservoir, when you open it, they get to see the filth, which is why they mostly prefer the poly tank. They think it's very neat, so when there is filth or dirt, they do not get to see it. This makes them prefer a poly tank to a reservoir'* (44-year-old Key informant IV)

Another male vendor participant during an in-depth interview in Amanfa conforms to the findings of the study, when he said:

'*They prefer the poly tank, and the reason is that sometimes I advise them that even if I am using the water, I use the poly tank. Because, if there is a problem on the main pipe when the problem is solved and the water is coming, it carries dirt, but when it gets to the poly tank and you are fetching it, the dirt* *goes down for the rest of the water to come up so that when you are fetching it, it looks safe*.' (47-year-old Key informant I).

Table 10: Preferred alternative water supply system to household water security

Alternative water supply systems	Communities				
	Asanko (%)	Buade (%)	Sokpoti (%)	Amanfa (%)	Total (%)
Wells	0.5	0.3	0.8	0.0	1.6
Reservoirs	20.0	6.3	6.3	10.4	43.0
Water Tanks	3.5	13.7	17.2	14.2	48.6
Rainwater Harvesting	0.8	4.3	1.0	0.8	6.9
N	98	97	100	100	395
Total	24.8	24.6	25.3	25.3	100

Source: Field Data, Asante (2023)

The perceived reasons that underscore respondents' choice of water supply systems were categorised under five determinants for the analysis. These include the water security determinant (i.e., quality, availability, accessibility, safety, and affordability) as the main reason, income, cost of water, seasonal variations, and location and time as other determinants for a preferred alternative water supply system (Figure 8).

From the analysis in Figure 8, the result shows that 34.7 percent of respondents prefer a specific alternative water supply system due to the availability of the water supply system, while 42.2 percent prefer an alternative water supply system mainly because it is accessible to them. Again, 9.6 percent and 6.6 percent prefer alternative water systems due to quality and affordability, respectively. Only 6.9 percent prefer a particular alternative water supply system because it is the safest alternative water supply system for their water supply. This indicates that safety is a minor issue considered by households when choosing a preferred alternative water supply system for household water security. Also, this might be attributed to the fact that water is a basic need for a livelihood and regardless of its safety, people will still have to use it. This finding reflects Vormawor (2017) which suggested that households prioritise factors including water source quality, availability, cost, and accessibility when purchasing water for domestic use. This conforms to the conceptual framework (Figure 1) that describes that households' preference for alternative water supply systems is determined by availability, affordability, quality, safety, and accessibility for their household water security reasons.

To validate the quantitative data, the study further sought to find the reasons why accessibility and availability are critical for household choice of a particular alternative water supply system. During an in-depth interview with a male water vendor participant in Buade, revealed that;

'*I will say some look at these things while others do not. The reason why I am saying some people look at these factors and others do not is that the poly tank, for instance, is covered so you only fill the poly tank from below or the mouth of the poly tank, and it's hygienic. The 'Bula' (reservoir) too, you fill it with water and not with your hand so it makes it hygienic for sale. Some fetch without looking at these reasons.*' (54-year-old Key informant III).

To verify the finding further, another 44-year-old male participant in Asanko noted that:

The thing is, everyone likes that when he sells or buys something, he or she has to get it where it is affordable to help them. They also look at the water to *see if it is clean or not because they use it for their health. They also look at the differences in affordability, and it is not far to get water, or if there is no water, that is when they go to long distances to access water, even if it is Tamale.*

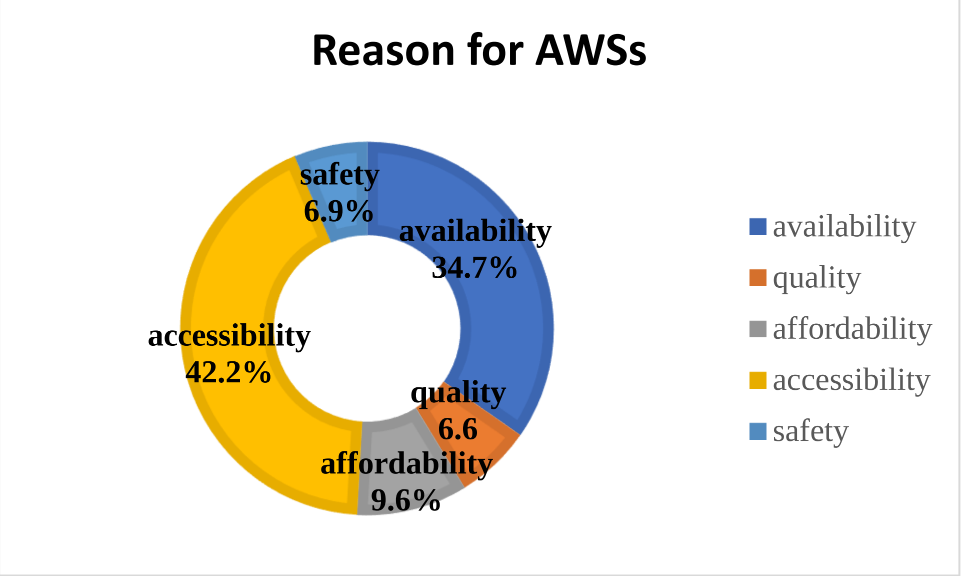


Figure 8: Determinant reason for preferred alternative water supply systems
Source: Field Data, Asante (2023)

The study also revealed that there exists a link between preferred alternative water supply systems and the main reasons for which these choices were made, as well as the selected communities and the main reasons for which these preferences were made. Table 11 presents a cross-tabulation between preferred alternative water supply systems by respondents and the reason determinant for their preference.

It can be observed from Table 11 that 21.3 percent prefer water tanks (Poly tanks) because it is accessible, 17.5 percent because of their availability, 4.3 percent due to their affordability, 3.3 percent, and 2.3 percent because of their safety and quality, respectively. The second most preferred alternative water supply system is reservoirs (19.2 percent), which is a result of their accessibility; 13.0 percent is due to their availability, 5.1 percent is because it is affordable; 3.5 percent is due to its quality; and 2.3 percent is because it is safe. Thus, the people consider safety and quality of water to be the least important issues when it comes to their preferred alternative water supply system and decisions that influence their preference. This finding parallels the view of Vermawor (2017), who opined that households prefer water sources because of quality and availability. A 54-year-old male water vendor agreed to this finding during an in-depth interview in Sokpoti:

'People often prefer to buy water from people who are neat and trustworthy, especially when it comes to selling water. They consider factors such as the location and the person they are buying from, as well as the quality of the water. For instance, people may wait for pipes to open to get water directly or fetch in excess to sell kenkey or 'banku' when the tap is closed. Additionally, they may bring wood and other materials into the water, which can cause Odor. Despite these factors, people still choose to fetch water from a well-maintained system, even in times of water shortages or closed taps.'

Another water vendor in Amanfa confirmed this view during an in-depth interview when she noted that:

'*The well, rainwater, poly tank, and 'bula' (reservoir) are all essential components in the water supply system. The poly tank (water tank) is covered to prevent air from entering, but it can be contaminated with sweat, rags, and gum. The rainwater can become dirty even with sunlight, making it difficult to maintain cleanliness. The quality of the well is high, but the price is low. It is* *impossible to predict how many people will use each component, as they may fetch different sources for different purposes.*' (47-year-old Key informant I).

Table 11: Preferred alternative water supply systems and the main reason for preference.

Preferred Alternative water supply systems	Reasons for Preference						
	Availability (%)	Quality (%)	Affordability (%)	Accessibility (%)	Safety (%)	Total (%)	N
Wells	0.8	0.2	0.0	0.2	0.2	1.4	6
Reservoirs	13.0	3.5	5.1	19.2	2.3	43.1	170
Water Tanks	17.5	2.3	4.3	21.3	3.3	48.7	192
Rainwater Harvesting	3.5	0.5	0.2	2.0	0.5	6.7	27
Total	34.8	6.5	9.6	42.8	6.3	100.0	395

Source: Field Data, Asante (2023)

The study also included a cross-tabulation of individual communities and the reasons for their preferred alternative water supply system in Krowor. Table 12 presents other determinants for preferred alternative water supply systems and communities in the study area.

From the analysis in Table 12, the results indicate that 14.7 % and 11.9 % of respondents in Buade and Asanko respectively prefer alternative water supply systems because of their accessibility, in terms However, in Sokpoti (13.2 percent) and Amanfa (12.4 percent) prefer alternative water supply system as a result of its availability while 9.6 percent was because of its affordability, 6.6 percent due it's quality and 6.3 percent because it is safe. A 34-year-old male water vendor further corroborated this finding during an in-depth interview in Amanfa when he indicated that:

You see, it depends on where you are and the area you are in. To me, in my environment, they do not think of that because they need water, and they want to fetch water, that is all. They do not consider this stuff. Yes, but you might go to other environments. Maybe those environments consider all those things. In my environment, they do not consider all those.

Table 12: Selected Communities and reasons for their preference

Name of Communities	Availability (%)	Quality (%)	Affordability (%)	Accessibility (%)	Safety (%)	Total (%)	N
Asanko	4.5	1.8	5.1	11.9	1.5	24.8	98
Buade	4.5	2.5	1.3	14.7	1.5	24.5	97
Sokpoti	13.2	1.0	2.8	6.8	1.5	25.3	100
Amanfa	12.4	1.3	0.5	9.4	1.8	25.3	100
Total	34.6	6.6	9.6	42.8	6.3	100	395

Source: Field Data, Asante (2023)

There are other determinants considered by households that determine their preferred alternative water supply systems for their household water security. However, in some cases, a blend of two or more of these other reasons was considered before the decision to choose a specific alternative water supply system was made. Therefore, the study sought to find out if these other reasons would influence households' preferred alternative water supply systems for household water security in Krowor. From the results presented in Table 13, 40.0 percent of respondents agree that income level is a reason for their choice of alternative water supply systems, while 13.9 percent were not sure about their income level influencing their choice of alternative water supply systems. However, 46.1 percent of the respondents disagreed with the view that income level is a reason for their choice of alternative water supply systems. This finding that the income level of individuals does not influence the choice of alternative water supply system is not in tandem with the findings of Osei-Akoto (2014) and Nketiah Amponsah, Woedem, and Senadza (2019), who opined that a variety of socioeconomic and geographical factors, including one's income level, play a role in determining which water is chosen for domestic use.

The location of an alternative water supply system is also considered a reason for some choices of alternative water supply systems. As shown in Table 13, one's location of an alternative water supply system is the least considered issue when 58.1 percent of respondents confirmed such a view, while 29.9 percent agreed that the location of an alternative water supply system plays a role in the choice of their preferred alternative water supply systems. Thus, regardless of the location of their preferred alternative water supply system is from their homes, it is unlikely that one will not switch to other alternative water supply systems that are available in the community. This contradicts the work of Osei-Akoto (2014), who argued that location and distance to water sources affect a household's choice of water sources.

Distance from the household to the water supply systems has the least influence on time spent in water collection, which is one of the other reasons for the choice of an alternative water supply system (58.1 percent), followed by 29.9 percent who conform to the view that time spent in water collection to a greater extent may influence their choice of an alternative water supply system, while the remaining 11.9 percent agreed or disagreed that time spent collecting water may influence their choice of an alternative water supply system. All things being equal, distance is transformed into time spent in water collection from an alternative water supply system. Therefore, households may prefer an alternative water supply system, irrespective of the time they will spend collecting water for their household water security. These findings are not in accordance with the findings of Vormawor (2017), who argued that location and time spent in water collection will have a greater influence on the choice of water supply sources.

Despite the variation in seasonal changes in Ghana, during the rainy season, rainwater complements as the ideal alternative water source. This influences the extent to which households will depend on other sources. From the results shown in Table 13, 58.7 percent of respondents indicated that seasonal changes play a minimal role as a reason for their choice of alternative water supply system, while 26.6 percent confirmed that seasonal changes play a direct role in their choice of preferred alternative water supply. Only 14.7 percent were undecided about seasonal variation playing a role in their choice of alternative water supply system. This converges with the views of Vormawor (2017) on seasonal changes playing an indirect role in the choice of water supply source. A participant during an in-depth interview in Asanko had an interesting view on time spent in water collection as well as distance when he said*:*

'They do not consider whether they have access to water or whether they will spend two hours fetching water. They form a queue when it gets to your turn, and you fetch it but when it is not your turn, you have to wait. They do not complain about time at all.' (44-year-old Key informant IV).

Subsequently, a water vendor interviewed opined that time spent collecting water and the distance a person would travel do not influence the choice of preferred alternative water supply systems. This was what a participant during an in-depth interview in Buade had this to say:

'*No, they do not consider the time they would spend. The individuals want to get water and have gotten it. If the individual spends about 30 minutes to get water, the individual has gotten water, or even if it's 5 minutes, the individual has gotten water. So, the individual does not consider time. Also, the accessibility means that the thing is there and can be bought. The person knows that when I go here, I will get it, so there is no problem coming to fetch water every day because of the access; when the tap is opened and it is flowing, they fetch it there but when it is close you get close to someone who has the poly tank. Even if it is far, the person will come and fetch because the person has no option'* (54-year-old Key informant III).

Finally, 60.8 percent of respondents indicated that the cost of purchasing water from an alternative water supply system plays an indirect role in their choice of preferred alternative water supply system, while 25.3 percent agreed with the view that the cost of purchasing water from an alternative water supply system influences their choice of alternative water supply system. Thus, water is a necessity irrespective of the cost involved; people will still afford the cost of water from their preferred alternative water supply system, whereas those with the cost of purchasing water influencing their choice expressed their views that some alternative water supply systems may be expensive while depending on other less expensive options of alternative water supply systems. This contradicts the finding of Rahut et al. (2015), who argued that affordability affects people's choices and behaviour and that wealthier households have better access to and can afford the installation and monthly rates of piped water, as opposed to poorer households. It affirms the theory underpinning the work that underscores that individuals would choose an alternative water supply system that maximises benefit (water security) and minimises cost (water insecurity) for their household water needs. A 34-year-old male water vendor participant confirmed this finding during an in-depth interview in Amanfa said that:

They look at the cost because we do not depend on one price. I do not know how others do theirs, but I am into different vendors, doing some investigation so that I know how to fix my price. I realised the prices are different. That is, market-wise you see, most times you have to consider certain things. I like this one very little. That is why I get a lot of people, so if I do not even operate, people come knocking at my door. People come knocking on my door because mine is very less expensive.

Table 13: Reasons for the preferred alternative water supply systems for household water security

Other reasons	Yes (%)	No (%)	Not sure (%)	Total	N
Income level is a reason for the choice of preferred AWSs	40.0	46.1	13.9	100	395
Location is a reason for the choice of preferred AWSs	29.9	58.1	11.9	100	395
Time spent in water collection is a reason for the choice of preferred AWSs	29.9	58.1	11.9	100	395
Seasonal changes are a reason for the choice of preferred AWSs	26.6	58.7	14.7	100	395
The cost of water from AWSS is a reason for preferring AWSS'	25.3	60.8	13.9	100	395

Source: Field Data, Asante (2023)

Benefits of Alternative Water Supply Systems for Household Water Security.

Reasons for using alternative water supply systems

In pursuance of the third objective of the study, the study intended to find out how alternative water supply systems benefited household water security in the study area. There were various reasons for using alternative water supply systems for household water security. The study found that 13.2 percent of the total respondents had cost savings as their reason for using alternative water supply systems for their household water security, followed by improved water quality (3.8 percent), then increased water accessibility (7.8 percent), improved water availability (74.4 percent), and other uses (0.8 percent) (Table 14).

In Table 14, respondents in Asanko had 46.0 percent of respondents who had reasons for using alternative water supply systems due to their improved water availability in the community, with Amanfa having the highest above 98 percent. However, in terms of increased water accessibility and cost savings as benefits for using alternative water supply systems, people in Asanko accounted for 17.3 percent and 30.6 percent of the total respondents, respectively. These findings are in accordance with Bichai et al. (2015), who claimed that using the alternatives will inevitably make potable water available for the majority of required needs. Alternative water supply systems (AWSs) have been cited as having a significant impact on diversifying and enhancing water supply sources (Agudelo-Vera et al., 2013).

Table 14: Communities by benefits of using alternative water supply systems

Name of Community	Cost saving	Improved water quality	Increased water accessibility	Improved water availability	Others	Total
Asanko	30.6	5.1	17.3	46.0	1.0	100
Buade	14.4	6.2	11.3	66.0	2.1	100
Sokpoti	8.0	2.0	3.0	87.0	0.0	100
Amanfa	0.00	2.0	0.00	98.0	0.00	100
Total	13.2	3.8	7.8	74.4	0.8	100

Source: Field Data, Asante (2023)

AWSs and water shortages to household water security

With people having to transport water from alternative water supply systems outside their homes, the study needed to identify the impact of alternative water supply systems on water shortage, stress, and vulnerabilities for the household. From Table 15, the study found that the majority (90.4 percent) of respondents said alternative water supply systems have decreased water shortages for their household water security, while the remaining 9.6 percent oppose the view that alternative water supply systems have decreased water shortages for their household water security. Further, through a breakdown of the data to understand the dynamics of alternative water supply systems' impact on water shortages in the communities, the study also found that the majority of the people in the individual communities agree that there is improvement in the water supply. These agreements were identified as both people in Asanko and Sokpoti had the same level of agreement (24.0 percent), while 0.8 percent and 1.3 percent of respondents said water shortages are still a problem despite the availability of alternative water supply systems in Asanko and Sokpoti, respectively. People in Buade (24.7 percent) agreed with the view that the presence of alternative water supply systems has lessened the issue of water shortage. However, in Amanfa, 20.0 percent confirmed the view that alternative water supply systems do solve water shortages while the remaining 5.2 percent disagreed with the indication that alternative water supply systems have reduced water shortages in the community. Findings from this study replicate the view of Jussah, Orabi, Sušnik, Bichai, and Zevenbergen (2020), who argued that potentially alternative water supply systems have been shown to contribute to supply augmentation and diversification by improving system resilience and service. In developed economies, water transport tends to be of a short-term nature and relied upon in response to emergency cases such as water pipes freezing or being used to supply isolated rural communities (Arasmith, 2011).

Table 15: Alternative water supply systems and water shortages

Name of **Community**	**Alternative water supply on Water shortage**			
	Yes %	No %	Total %	N
Asanko	24.1	0.8	24.9	98
Buade	22.3	2.3	24.6	97
Sokpoti	24.0	1.3	25.3	100
Amanfa	20.0	5.2	25.2	100
Total	90.4	9.6	100	

Source: Field Data, Asante (2023)

AWSs and water scarcity, stress, and vulnerabilities to household water security.

Respondents in both communities identified alternative water supply systems as a means of improving water scarcity as well as reducing the stress and vulnerabilities households would go through to access water for their household water security. The study found that households benefit greatly from water scarcity due to the availability of alternative water supply systems in their communities. Again, alternative water supply systems have enabled respondents to reduce the stress and vulnerabilities they would encounter for their household water needs. Based on the responses, improvements in water scarcity as well as stress and vulnerabilities were categorised under three main items. These include "yes", "no", and "not sure". As shown in Table 16, the study found that 84.8 % of respondents agreed it had reduced the level of stress and vulnerabilities they may encounter for their household water security needs, while 7.9 percent were undecided about alternative water supply systems' positive impact on stress and vulnerabilities. Only 7.3 percent of respondents, however, opposed the view that alternative water supply systems have decreased the stress and vulnerability households go through to access water. This finding confirms the view of Jepson et al. (2017), who argued that water security is the capacity to access water without stress and to benefit from reliable, affordable, sufficient, and safe water for healthy lives and well-being.

In identifying the positive impact of alternative water supply systems on stress and vulnerability to respondents, a 34-year-old male water vendor confirmed that;

Let me say yes because when there is no water, especially where I am now, people go far away to get water. That even causes more stress because someone might have five 'gallons', eight 'gallons', or ten 'gallons.' When they come to my place to fetch or purchase water, the stress level is reduced. But *when there is none and the person goes to a different place, this number of gallons is not easy to carry because they are heavy, but when the pipe is flowing, they are happy because there is no stress to access water.*

A response that conforms to the findings of the study from another participant in Sokpoti said*:*

'We have helped the community a lot. In the past, when the tap was closed, sometimes the tap could be closed for three days, and even during these three days, there was water in the reservoir for households when the water of households get finished. I can say we are not in any sort of pain or suffering to access water. That is why I am saying alternative water supply systems have solved most of the stress and the vulnerability levels of households.' (58-year-old Key informant V)

The study also found that the majority of the respondents agreed with the assertion that alternative water supply systems have reduced the issues of water scarcity in the communities. From the analysis as seen in Table 16, 80.5 percent of the respondents indicate that the presence of alternative water supply systems has led to the reduction of water scarcity in the communities, followed by either agreeing or disagreeing on water scarcity due to the availability of alternative water supply systems (14.2 percent). Conversely, 5.3 percent of respondents oppose the view that alternative water supply systems have reduced water scarcity for household water security in their communities. As shown in Table 16, it was observed that indications for the reduction in water scarcity by alternative water supply systems for household water security were high in Asanko and Amanfa communities, accounting for 20.2 percent and 24.5 percent, respectively, followed by Buade (18.2 %) and

Sokpoti (17.5 %). However, opposing the view on the usage of alternative water supply systems reducing water scarcity for household water security was low across all communities in Krowor, accounting for only 2.0 percent, 0.7 percent, 2.3 percent, and 0.2 percent, respectively, in Asanko, Buade, Sokpoti, and Amanfa. This finding replicate Wilcox, Nasiri, Bell, and Rahaman (2016) findings, which posited that alternative water supply systems are sustainable systems of water that can contribute significantly to increasing water supply security in regions experiencing increasing water scarcity through extraction and low rainfall.

This was also confirmed during an in-depth interview with a water vendor in one of the communities, where a male water vendor revealed during an interview session that issues of water scarcity are now a thing of the past due to the many alternative water supply systems available. He said;

'*That one, I will say yes, because even if there is no water, I have to buy some from the water tanker to fill my poly tank so that I can sell* it *so that at least in one or two days there will not be total water scarcity. On the stress, I will not say yes because if I am the only person selling and if there are water shortages, you will see people carrying 'gallons' to search for water until they can bring it (water tankers supplies), then they will also start buying* it' (47-year-old Key informant I)

Another male water vendor participant during an in-depth interview in Amanfa gave a fascinating view on the issue of reduction in water scarcity, he said:

'*Frankly speaking, it has improved seriously because it was not like that. I have not experienced water scarcity for about a year now. Yes, seriously, it* *has improved. So, I think they are working on it very well'* (34-year-old Key informant II).

Table 16: AWSs and water scarcity, stress and Vulnerabilities

Stress and vulnerabilities (%)	Name of Community				
	Asanko	Buade	Nungua	Sea water	Total
No	0.5	2.0	4.8	0.0	7.3
Yes	21.5	20.2	18.0	25.1	84.8
Not sure	2.8	2.3	2.5	0.3	7.9
Total	24.8	24.5	25.3	25.4	100
Water scarcity (%)					
No					
Yes	2.0	0.7	2.3	0.2	5.3
Not sure	20.2	18.2	17.5	24.5	80.5
	2.5	5.6	5.6	0.5	14.2
Total	24.7	24.5	25.4	25.2	100

Source: Field Data, Asante (2023)

Alternative water supply systems and productive activities

Households in the study area use alternative water supply systems to scale up their productive activities and household water needs. As indicated by the study area, the study identified four main productive activities done by households. These include work productivity, housework productivity, school productivity, time spent in water collection, and household well-being. This underscores the theoretical underpinning of this study: a healthy body, safety, education, a good job, and the ability to visit loved ones are examples of valuable activities and states that contribute to people's well-being. Although they are tied to products and income, functioning explains what a person can do or be as a result of them. When a person's basic demand for food or water (a commodity) is met, they enjoy the benefits of being well-nourished (Sen, 1999).

From the analysis in Table 17, it was clear that the majority (94.2%) of respondents obtained water from alternative water supply systems as their means of getting to work early. However, the remaining 5.8 percent of respondents do not obtain their water through alternative water supply systems, which enable them to get to work early. On house chore productivity, the analysis revealed that the majority (94.9%) of respondents had enough water from alternative water supply systems for their house chore activities, while the remaining (5.1 %) of respondents did not use water from alternative water supply systems for their house chore activities. Furthermore, the study also found that 90.4 percent of respondents revealed that their children can go to school regularly since they have access to water from alternative water supply systems for their household water needs. Inversely, 9.6 percent of respondents do not think alternative water supply systems affect the productive activity of their children going to school. Moreover, usage of alternative water supply systems positively affects household livelihood, as the analysis revealed that the majority (94.7%) of respondents use water from alternative water supply systems for their livelihood support. Therefore, it signifies that people in the municipality depend on alternative water supply systems for their productive activities and household water security. These findings confirm the views of Jepson et al.'s (2017) approach to capability, who argued that water security, in which access to adequate water is inextricably linked to "the functioning necessary for basic human existence.

They said that society cannot move forward if people do not have access to enough safe water and sanitation. This also confirms Lowe et al.'s (2019) work, which highlighted better health, time savings, expenditure savings, empowerment, community capacity, food security and improved nutrition, school attendance, productivity, and income as potential implications of improved water on livelihoods.

These findings were also confirmed during an in-depth interview with a water vendor. A man, aged 44, revealed that;

Going to work early, the alternative water supply system has helped in some way. When you know you want to go to work and there is no water, you know that when you come here by 5:30am, you will get water. When the water is not finished, fine, but when there is water inside the systems, they will get some. When there is water inside the supply systems, it can take about two days for it to get finished; sometimes it gets finished and people do not get water. It has helped the natives go to work. In terms of house work, the same thing applies. They use it to cook food for sale, and at some request, they fetch it to their homes for cooking and then to sell. It has helped everyone, even with the schoolchildren, especially whether there is a queue or not, they fetch directly. They are not allowed to wait to delay their school activities.

Another participant interviewed said:

'*Yes, definitely, because if you do not have water, how are you going to wash? Yes, your washing will be slow; everything will be slow. I could remember there was a time that at least it was Sunday that they had to go to church, and when we went to church, they were saying that because there was no water, we had to walk over a distance in search of water. So, it also contributes a lot* *by making sure there is water available every day*.' (47-year-old Key Informant I).

Table 17: Alternative Water Supply Systems and Household Productive Activities

Productive activities	Yes		No		
	Freq	Percent	Freq	Percent	N
Work	372	94.2	23	5.8	395
House chores	375	94.9	20	5.1	395
Education	357	90.4	38	9.6	395
Livelihoods support	374	94.7	21	5.3	395

Source: Field Data, Asante (2023)

Alternative water supply systems and conventional water supply systems

The study sought to find out whether alternative water supply systems have reduced the pressure on traditional water supply systems in Krowor. Respondents were thus asked to indicate a yes or no response to the notion that alternative water supply systems reduce pressure on traditional water supply systems. From the results presented in Table 18, 47.4 percent of respondents indicated that alternative water supply systems have decreased their dependency on traditional water supply systems. Also, 29.6 percent of respondents, however, noted that the supply systems have not reduced the dependency on traditional water supply systems, while 23.0 percent of respondents were undecided on the view that alternative water supply systems have decreased the dependency on traditional water supply systems. It is evident based on the overwhelming majority's indication that the usage of alternative water supply systems has reduced the dependency on traditional water supply systems in Krowor. These findings corroborate the views of Loáiciga (2014), who argued that AWSs present a substantial opportunity to enhance water efficiency and free up conventional sources for potable supply. The burden on existing sources can be lessened, and the supply-demand gap can be closed with the help of alternative water supply sources (Agudelo-Vera et al., 2013).

The study, therefore, sought to find out the reasons why alternative water supply systems have reduced the dependency on traditional water supply systems. During an interview session, one male water vendor noted;

'Let me send you back to those days when we were using the Akosombo, and maybe I have stored some water in the poly tank. That is an advantage for me as a vendor because I will not sell it to the users as I do sell from a normal pipe. I will be afraid to sell the water in the poly tank because when it finishes that will get me into trouble because I had to go and access water for myself which will not be easy. So, it has reduced the pressure on conventional water supply systems (34-year-old Key informant II)

Another response from a 58- year-old male participant who sought to agree to the assertion that alternative water supply systems have decreased dependency on the traditional water supply systems in Sokpoti said that:

Ooh, we do not have many problems because the tap is not closed for 24 hours. Hardly will you see the tap closed for 24 hours in this area. That was in the past, but in recent times, it is hard for you to see that the tap has been closed for 24 hours. Even if they close it for 24 hours, it would still be open for some people if the water was flowing; if it reached their end, it would close by 12; another day the water itself would go forward. So, we do not have much of a problem.

The study also included a cross-tabulation between the communities and a reduction of dependency on traditional water supply systems as a benefit of alternative water supply systems usage. Analysis from Table 18 reveals that except for Buade (10.1 percent), all respondents view alternative water supply systems as having reduced dependency on traditional water supply systems in Sokpoti (12.9 percent), Asanko (12.2 percent), and Amanfa (12.2 percent), respectively. In Buade, 11.6 percent of respondents oppose this assertion that alternative water supply systems reduce the dependency on traditional water supply systems. Conversely, the analysis shows that the indication that alternative water supply systems reduce dependency on traditional water supply systems significantly cuts across all communities.

Table 18: Alternative Water Supply Systems and Conventional Water Supply Systems

Communities	**AWSs and traditional water supply systems (%)**				
	Yes	No	Not sure	Total	N
Asanko	12.2	4.3	8.3	24.8	98
Buade	10.1	11.6	2.8	24.5	97
Sokpoti	12.9	7.1	5.3	25.3	100
Amanfa	12.2	6.6	6.6	25.4	100
Total	47.4	29.6	23.0	100	395

Source: Field Data, Asante (2023)

Challenges in Accessing Alternative Water Supply Systems

The challenges individual communities face when accessing alternative water supply systems for their household water security were evaluated on a 3-point Likert scale after discussing other related issues in the previous sections. These challenges include the cost of water, the safety of the water supply systems, maintenance of the water supply systems, treatment of water, unacceptability for drinking purposes, and water quality. Out of the 395 respondents earmarked for the study, all 395 responded. This represents a response rate of 100%. As a result, data used for objective four were obtained from all 395 respondents for the study because the average response rate for a large sample size (100 and above) is 52.7 percent, while for a smaller sample size (20 and below), should be 80 percent or more (Kaplowitz et al., 2014; Nielson & Knardahi, 2016). This then justifies that, with a 100 percent response rate, the data available was useful for this analysis. Table 20 shows respondents' responses to various questions about their level of agreement regarding the challenges of accessing alternative water supply systems for their household water security.

Analysis from Table 19, clearly indicated that the most challenging issue in accessing alternative water supply systems has to do with the unacceptability of water for drinking purposes to households with 84.3 percent of respondents agreeing to it. Thus, respondents would use alternative water supply systems for other domestic water purposes like cooking, bathing, and washing while purchasing sachet water as their main source of drinking water because they perceived the sachet water to be safer than the alternative water supply systems. A male vendor interviewed in Sokpoti gave this reason;

'*The water is salty; you cannot drink it unless the salt has been extracted from it. Again, what they use it for is to cook and for washing. When you use it for washing, it doesn't lather with soap like the way Akosombo water did. Sometimes, when you put the water into any metallic bowl or bucket, it rusts.*

No matter how they do it, it cannot be compared to the one from Akosombo' (58-year-old Key informant V).

Another interesting reason came out during an in-depth interview with a male vendor in Amanfa, when he revealed:

'*You know it is exactly this one that is direct to your stomach. But if you tell me, I should drink this one. This one is also going direct, so if there are some bacteria in it, meaning that through this one you have been told that this one is purified, so you understand it. But if you tell me this one is purified, I will not. When these people are coming, they will tell you we put the water in the poly tank and bring it through the machine again for you to sieve it before you drink it. But this one is direct. You know, the first time they drank from the tap directly, they were not afraid, but now someone will say our eyes have opened to the extent that we think this one is poor. So, they will not drink it.*

We are being deceived; they are purifying this one. So, it is bad. He noted that so far as this one we are drinking it, we also use it for washing and cooking, that is all. Even with the cooking- you boil it, so whatever is in the water will go. But this one, it is a direct drink that goes straight into the stomach. So, if you tell me I should go and put my mouth on that tap and drink it, no way.' (47-year-old Key informant I)

One participant's reason for why purified water was preferred for drinking purposes as compared to alternative water supply systems was the perceived treatment of the purified water, which has made it drinkable as compared to water stored in alternative water supply systems. He said:

'*The 'pure' water has passed through a lot of processes and has been well distilled and made drinkable. Because it is also safe, they like pure water, but* *with the 'bula' (reservoir), when water is stored in it for a little while, you can see dirt at the bottom. Again, when the tap is opened it is accompanied by dirt and when it is stored for a longer time, the dirt accumulates. That is why people prefer purified water*.' (44-year-old Key informant IV).

Another challenge has to do with the water from the alternative water supply systems being expensive. The data from the survey showed that more than half (77.5 percent) of all respondents confirmed the view that water from alternative water supply systems for their household water security is expensive. This, then, made other options for alternative water supply systems clear to people with low-cost access for their household water security. In an in-depth interview with a water vendor in Asanko, a-44-year-old revealed that:

The challenge and problem we have is that Ghana Water Company has increased the price of water to us, the vendors that made us feel this great impact. We have to increase the prices for the users to bear the cost.

Another male participant had a contrasting view about the cost of purchasing water from alternative water supply systems. He opines that the cost of water from the water supply systems is not an issue to worry about if these systems are accessible, but when water becomes scarce, that is where the increment comes in. During the interview, he highlighted:

'*Oh no, it does not affect them. From time to time, they get access to these alternative water systems, so it is not much of a worry to them than if they do not get access to the water systems*.' (54-year-old Key informant III)

The other challenge was how much time is spent on water collection from alternative water supply systems. The data showed that more than half (60.5 percent) of respondents indicated that collecting water from alternative water supply systems consumes too much time. This indicates that respondents have to queue for minutes or hours to access water from the alternative water supply systems. Furthermore, maintenance of the alternative water supply systems was challenged, and 48.8 percent of respondents were of the view that alternative water supply systems lack maintenance.

This could be attributed to the fact that some of the water supply system infrastructure has been built over years without improvement or that water stored in the systems has not finished for such maintenance. A 44-year-old male water vendor confirmed this finding when he said:

Water is life, and therefore your system should be clean. Because maybe the person fetching the water does it purposely for drinking if the person cannot afford the purified water. The person then fetches the water into something for drinking. We decided to keep the system clean so that the individuals buying it will get good health from using this water supply system.

Another participant viewed maintenance as a contributing factor that affects water access from these alternative water supply systems. In his opinion, during an in-depth interview session in Buade, he said:

'*If you do not keep the water supply system clean, you will not also get clean water. It will be a terrible thing to you. If something is an eye saw, you will not feel comfortable using or seeing it. Because you will be drinking from these systems, you have to maintain them so that people will benefit from accessing the water*.' (54-year-old Key informant III).

When respondents were asked to evaluate the safety of alternative water supply systems for their household water security, about 60.5 percent said that alternative water supply systems were safe for their household water security. This answer was given based on their understanding of alternative water supply systems. The remaining 20 percent and 19.5 percent of the respondents said that alternative water supply systems are unsafe or undecided, respectively. This was because most alternative water supply systems built or sitting have been covered with impenetrable materials. The study further sought to validate the reasons why safety is not considered a challenge. A 44-year-old water vendor, during an in-depth interview, noted that:

The company checks the cleanliness of the water when opening and closing the tap from Ghana Water Company. After fixing a fault, the water remains clean. We wait until the water gets clean before we fetch it into our 'Bula' (reservoir). However, consumers often complain about the dirty water, claiming it is used only for washing utensils and cooking. Therefore, we wait for clean water before selling it to consumers.

A male water vendor participant also has this to say:

'They will never complain about it. Let us say at first, they were using the Akosombo, and now, it is the seawater. Where will you fetch the water? You do not have any options. Will you carry your water 'gallon' from here, go to, let us say, Ashaiman, and fetch water? No! So, definitely, whatever the water vendor has here is what the user is going to use. So, they have no option than to use this water supply system for their household water security' (47-year-old Key informant I).

Another observation made from the data revealed that 38.0 percent of respondents were, however, in disagreement with the view that transporting or carrying water on the premise of alternative water supply systems requires energy. The community members, who relied on the systems as their source of domestic water uses, believed that carrying water or transporting it was taken care of by the water suppliers. Unlike in the past, water suppliers or vendors have provided pipe holes or smaller pipes connecting to the water supply systems to households' homes for water supply at a fee. Therefore, there is less laborious work or energy required in transporting water from the source to the household. This finding parallels Vormamwor's (2017) study, which argued that carrying and transporting water over long distances poses a greater risk.

This was confirmed during an in-depth interview session when a 54-year-old male water vendor in Buade said:

I can say it reduces the level of individuals carrying water. Back in the day, there were people called 'awanlowa'. In 1967, the 'awanlowa' had a stick put at the extreme ends of the tank to fetch water for the females; in those days, there was a government pipe. If you want, you can call the 'awanlowa' to fetch water for you. It is just, like now, quite similar. If you let me know you want water, I will then connect the pipe holes to access the water for you. The same thing the man carries is what I have brought to your home. I don't carry them; I just connect them when it is full and then I close it.

Another participant during an interview highlighted this as a reason for requiring less energy to carry or transport water to their household. He opined:

'*One thing is that selling water became a competition. So, because it became a competition, there might be an old person without any grandchildren by his side. Even if there is a grandchild, the child might decide not to go. But now* *people have decided to call me so that they will use the pipe holes to fetch water, and now it has become a whole work on its own*.' (58-year-old Key informant V).

The last but not least challenge has to do with the treatment of water from alternative water supply systems for household water security. It is observed that the majority (44.8 percent) of respondents were undecided about the view that treatment of water from alternative water supply systems poses a threat to their household water security needs, followed by disagreement (32.4 percent) and agreement (23.0 percent) on how treatment of water from alternative water supply systems poses a challenge to their household water security. This indicates that most respondents are convinced of water from alternative water supply systems; this then makes them consume water from the systems without prior treatment. A 58-year-old male water vendor in Sokpoti confirmed the finding when he said:

A big challenge: If you are referring to water treatment, no one likes something bad. If it is high and the rubber is placed under it when opened, you can see it is even cleaner than the pipe water. When you give it like one hour or two hours, you will not see any dirt, but when the water flows and washes your system, it comes out of the poly tank for you to see the dirt that settles under it.

A participant during an interview in Buade also expressed his thoughts on treated water, from alternative water supply systems to household water security. He said people had running stomachs and watery stools mainly because water is not adequately treated from the source before use. In his narration, he said:

‘*When sea water initially came, people who drank it had running stomachs and watery stools. This meant clearly that the treatment was not so good.*’ (54-year-old Key Informant III)

Finally, data showed that though there were challenges in accessing alternative water supply systems to meet household water needs in the municipality, the issue of water quality falls out of the pecking order. More than three-quarters of respondents surveyed were undecided on the view that poor water quality from alternative water supply systems is a grave issue for their household water security, while 25.6 percent and 29.3 percent respectively, either agreed or disagreed on the view that poor water quality from alternative water supply systems serves as a hindrance or not to their household water security. This finding of the study re-echoed the Vormawor (2017) conclusion that most people do not see poor water quality from alternative water sources as a challenge to their household water needs. Also, a 34-year-old male water vendor in Amanfa reiterated the finding when he noted:

To me, I do not see it as a challenge because I do not store my water for more than a month. I do not do that because my customers are very important to me. When I am doing that, then I am killing them, and when that happens to them, whom am I going to sell the water to? So, I do not store my water for one or two months.

Again, a male participant had similar claims to those of the study found. He underscored the importance of quality water but thought households would not consider water quality before they access water for their household water security. His opinion was expressed as:

'*Oh, they do not. The thing is, when the water is of good quality, you would know. If it is dirty, you know the water is dirty. Once you bring a bowl or a bucket and the water is fetched which is ok, they do not consider whatever is in the water because that is nobody's business*.' (47-year-old Key informant I).

Table 19: Challenges in accessing alternative water supply systems

Challenges	Agree %	Disagree %	Neutral %	Rating Scores	Rank	N
Water from AWSs is usually unacceptable for drinking purposes	84.3	6.6	9.1	275.2	1	395
Water from AWSs is usually expensive	77.5	8.1	14.4	263.1	2	395
Collecting water from AWSs is usually time-consuming	60.5	12.9	26.6	233.9	3	395
Alternative water supply systems are not well-maintained	48.4	12.4	39.2	209.2	4	395
Alternative water supply systems are not safe for water supply	20.0	60.5	19.5	200.5	5	395
Transporting water from AWSs is usually energy-intensive	28.3	38.0	33.7	194.6	6	395
Water from alternative water supply systems is not adequately treated	23.1	32.1	44.8	178.3	7	395
The quality of water from alternative water supply systems is often poor	25.6	29.3	45.1	180.5	8	395

Scale and Rank score interpretations: [1-3 (3, Agree) (1, Neutral) 2(Disagree)* Scale *Summation of the % values]
Source: Field Data, Asante (2023)

Ways for Improving Alternative Water Supply Systems

In circumstances where the prevalence of water supply systems increases over a time and, more importantly, when water supply systems are a necessity of life, prudent measures are taken to improve them. In assessing respondents' ways of improving alternative water supply systems for household water security, the study sought to find out if respondents recommend a certain alternative water supply system for their household water security. This section was considered essential since it allowed the study to deduce from the responses of those who use a certain water supply system over the others in their homes. The study further sought to explore if households would recommend alternative water supply systems to others for their household water security in the absence of water insecurity from the conventional water supply systems in the study communities.

From the analysis in Table 20, 39.7 percent of respondents agreed with the view that their household recommended the usage of a certain alternative water supply system for their household water security while 60.3 percent opposed the view of their household recommending the usage of a certain alternative water supply system for their household water security. Subsequently, disaggregating the data further shows that 16.7 percent of those who use a certain alternative water supply system recommended by their household are from Buade, while those who oppose their household's recommendation to use a certain alternative water supply system are from Amanfa (25.0 percent). In Sokpoti and Asanko, they have varied decisions about using a certain alternative water supply system for their household water security, accounting for 11.8 percent and 10.6 percent for agreement, and 13.0 percent as well as 14.7 percent for opposing this view, respectively. Also, 157 (39.7%) out of 395 respondents who agreed to the view that their household recommends using a certain alternative water supply system for their household water security, in all communities, the household recommended the use of reservoirs (58.6 percent), followed by water tanks (30.6 percent). The remaining respective 7.6 percent and 3.2 percent represent rainwater harvesting and wells in all communities.

Households in Asanko, Buade, and Sokpoti mostly recommend the use of reservoirs for their household water security, accounting for 24.2 percent, 18.5 percent, and 15.2 percent, respectively. However, in terms of water tank recommendations from households, only 17.2 percent of respondents in Buade would recommend it for their household water security. The study further sought to find out the reason why households would recommend using a certain alternative water supply system for their household water security in the Krowor Municipality. It was observed that those who had certain alternative water supply systems recommended for their household water security indicated the reason that these alternative water supply systems can store water in case of any water insecurity for future household use. Thus, the overwhelming majority of people would overlook the attributes or importance of using a certain water supply system for their water needs. In Amanfa, for instance, a 34-year-old male water vendor expressed during an in-depth interview session that:

Water access is a common concern for everyone, and people often rush to areas where people are accessing water. Storing water helps prevent issues like tap failures and delays from the Ghana Water Company. Storing water also helps prevent problems and inconveniences for both the company and its customers. Water is a vital resource, and it is essential for everyone to have access to water.

Table 20: Recommendations on forms of Alternative Water Supply Systems

Community Name	Yes %	No %	Total %	Yes, and types Wells %	Reservoirs %	Water tanks %	Rain water Harvesting %	Total %	N
Asanko	11.8	13.0	24.8	0.6	24.2	5.1	0.0	29.9	98
Buade	16.9	7.6	24.6	2.0	18.5	17.2	5.1	42.8	97
Sokpoti	10.6	14.7	25.3	0.6	15.2	8.3	2.5	26.6	100
Amanfa	0.3	25.0	25.3	0.0	0.6	0.0	0.0	0.6	100
Total	39.7	60.3	100	3.2	58.6	30.6	7.6	100	395

Source: Field Data, Asante (2023)

From Table 21, it is found that over half (62.8 percent) of respondents would recommend the systems to others experiencing water insecurity for their household water security. In recounting the motivation that informed their decision to recommend such water supply systems, respondents cited how frequently they get water from their preferred choice of alternative water supply system; water is easily accessed without hassle, coupled with the safety of the water supply system. From the results, however, 33.8 percent and 3.4 percent of respondents were opposing or undecided on the view that they would not recommend alternative water supply systems to others for their household water security, respectively. Those who were unwilling to recommend alternative water supply systems cited how the water supply systems are inadequately maintained, the cost of purchasing water for the water supply is expensive, and water from the alternative water supply may be of poor quality. What a male participant interviewed in Asanko had to say from a socio-economic perspective:

'*For this, it is your choice. An individual may not prefer to fetch from a poly tank but rather from a reservoir. People know it here already, and it is* *like a wholesale market where a lot of people come here. People say I am going to this place to fetch water, so it's like a wholesaler, and people know this. However, the thing is that it is my business, and if you continue telling people to practise this system, you will collapse your business. When an individual does it, the individual will be happy to be part of this system...*' (44-year-old key informant IV)

Table 21: Recommendation of Alternative Water Supply Systems to Household Water Security

Recommending alternative water supply systems for household water security	Name of Community Asanko %	Buade %	Sokpoti %	Amanfa %	Total %
N	98	97	100	100	395
Yes	15.2	16.9	14.4	16.2	62.8
No	8.9	5.8	10.1	9.1	33.8
Undecided	0.8	1.8	0.8	0.0	3.4
Total	24.7	24.6	25.3	25.3	100

Source: Field Data, Asante (2023)

Moreover, the study sought to ascertain ways through which alternative water supply systems could be improved in the communities under study. From the analysis in Figure 9, 32.5 percent of respondents suggested water supply systems can be improved with frequent maintenance work on the existing water supply systems; 18.7 percent suggested the need for a reduction in the cost of water from alternative water supply system to enhance their household water security; 17.7 percent opined alternative water supply systems can be improved with regular treatment of stored water before sold to consumers for their household water security; and 15.9 percent recommended the need for investment in existing or new facilities to ensure constant supply of water. Education, research, and pipe connection to households were other ways respondents thought could improve alternative water supply systems' services for household water security, accounting for 9.4 percent, 5.6 percent, and 0.3 percent, respectively. To complement this finding, a male water vendor during an in-depth interview in Sokpoti recommended that:

"*Let us put the Akosombo aside; when you dig a borehole, it is okay, but if you cannot get water. Some of the boreholes, when dug, get water. For instance, I cleared all the salt from the water and treated it well, so they prefer the borehole to Akosombo water. This is because when you use it for bathing or washing, it lathers. You see, but as for me alone, I will say people should use the poly tank because it is the best. If you do not wash inside for ten years, all the dirt will settle down, but the 'bula' (reservoir) is made of the block.*

I have laid a roof on the 'bula' (reservoir), but when it is the rainy season, you have to be extremely careful because when it rains, it pours on the roofing and some enter the 'bula' (reservoir). With the borehole, there are unpleasant materials beneath, and all the scent will enter. With the poly tank when it rains, it will not enter unless the tank bursts, so there is no other system that can be compared to the poly tank. With the poly tank, you will not have issues, but with the 'bula' (reservoir), it is always patched with cement because of leakages." (58-year-old Key informant V)

Another participant during an in-depth interview in Buade also suggested that rainwater harvesting should be practised in every household to reduce the pressure on the water sources. He highlighted:

When it rains, we have to store rainwater. Yes, we have to install rainwater, but we are not able to. The reason why we cannot install rainwater systems is *the cost and the ability to install them in all households so that there will be an abundance of water to access.*' (54-year-old Key informant IV)

Subsequently, another participant suggested a direct pipe connection to every indwelling household at a subsidised fee by the Government of Ghana through Ghana Water Company Limited. His suggestion reads:

'*You see, I will urge, if you have the power to do that, that everyone get the pipe in their community. Like the way I think we are improving recently, I realise they are embarking on bringing in this kind of pipe. You know, just bring in your ID card and a photocopy of your Ghana Card, and they will connect the pipe. Yes, the water is everywhere, and you see this sea water; the sea is all over the place, and they can even do that. They can extend that same project to another region so that everyone will be okay. I do not think we are the only ones getting the water flowing every day; some villages do not have it. So, I will urge them to embark on this project in the other cities for everyone to be okay because we are all Ghanaians*.' (34-year-old Key Informant II).

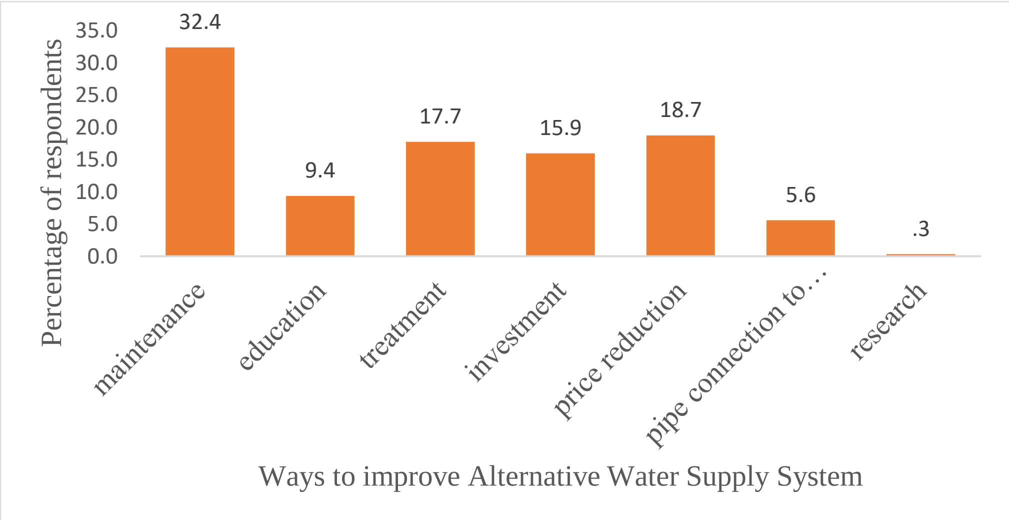


Figure 9: Ways to improve alternative water supply systems for household water security
Source: Field Data, Asante (2023)

Consequently, Table 22 presents the further breakdown of data needed to understand the dynamics of ways to improve alternative water supply systems in communities.

Further decomposition of the data shows that people in Buade (13.2 percent) thought water services from alternative water supply systems could be improved with regular maintenance work on existing water supply systems, while 16.2 percent of respondents in Amanfa suggested reducing the cost of water so they could afford the services of alternative water supply systems for their household water security. People in Asanko (7.6 percent) and Sokpoti (6.6 percent), however, suggested the need for investment in water facilities to ensure a continued supply of water and the treatment of stored water before vending to consumers, respectively.

Table 22: Ways to improve alternative water supply systems in communities

Ways	Community				
	Asanko %	Buade %	Sokpoti %	Amanfa %	Total %
Maintenance	8.3	13.2	8.9	2.0	32.4
Reduced cost	0.2	1.8	0.5	16.2	18.7
Treatment	7.6	2.8	6.6	0.8	17.7
Investment	5.6	1.3	6.6	2.5	15.7
Pipe connection	0.8	0.8	1.5	2.5	5.6
Education	2.3	4.5	1.3	1.3	9.4
Research	0.0	0.0	0.0	0.3	0.3
Total	24.8	24.6	25.3	25.3	100.0

Source: Field Data, Asante (2023)

Chapter Summary

This chapter discussed the results of alternative water supply systems for household water security in Krowor Municipality of the Greater Accra Region. The chapter revealed that the majority (92.7%) of the households used alternative water supply systems in the absence of water supply from Ghana Water Company Limited for their household water security. Households in various communities offered unique reasons for why they used or did not use some alternative water supply systems for their household water security. It can be established that households have greatly benefited from the use of alternative water supply systems. Again, water security indicators such as availability, safety, accessibility, affordability, and quality explain households preferred alternative water supply systems, while the cost of water, location of the water supply systems, time spent in water collection, and seasonal changes do not explain households preferred alternative water supply systems to household water security. The usage of alternative water supply systems led to increased water supply and productive activities, a relative reduction in water shortages, and reduced stress and vulnerability. The subsequent chapter presents the summary, conclusion, and recommendations.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter summarises the findings of the study. It also highlights conclusions drawn from the study as well as suggests recommendations based on the conclusions of the study while presenting some areas for further research.

Summary

The main objective of the study was to examine alternative water supply systems for household water security at Krowor Municipality in the Greater Accra Region. The study used a mixed-methods approach, comprising a survey of 395 households and five key informant interviews purposefully selected. Stratified and systematic random sampling techniques were used to reach households across Asanko, Buade, Sokpoti, and Amanfa in the study area. The interview schedule was used to collect data from households, while an interview guide was used for the key informants' in-depth interviews.

The key findings were as follows:

1.The water sources available for household water security include surface water through pipe-borne water (in-household pipe and public standpipes) from Ghana Water Company Limited, groundwater, and rainwater.

2. The majority (99.5 %) of households' source of water was pipe-borne water from Ghana Water Company Limited through public standpipes. This, then, means households have access to water via standpipes outside their dwellings.

3.The available types of alternative water supply systems for household water security include water tanks (poly tanks), reservoirs, rainwater harvesting, wells, standpipes, and tanker supply.

4.The majority (57.0%) of the respondents accessed water from water reservoirs for their household water security.

5.The majority (92.7%) of respondents used alternative water supply systems when the pipes became unreliable as a stopgap for their household water security.

6. Almost half (47.8%) of the respondents collect water from alternative water supply systems every week, and the uses of water are mostly for washing (32.7%) and bathing (32.6%).

Objective two's key findings were as follows:

1. Reservoirs (51.6%) and water tanks (poly tank) (41.5%) were the available alternative water supply systems in all communities.
2. Water tank (poly tank) (48.6%) was the most preferred alternative water supply system for household water security in the Buade, Sokpoti, and Amanfa communities. Conversely, the water reservoir (43.0%) was the most preferred alternative water supply system in the Asanko and Amanfa communities.
3. Determinants such as income level, cost of purchasing water, location of water supply systems, time spent in water collection, and seasonal changes all have no influence on respondents preferred alternative water supply systems for their household water security.

The key findings from objective three were highlighted as:

1. The majority (74.4%) of the respondents have seen improvements in accessing water for their household water security due to the availability of alternative water supply systems in all communities. Similarly, most (90.4%) of the respondents agreed that alternative water supply systems have decreased water shortages for their household water needs.

2. The majority (80.5%) of the respondents perceived alternative water supply systems to solve issues of water scarcity as well as reduced levels of stress and vulnerability.

3.Another benefit of alternative water supply systems based on responses was that they influence productive activities including work, school, house works, and the well-being of households in all communities.

4. About 47.3% percent of the respondents indicated that alternative water supply systems have reduced dependency on conventional water supply systems.

The key findings from objective were as follows:

- The majority (84.3%) of the respondents confirmed that drinking water from alternative water supply systems poses a great threat to their household water security.
- Most (77.5%) of the respondents indicated that the cost of water from alternative water supply systems is expensive, while 60.5% are of the view that too much time is consumed when fetching from alternative water supply systems.
- Almost half (48.8%) of the respondents were of the view that alternative water supply systems are inadequately maintained.

Conclusions

The majority of the sampled households used alternative water supply systems for their household water security. Pipe-borne water via standpipe was found to be a source for domestic water needs. Most of the users of alternative water supply systems preferred water storage tanks to other alternative water supply systems for their household water security. The study found most usages of alternative water supply systems for domestic water needs include bathing, cooking, and washing. Conversely, the study found that households use sachet water as their source of drinking water due to its perceived level of treatment compared to alternative water supply systems, which perceive water as salty due to the operation of seawater desalination.

The determinants for choosing a preferred alternative water supply system for household water security were water security indicators (availability, quality, safety, accessibility, and affordability), time spent in the collection, and cost of purchasing water from the identified alternative water supply systems. The study also concludes that there exists a relationship between preferred alternative water supply systems and water security indicators.

The outcomes of alternative water supply systems for household water security were that users had reduced levels of stress and vulnerability, decreased water shortages, improved water scarcity, improved water availability, escaped water insecurity with relatively lower dependency on conventional water supply systems, and improved productive activities in households.

The challenges in accessing alternative water supply systems for household water security were that the water supply lacked maintenance, the cost of water from the water supply was expensive, the water supply systems were unacceptable sources of drinking water, and respondents consumed too much time accessing water from identified alternative water supply systems for their domestic water needs.

Recommendations

Based on the findings and conclusion of the study, the following recommendations are made;

1. The Krowor municipal assembly, through the water and sanitation department, should deploy real-time water supply data to coordinate water distribution. This could be done by allowing the municipality to identify and address water scarcity zones efficiently. This could reduce the pressure on existing municipal water systems, increasing water accessibility during unreliable water supply.
2. The Ghana water company limited in the municipality should establish a strong collaboration between the department of community development and the various water suppliers or vendors in the community to help educate and sensitise sustainable alternative water supply systems for household water security. This could be done by having indigenous policies to maintain, manage, and monitor the sustainability of these water supply systems in a bid to ease the issue of water insecurity in the municipality.
3. Households should be encouraged to invest in procuring water storage tanks and water installations to store water at homes for

households with unreliable water supply. This will drive the uptake of alternative water supply systems in pursuit of household water security in areas with water scarcity.

Suggesting Further Research

The study suggests further research should be conducted into the replication and sustainability of available alternative water systems in other communities. This should employ comprehensive measurements such as quality, quantity, and cost to capture the dynamics of alternative water supply systems and household water security.

REFERENCES

Abanyie, S. K., Amuah, E. E. Y., Douti, N. B., Owusu, G., Amadu, C. C., & Alhassan, B. (2021). WASH in selected basic schools and possible implications on health and academics: an example of the Wa municipality of Ghana, West Africa. A*merican Journal of Environmental Science and Engineering*, *5*(1), 15-20.

Ablo, A. D., & Yekple, E. E. (2018). Urban water stress and poor sanitation in Ghana: perception and experiences of residents in the Ashaiman Municipality. *GeoJournal*, *83*(3), 583-594.

Abraham, M., & Voss, T. (2004). Contributions of Rational Choice Theory to Modern Sociology: An Overview. *Advances in Sociological Knowledge: Over half a Century*, 127-150.

Abubakar, I. R. (2018). Strategies for coping with inadequate domestic water supply in Abuja, Nigeria. *Water international*, *43*(5), 570-590.

Abubakar, M. C. (2018). Potential contribution of alternative water supply systems to urban water security [Case study: New Achimota & Nima, Accra, Ghana].

Ackerman, K. V., Mixon, D. M., Sundquist, E. T., Stallard, R. F., Schwarz, G. E., & Stewart, D. W. (2009). RESIS-II: An updated version of the original reservoir sedimentation survey information system (RESIS) database. *US Geol. Surv. Data Ser*, *434*.

Adams, E. A., & Vasquez, W. F. (2019). Do the urban poor want household taps? Community preferences and willingness to pay for household taps in Accra, Ghana. *Journal of Environmental Management*, *247*, 570-579.

Adank, M., Darteh, B., Moriarty, P., Osei-Tutu, H., Assan, D., & van Rooijen, D. (2011). Towards integrated urban water management in the Greater Accra Metropolitan Area. *SWITCH (Ed.). Accra, Ghana*.

ADB 2013 *Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific* (Manila: Asian Development Bank)

Adjakloe, Y. A. (2010). *Access to and management of portable water in the Ga West municipality*. University of Cape Coast, Cape Coast.

Adjakloe, Y. A. (2014). Accessing water for domestic use: the challenges faced in the Ga West Municipality, Ghana. *International Journal of Social Science and Humanities Research*, *3*(12), pp.78-91.

Adomfmonline (2020). Water shortage to hit Tema, Nungua, Spintex, East Legon, et al. https://www.adomonline.com/official-water-shortage-to-hit-tema-nungua-spintex-east-legon-et-al**.** (Accessed 10th June, 2021)

Adonadaga, J. A. (2019). An assessment of the potential contribution of alternative water supply systems to urban water security for the Madina municipality of Accra-Ghana.

Agudelo-Vera, C. M., Keesman, K. J., Mels, A. R., & Rijnaarts, H. H. (2013). Evaluating the potential of improving residential water balance at building scale. *Water research*, *47*(20), 7287-7299.

Ahiablame, L. M. (2012). Development of methods for modelling and evaluation of low impact development practices at the watershed scale. Purdue University, Indiana

Ahlers, R., Cleaver, F., Rusca, M., & Schwartz, K. (2014). Informal space in the urban waterscape: Disaggregation and co-production of water services. *Water Alternatives*, *7*(1), 1-14.

Ahmadi, M. S., Sušnik, J., Veerbeek, W., & Zevenbergen, C. (2020). Towards a global day zero? Assessment of current and future water supply and demand in 12 rapidly developing megacities. *Sustainable Cities and Society*, *61*, 102295.

Ainuson, K. G. (2010). Urban water politics and water security in disadvantaged urban communities in Ghana. *African Studies Quarterly*, *11*(4), 59-82.

Akoto, O., & Abankwa, E. (2014). Evaluation of Owabi Reservoir (G hana) water quality using factor analysis. *Lakes & Reservoirs: Research & Management*, *19*(3), 174-182.

Aleixo, B., Pena, J. L., Heller, L., & Rezende, S. (2019). Infrastructure is a necessary but insufficient condition to eliminate inequalities in access to water: research of a rural community intervention in Northeast Brazil. *Science of the Total Environment*, *652*, 1445-1455.

Alhassan, H., & Kwakwa, P. A. (2014). When water is scarce: the perception of water quality and effects on the vulnerable. *Journal of Water, Sanitation and Hygiene for Development*, *4*(1), 43-50.

Alim, M. A., Rahman, A., Tao, Z., Samali, B., Khan, M. M., & Shirin, S. (2020). Suitability of roof harvested rainwater for potential potable water production: A scoping review. *Journal of cleaner production*, (*248)*, pp.119226.

Amankwaa, E. F., Owusu, A. B., Owusu, G., & Eshun, F. (2014). Accra's poverty trap: Analysing water provision in urban Ghana. *Journal of Social Science for Policy Implications*, *2*(2), 69-89.

Andoh, C., Gupta, S., & Khare, D. (2018). Status of rainwater harvesting (RWH) in Ghana. *Current World Environment*, *13*(1), 172.

Arapto, P., & Adisenu, E. (2006). Challenges of community participation in an integrated WATSAN project in a peri-urban set-up: The case of Old Ningo. *PRONET-Ghana, Accra*.

Ariyabandu, R. D. S. (2001). Varieties of water harvesting. *Making Water Everybody's Business: Policy and Practice of Water Harvesting, Centre for Science and Environment, New Delhi*.

Armour, J., & Gordon, J. N. (2014). Systemic harms and shareholder value. *Journal of Legal Analysis*, *6*(1), 35-85.

Arouna, A., & Dabbert, S. (2010). Determinants of domestic water use by rural households without access to private improved water sources in Benin: A seemingly unrelated Tobit approach. *Water resources management*, *24*, pp.1381-1398.

Asenso-Boadi, F. M., & Vondolia, G. K. (2013). *Private Sector Participation in the Provision of Quality Drinking Water in Ghana's Urban Areas: Are People Willing to Pay?* AERC.

Asian Development Bank, & Asia-Pacific Water Forum. (2013). *Asian Water Development Outlook 2013: Measuring Water Security in Asia and the Pacific*. Asian Development Bank.

Assefa, Y.T.; Babel, M.S.; Sušnik, J.; Shinde, V.R. (2018) Development of a Generic Domestic Water Security Index, and Its Application in Addis Ababa, Ethiopia. *Water*, 11-37.

Babbie, E., & Mouton, J. (2001). The practice of social research: South African edition. *Cape Town: Oxford University Press Southern Africa*.

Bakker, K. (2007). Trickle down? Private sector participation and the pro-poor water supply debate in Jakarta, Indonesia. *Geoforum*, *38*(5), 855-868.

Bakker, K., Kooy, M., Shofiani, N. E., & Martijn, E. J. (2008). Governance failure: Rethinking the institutional dimensions of urban water supply to poor households. *World Development*, *36*(10), 1891-1915.

Balogun, I. I., Sojobi, A. O., & Oyedepo, B. O. (2016). Assessment of rainfall variability, rainwater harvesting potential and storage requirements in Odeda Local Government Area of Ogun State in South-western Nigeria. *Cogent Environmental Science*,*2*(1), 1138597.

Barnes, D. A. (2009). *Assessment of rainwater harvesting in Northern Ghana* (Doctoral dissertation, Massachusetts Institute of Technology).

Barron, J. (2009). *Rainwater harvesting: a lifeline for human well-being*. UNEP/Earthprint.

Bartels, L. E., Bruns, A., & Alba, R. (2018). The production of uneven access to land and water in peri-urban spaces: de facto privatisation in greater Accra. *Local environment*, *23*(12), 1172-1189.

Bartram, J., & Cairncross, S. (2010). Hygiene, sanitation, and water: forgotten foundations of health. *PLoS medicine*, *7*(11), e1000367.

Bartram, J., & Cairncross, S. (2010). Hygiene, sanitation, and water: forgotten foundations of health. *PLoS medicine*, *7*(11), e1000367.doi: 10.1371/journal.pmed.1000367

Baumann, E., & Danert, K. (2008). Operation and maintenance of rural water supplies in Malawi: study findings. *SKAT–Zurich, Switzerland: Swiss Resource Centre and Consultancies for Development*.

Becker, G. S. (1976). *The economic approach to human behavior* (Vol. 803). University of Chicago press.

Bell, S., & Aitken, V. (2008). The socio-technology of indirect potable water reuse. *Water Science and Technology: Water Supply*, *8*(4), 441-448.

Bello-Dambatta, A., Kapelan, Z., & Butler, D. (2014). Impact assessment of household demand saving technologies on system water and energy use. *British Journal of Environment and Climate Change*, *4*(2), 243-260

Bhattacherjee, A. (2012). Social science research: Principles, methods, and practices.

Bichai, F., & Cabrera Flamini, A. (2018). The Water‐Sensitive City: Implications of an urban water management paradigm and its globalization. *Wiley interdisciplinary reviews: water*, *5*(3), e1276.

Bichai, F., Grindle, A. K., & Murthy, S. L. (2018). Addressing barriers in the water-recycling innovation system to reach water security in arid countries. *Journal of Cleaner Production*, *171*, S97-S109.

Bichai, F., Ryan, H., Fitzgerald, C., Williams, K., Abdelmoteleb, A., Brotchie, R., & Komatsu, R. (2015). Understanding the role of alternative water supply in an urban water security strategy: an analytical framework for decision-making. *Urban Water Journal*, *12*(3), 175-189.

Bichai, F. and Smeets, P., (2014). Integrating water quality in urban water management and planning when addressing the water security challenge. In: Q.Grafton, ed. Understanding and Managing Urban Water in Transition. New York: Springer Publishing.

Bichai, F., Kajenthira, A., & Murthy, S. (2018). Integrating water recycling as a supply augmentation strategy to reach sustainable and equitable water security: A diagnosis of barriers in the global innovation system. *Journal of Cleaner Production – Special Issue on the Dynamics of Water Innovation*, 171, S97–109

Bichai, F., Ryan, H., Fitzgerald, C., Williams, K., Abdelmotef, A., Brotchie, R ., & Komatsu, R. (2015). Understanding the role of alternative water supply in an urban water security strategy: An analytical framework for decision making. *Urban Water Journal*, 12(3), 175–189

Binz, C., Harris-Lovett, S., Kiparsky, M., Sedlak, D. L., & Truffer, B. (2016). The thorny road to technology legitimation—Institutional work for potable water reuse in California. *Technological Forecasting and Social Change*, *103*, 249-263.

Bizikova, L., Roy, D., Swanson, D., Venema, H. D., & McCandless, M. (2013). *The water-energy-food security nexus: Towards a practical planning and decision-support framework for landscape investment and risk management* (pp. 16-20). Winnipeg: International Institute for Sustainable Development.

Bohman, A. (2010). *Framing the water and sanitation challenge: A history of urban water supply and sanitation in Ghana 1909-2005*. Department of Economic History, Umeå University.

Boltz, F., Poff, N. L., Folke, C., Kete, N., Brown, C. M., Freeman, S. S. G., ... & Rockström, J. (2019). Water is a master variable: Solving for resilience in the modern era. *Water Security*, *8*, 100048.

Boretti, A., & Rosa, L., (2019.) Reassessing the projections of the World Water Development Report. *npj Clean Water*, 2(1), pp.1-6.

Braih, O. (2017). *Assessment of the potential contribution of alternative water supply systems to urban water security: A case study of Lilongwe City in Malawi*. MSc Thesis, UNESCO-IHE.

Braimah, I., Obeng Nti, K., & Amponsah, O. (2018, June). Poverty penalty in urban water market in Ghana. In *Urb*an (Vol. 29, No. 2, pp. 147-168). Springer Netherlands.

Brown, R. R., & Farrelly, M. A. (2009). Delivering sustainable urban water management: a review of the hurdles we face. *Water science and technology*, *59*(5), 839-846.

Brown, R. R., Keath, N., & Wong, T. H. (2009). Urban water management in cities: historical, current and future regimes. *Water science and technology*, *59*(5), 847-855.

Burn, S., Maheepala, S., & Sharma, A. (2012). Utilising integrated urban water management to assess the viability of decentralised water solutions. *Water Science and Technology*, *66*(1), 113-121.

Cabrera, E., Espert, V., & López, P. A. (1999). Water Supply Systems in Drought Periods. The Case of Spain. In *Drought Management Planning in Water Supply Systems: Proceedings from the UIMP International Course held in Valencia, December 1997* (pp. 1-21). Springer Netherlands.

Calow, R., Ludi, E., & Tucker, J. (2013). Achieving water security. *Lessons from Research in Water Supply, Sanitation and Hygiene in Ethiopia, Overseas Development Institute (ODI), London.*

Carrard, N., Madden, B., Chong, J., Grant, M., Nghiêm, T. P., Bùi, L. H., ... & Willetts, J. (2019). Are piped water services reaching poor households? Empirical evidence from rural Viet Nam. *Water research*, *153*, pp.239-250.

Carter, R. C., & Danert, K. (2003). The private sector and water and sanitation services—policy and poverty issues. *Journal of International Development*, *15*(8), 1067-1072.

CEHI (2009). Rainwater – *Catch It While You Can. A Handbook for Rainwater Harvesting in the Caribbean: Caribbean Environmental Health Institute*. Caribbean Environmental Health Institute and United Nations Environment Programme, Castries, St Lucia

Cembrowicz, R. G. (1992). Water supply systems optimization for developing countries, In: *Pipeline Systems* ed. by B. Coulbeck & E. Evans, Ch. 26, 59-76. Kluwer Academic Publisher

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. sage.

Chenoweth, J., Malcolm, R., & Pedley, S. (2013). Household water security and the human right to water and sanitation. In *Water security* (pp. 325-336). Routledge.

Chidya, Russel CG, Wapulumuka O. Mulwafu, and Sembeyawo CT Banda (2016). "Water supply dynamics and quality of alternative water sources in low-income areas of Lilongwe City, Malawi." *Physics and chemistry of the earth, parts a/b/c* 93 (2016): 63-75.

Chou, Chia, John CH Chiang, Chia-Wei Lan, Chia-Hui Chung, Yi-Chun Liao, and Chia-Jung Lee. "Increase in the range between wet and dry season precipitation." *Nature Geoscience* 6, no. 4 (2013): 263-267.

Chowdhury, M. F. (2014). Interpretivism in aiding our understanding of the contemporary social world. *Open Journal of Philosophy*, *2014*.

Chris, W. (2012). Understanding water scarcity: Definitions and measurements. *Water Security, United Nations Educational Scientific and Cultural Organization*.

Citifmonline (2017). Ghana Water losing Ghc6m monthly to Teshie desalination plant. https://citifmonline.com/2017/10/ghana-water-losing-ghc-6m-monthly-to-teshie-desalination-plant.(Accessed December, 5. 2022).

Clark, R., Gonzalez, D., Dillon, P., Charles, S., Cresswell, D., & Naumann, B. (2015). Reliability of water supply from stormwater harvesting and managed aquifer recharge with a brackish aquifer in an urbanising catchment and changing climate. *Environmental Modelling and Software*, 72, 117–125

Cobbinah, P. B., Erdiaw-Kwasie, M. O., & Amoateng, P. (2015). Africa's urbanisation: Implications for sustainable development. *Cities*, *47*, 62-72. doi: 10.1016/j.cities.2015.03.013

Coenen, L., & López, F. J. D. (2010). Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. *Journal of cleaner production*, *18*(12), 1149-1160.

Cole, M. J., Bailey, R. M., Cullis, J. D., & New, M. G. (2018). Spatial inequality in water access and water use in South Africa. *Water Policy*, *20*(1), 37-52.

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

Cook S, Tjandraatmadja G, Ho A, Sharma A (2009) Definition of decentralised systems in the South East Queensland context. Urban water security research alliance technical report no. 12. http://www.urbanwateralliance.org.au/. Accessed 26 September 2022.

Cook, C. and Bakker, K. (2012) 'Water security: Debating an emerging paradigm', *Global Environmental Change*, 22(1), pp. 94–102. doi: 10.1016/j.gloenvcha.2011.10.011.

Cosgrove, W. J., & Rijsberman, F. R. (2014). *World water vision: making water everybody's business*. Routledge.

Creswell, J. W. (2009). Mapping the field of mixed methods research. *Journal of mixed methods research*, *3*(2), 95-108. Sage Publications, New York.

Creswell, J. W. (2014). Qualitative, quantitative and mixed methods approach. Sage publications, New York.

Dapaah, E. K., & Harris, L. M. (2017). Framing community entitlements to water in Accra, Ghana: A complex reality. *Geoforum*, *82*, 26-39. doi: 10.1016/j.geoforum.2017.03.011.

Daley, K., Truelstrup Hansen, L., Jamieson, R. C., Hayward, J. L., Piorkowski, G. S., Krkosek, W., ... & Huang, Y. (2018). Chemical and microbial characteristics of municipal drinking water supply systems in the Canadian Arctic. *Environmental Science and Pollution Research*, *25*, 32926-32937.

De França Doria, M. (2010). Factors influencing public perception of drinking water quality. *Water policy*, *12*(1), 1-19.

De Villiers, M. R. (2005). Three approaches as pillars for interpretive information systems research: development research, action research and grounded theory. In *Proceedings of the 2005 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries* (pp. 142-151).

Domènech, L., & Saurí, D. (2011). A comparative appraisal of the use of rainwater harvesting in single and multi-family buildings of the Metropolitan Area of Barcelona (Spain): social experience, drinking water savings and economic costs. *Journal of Cleaner production*, *19*(6-7), 598-608.

Dos Santos, S. M., & De Farias, M. M. M. W. E. C. (2017). Potential for rainwater harvesting in a dry climate: Assessments in a semiarid region in northeast Brazil. *Journal of Cleaner Production*, 164, 1007–1015

Dzidic, P., & Green, M. (2012). Outdoing the Joneses: Understanding community acceptance of an alternative water supply scheme and sustainable urban design. *Landscape and Urban Planning*, *105*(3), 266-273. doi: 10.1016/j.landurbplan.2011.12.023

Efe, S. I. (2006). Quality of rainwater harvesting for rural communities of Delta State, Nigeria *Environmentalist*, *26*(3), 175-181.

Eguavoen, I. (2008). *The political ecology of household water in Northern Ghana* (Vol. 10). LIT Verlag Münster.

Elster, J. (1989). *Solomonic judgements: Studies in the limitation of rationality*. Cambridge University Press.

Engel, S., Iskandarani, M., & del Pilar Useche, M. (2005). *Improved water supply in the Ghanaian Volta Basin: Who uses it and who participates in community decision-making?* Intl Food Policy Res Inst.

European Environment Agency. Results and lessons from implementing the Water Assets Accounts in the EEA area. In *Technical Report n.7/2013*; European Environment Agency: Luxembourg, 2013.

Falguni, A., & Vanza, M. G. (2012). Structural control system for elevated water tank. *International Journal of Advanced Engineering Research and Studies*, *1*(III), 325-328.

Falkenmark, M. (1990). Global water issues confronting humanity. *Journal of Peace Research*, 27(2), 177-190.

Farmani, R., Walters, G. A., & Savic, D. A. (2005). Trade-off between total cost and reliability for Anytown water distribution network. *Journal of water resources planning and management*, *131*(3), 161-171.

Feachem, R. (1978). *Water, health and development. An interdisciplinary evaluation*.

Foster, S. and MacDonald, A. (2014) 'The "water security" dialogue: Why it needs to be better informed about groundwater', *Hydrogeology Journal*, 22(7), 1489–1492. doi:10.1007/s10040-014-1157-6.

Fotuè, L. A. T. (2013). Awareness and the demand for improved drinking water source in Cameroon. *International Journal of Economic Practices and Theories*, 3(1), 50-59.

Gariba, J. M., & Amikuzuno, J. (2019). Water security impacts on smallholder agriculture in the Sisili-Kulpawn Basin of the Northern Region of Ghana.

Garrick, D. and Hall, J.W. (2014) 'Water security and society: Risks, metrics, and pathways', *Annual Review of Environment and Resources*, 39(1), 611–639. doi:10.1146/annurev-environ-013012-093817.

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

Gerlak, A.K. and Wilder, M. (2012) 'Exploring the textured landscape of water insecurity and the human right to water', *Environment: Science and Policy for Sustainable Development*, 54(2), 4–17. doi:10.1080/00139157.2012.657125.

Ghana Statistical Service (2012).*2010 Population and Housing Census: Final Result*. Accra, Ghana.Availablefrom: http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf

Ghana Statistical Service (GSS). (2018). District annual report. Retrieved from http://www.gss.gov.gh.

Ghana Statistical Service (GSS). (2021). *Population and housing census 2021*. Data Production Unit Ghana Statistical Service (GSS)

Ghana Statistical Service. (2009). Demographic and health survey. http://www.measuredhs.com/pubs/pdf/FR221/FR221%5B13Aug2012%5D.pdf. Accessed January 10, 2022

Ghana Statistical Service. Ghana Living Standards Survey 7. 2018. Available from: https://www2.statsghana.gov.gh/nada/index.php/catalog/97 [Accessed 20/03/2021].

Ghana Water Company Limited (GWCL) (2019). Annual report www.gwcl.com.gh. (Accessed on July 31, 2022).

Ghana Water Company Limited (GWCL) (2016). *Ghana water company limited costumer charter*. Accra: Ghana Water Company

Gilman, E., Van Lavieren, H., Ellison, J., Jungblut, V., Wilson, L., Areki, F., ... & Yuknavage, K. (2006). Pacific Island Mangroves in a Changing Climate and Rising Sea-UNEP Regional Seas Reports and Studies No. 179. *N/A*.

Gimelli, F. M., Bos, J. J., & Rogers, B. C. (2018). Fostering equity and wellbeing through water: A reinterpretation of the goal of securing access. *World Development*, *104*, 1-9.

Gleick, P. H., & Palaniappan, M. (2010). Peak water limits to freshwater withdrawal and use. *Proceedings of the National Academy of Sciences*, *107*(25), 11155-11162. doi:10.1073/pnas.1004812107.

Global Water Partnership (2000), *Towards Water Security: A Framework for Action*, Stockholm

Grey, D., & Sadoff, C. (2005). Water resources, growth and development. *Prepared for the Panel of Finance Ministers, the UN Commission for Sustainable Development*.

Grey, D., & Sadoff, C. W. (2007). Sink or swim? Water security for growth and development. *Water policy*, *9*(6), 545-571.

Grönwall, J. (2016). Self-supply and accountability: to govern or not to govern groundwater for the (peri-) urban poor in Accra, Ghana. *Environmental Earth Sciences*, *75*(16), 1163.

Guhathakurta, S., & Gober, P. (2007). The impact of the Phoenix urban heat island on residential water use. *Journal of the American Planning Association*, *73*(3), 317-329.

Guyer, J. P. (2013) *Introduction to Water Supply, Treatment and Storage in Cold Regions*. Course No: C03-034, Continuing Education and Development, Inc.

Guzman JC, Brown D, & Khatiwada L, (2016). *Millennium Challenge Corporation Impact Evaluation: Water and Sanitation Component of the Ghana Compact*. Final Report. Notre Dame, IN: Notre Dame Initiative for Global Development

GWP (2014a) *Water Security: Putting the Concept into Practice*. Technical Committee Background Paper No. 20. GWP, Stockholm, Sweden.

GWP 2012 (*Global Water Partnership)* (2012*)*. Increasing water security: A development imperative. Stockholm: Global Water Partnership.

Gyampoh, B. A., Idinoba, M., & Amisah, S. (2008). Water scarcity under a changing climate in Ghana: options for livelihoods adaptation. *Development*, *51*(3), 415-417.

Handia, L., Tembo, J. M., & Mwiindwa, C. (2003). Potential of rainwater harvesting in urban Zambia, *Physics and Chemistry of the Earth, Parts A/B/C*, *28*(20-27), 893-896.

Hardy, D., Cubillo, F., Han, M., & Li, H. (2015). Alternative water resources: a review of concepts, solutions and experiences. *International Water Association (IWA), Alternative Water Resources Cluster*. London, United Kingdom.

Hekkert, M. P., Suurs, R. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological forecasting and social change*, *74*(4), 413-432.

Helmreich, B., & Horn, H. (2009). Opportunities in rainwater harvesting. *Desalination*, *248*(1-3), 118-124.

Hirschi, T. (2017). On the compatibility of rational choice and social control theories of crime. In *The reasoning criminal* (pp. 105-118). Routledge.

Hobbes, T. (1961). Of the natural condition of mankind. *Other books by the same author*, 155.

Hoekstra, A. Y., Buurman, J., & Van Ginkel, K. C. (2018). Urban water security: A review. *Environmental research letters*, *13*(5), 053002.

Höllermann, B., Giertz, S., & Diekkrüger, B. (2010). Benin 2025—Balancing future water availability and demand using the WEAP 'Water Evaluation and Planning' System. *Water resources management*, *24*(13), 3591-3613.

Hope, R. (2015). Is community water management the community's choice? Implications for water and development policy in Africa. *Water Policy*, *17*(4), 664-678.

Hope, R. (2015). Is community water management the community's choice? Implications for water and development policy in Africa. *Water Policy*, *17*(4), 664-678.

Howard, S. (2017). Human water security: It boils down to state bureaucratic capacity. Spring: Iowa

Hubbard, S. C., Meltzer, M. I., Kim, S., Malambo, W., Thornton, A. T., Shankar, M. B., ... & Brunkard, J. M. (2020). Household illness and associated water and sanitation factors in peri-urban Lusaka, Zambia, 2016–2017. *NPJ Clean Water*, *3*(1), 26.

Huitema, D., Mostert, E., Egas, W., Moellenkamp, S., Pahl-Wostl, C., & Yalcin, R. (2009). Adaptive water governance: assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda. *Ecology and society*, *14*(1).

Ibrahim, S. S. (2006). From individual to collective capabilities: the capability approach as a conceptual framework for self-help. *Journal of human development*, *7*(3), 397-416.

Ingram, A. (2016). *Spaces of security and insecurity: Geographies of the war on terror*. Routledge.

IWA (2015). Alternative Water Resources Conference Nanjing, China (May 26-28, 2015) (2015) *Water Science and Engineering*, 8(2): 174. doi: 10.1016/j.wse.2015.06.001.

Jaramillo, P., & Nazemi, A. (2018). Assessing urban water security under changing climate: Challenges and ways forward. *Sustainable cities and society*, *41*, 907-918.

Jennings, G. (2001). *Tourism research*. John Wiley and sons Australia, Ltd.

Jensen, O., & Nair, S. (2019). Integrated urban water management and water security: A comparison of Singapore and Hong Kong. *Water, 11*(4), 785.

Jensen, O., & Wu, H. (2018). Urban water security indicators: Development and pilot. *Environmental Science & Policy*, *83*, 33-45.

Jepson, W. (2014). Measuring 'no-win' waterscapes: Experience-based scales and classification approaches to assess household water security in colonias on the US–Mexico border. *Geoforum*, *51*, 107-120.

Jepson, W., Budds, J., Eichelberger, L., Harris, L., Norman, E., O'Reilly, K., Pearson, A., Shah, S., Shinn, J., Staddon, C. and Stoler, J., (2017). Advancing human capabilities for water security: A relational approach. *Water Security*, *1*, 46-52.

Jimenez, B., & Asano, T. (2008). Water reclamation and reuse around the world. *Water Reuse: an international survey of current practice, issues and needs*, *14*, 3-26.

JMP (2008) *Progress on Drinking Water and Sanitation: Special Focus on Sanitation*. World Health Organization and United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation, Geneva and New York.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, *33*(7), 14-26.

Jussah, O. (2017). Assessment of the potential contribution of alternative water supply systems to urban water security [A case study of Lilongwe City in Malawi].

Jussah, O., Orabi, M. O. M., Sušnik, J., Bichai, F. & Zevenbergen, C. (2020). Assessment of the potential contribution of alternative water supply systems in two contrasting locations: Lilongwe, Malawi, and Sharm El-Sheikh, Egypt. *Journal of Water and Climate Change*, *11*, 130–149.

Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS quarterly*, 67-93.

Kline, S. J., & Rosenberg, N. (2010). An overview of innovation. *Studies on science and the innovation process: Selected works of Nathan Rosenberg*, 173-203.

Komives, K., B. Akanbang, R. Thorsten, B. Tuffuor, W. Wakeman, E. Larbi, A. Bakalian, and D. Whittington. 2008. "Postconstruction support and the sustainability of rural water projects in Ghana." Paper presented at the 33rd WEDC International Conference, Accra, Ghana.

Kooy, M. (2014). Developing Informality: The Production of Jakarta's Urban Waterscape. *Water Alternatives*, *7*(1).

Kroneberg, C., & Kalter, F. (2012). Rational choice theory and empirical research: Methodological and theoretical contributions in Europe. *Annual review of sociology*, *38,* 73-92.doi: 10.1146/annurev-soc-071811-145441

Krowor Municipal Assembly, "The composite budget of Krowor Municipal Assembly,"2017 View at Google Scholar

Krstić, M. (2022). Rational choice theory–alternatives and criticisms. *Socijalna ekologija: časopis za ekološku misao i sociologijska istraživanja okoline*, *31*(1), 9-27.

Krstić, M., & Pavlović, N. (2020). Behavioral Economics: New Dimension in Understanding the Real Economic Behavior. In *Handbook of Research on Sustainable Supply Chain Management for the Global Economy* (pp. 281-298). IGI Global.

Kruger, L. W., & Neuman, W. L. (2006). Social Work Research Methods. Qualitative and quantitative application.

Kumar, R. (2018). *Research methodology: A step-by-step guide for beginners*. Sage Publications Limited.

Kumar, S., & Phrommathed, P. (2005). Research methodology Springer US.

Kumekpor, T. K. B. (2002). Research Methods and Techniques of Social Research, Accra. *Son Life Press and Services. Manchester School of Economic and Social Studies*, *24*, 203-244.

Kundzewicz, Z. W., & Stakhiv, E. Z. (2010). Are climate models "ready for prime time" in water resources management applications, or is more research needed?. *Hydrological Sciences Journal–Journal des Sciences Hydrologiques*, *55*(7), 1085-1089.

Lahiri-Dutt, K. (2015). Counting (gendered) water use at home: Feminist approaches in practice. *ACME: An International Journal for Critical Geographies*, *14*(3), 652-672.

Lahnsteiner, J., & Lempert, G. (2007). Water management in Nindhoek, Namibia. *Water Science and Technology*, *55*(1-2), 441-448.

Leduc, W. R. W. A. Agudelo-Vera, C. M. Rovers, R. Mels A. R.(2009)Expanding the exergy concept to the urban water cycle. Available at: edepot.wur.nl/171867 (Accessed 20 March 2022).

Lee, K. E., Mokhtar, M., Hanafiah, M. M., Halim, A. A., & Badusah, J. (2016). Rainwater harvesting as an alternative water resource in Malaysia: Potential, policies and development. *Journal of Cleaner Production*, 126, 218–222.

Leitch, C. M., Hill, F. M., & Harrison, R. T. (2010). The philosophy and practice of interpretivist research in entrepreneurship: Quality, validation, and trust. *Organizational Research Methods*, *13*(1), 67-84.

Libralato, G., Ghirardini, A. V., & Avezzù, F. (2012). To centralise or to decentralise: An overview of the most recent trends in wastewater treatment management. *Journal of environmental management*, *94*(1),6 1-68.

Loaiciga, H. A. (2014, December). Municipal Water in Drought-Stricken California: Thinking Outside the Box. In *AGU Fall Meeting Abstracts* (Vol. 2014, pp. H21N-02).

Loáiciga, H. A. (2015). Probability distributions in groundwater hydrology: Methods and applications. *Journal of Hydrologic Engineering*, *20*(5), 04014063.

Loftus, A. (2015). Water (in)security: Securing the right to water. *The Geographical Journal*, 181(4), 350–35.

Loucks, D. P. (2011). Optimizing water for life. *Water for food in a changing world*, 171-196.

Lowe, C., Ludi, E., Le Sève, M. D., & Tsui, J. (2019). Linking social protection and water security to empower women and girls. *ODI Working Paper*, (567). Available at https://www.odi. org/publications/ 16503-linking-social-protection-and-water-security-empower-women-and-girls (2019), Accessed 13th Mar 2022

Lundvall, B. Å. (2010). How can education systems contribute to creativity and innovation in the learning economy? In *Creativity in Education: Conference Report* (pp. 77-94). Ecole Internationale de Genéve.

Mack, L. (2010). The philosophical underpinnings of educational research.

Majuru, B., Suhrcke, M., & Hunter, P. R. (2016). How do households respond to unreliable water supplies? A systematic review. *International Journal of Environmental Research and Public Health*, *13*(12), pp.1222-1312.

Malley, Z. J. U., Taeb, M., Matsumoto, T., & Takeya, H. (2009). Environmental sustainability and water availability: Analyses of the scarcity and improvement opportunities in the Usangu plain, Tanzania. *Physics and Chemistry of the Earth, Parts A/B/C*, *34*(1-2), 3-13.

Mankad, A., Walton, A., & Alexander, K. (2015). Key dimensions of public acceptance for managed aquifer recharge of urban stormwater. *Journal of Cleaner Production*, *89*, 214-223.

Manyire, H., & Asingwire, N. (1996). State and dynamics of social policy practice and research in Uganda: a research report.

Mapunda, D. W., Chen, S. S., & Yu, C. (2018). The role of informal small-scale water supply system in resolving drinking water shortages in peri-urban Dar es Salaam, Tanzania. *Applied Geography*, *92*, pp.112-122.

March, H., & Sauri, D. (2017). When sustainable may not mean just: a critical interpretation of urban water consumption decline in Barcelona. *Local Environment*, *22*(5), 523-535.doi:10.1080/13549839.2016. 1233528.

Marlow, D. R., Moglia, M., Cook, S., & Beale, D. J. (2013). Towards sustainable urban water management: A critical reassessment. *Water research*, *47*(20), 7150-7161.

Marston, A. J. (2014). The Scale of Informality: Community-Run Water Systems in Peri-Urban Cochabamba, Bolivia. *Water Alternatives*, *7*(1).

Mason, L. R. (2014). Examining relationships between household resources and water security in an urban Philippine community. *Journal of the Society for Social Work and Research*, *5*(4), 489-512.

Mason, M. M., & Lee, H. J. (Eds.). (2012). *Reading colonial Japan: text, context, and critique*. Stanford University Press.

Mati, B., De Bock, T., Malesu, M., Khaka, E., Oduor, A., Meshack, M., & Oduor, V. (2006). Mapping the potential of rainwater harvesting technologies in Africa. *A GIS overview on development domains for the continent and ten selected countries. Technical Manual*, *6*, 126.

Mayer, B. K., Gerrity, D., Rittmann, B. E., Reisinger, D., & Brandt-Williams, S. (2013). Innovative strategies to achieve low total phosphorus concentrations in high water flows. *Critical Reviews in Environmental Science and Technology*, *43*(4), 409-441.

McCarthy, B., & Chaudhary, A. R. (2014). Rational choice theory and crime. *Encyclopedia of crime and criminal justice*, pp;4307-4315.

McCartney, M., & Smakhtin, V. (2010). *Water storage in an era of climate change: addressing the challenge of increasing rainfall variability. Blue paper* (No. 615-2016-40943).

McDonald, R. I., Douglas, I., Grimm, N. B., Hale, R., Revenga, C., Gronwall, J., & Fekete, B. (2011). Implications of fast urban growth for freshwater provision. *Ambio*, *40*(5), 437-446

McDonald, R. I., Weber, K., Padowski, J., Flörke, M., Schneider, C., Green, P. A., ... &

Mehta, L., Allouche, J., Nicol, A., & Walnycki, A. (2014). Global environmental justice and the right to water: The case of peri-urban Cochabamba and Delhi. *Geoforum*, *54*, 158-166.

Mehta, L., Marshall, F., Stirling, A., Shah, E., Smith, A., Thompson, J., & Movik, S. (2007). Liquid Dynamics: challenges for sustainability in water and sanitation.

Merriam, S. B., & Grenier, R. S. (Eds.). (2019). *Qualitative research in practice: Examples for discussion and analysis*. John Wiley & Sons.

Mguni, P., Herslund, L., & Jensen, M. B. (2016). Sustainable urban drainage systems: examining the potential for green infrastructure-based stormwater management for Sub-Saharan cities. *Natural Hazards*, *82*(2), 241-257.

Ministry of Water Resources, & Works & Housing. (2007). *National water policy*. Ministry of Water Resources, Works and Housing. Accra, Ghana.

Mishra, B. K., Kumar, P., Saraswat, C., Chakraborty, S., & Gautam, A. (2021). Water security in a changing environment: Concept, challenges and solutions. *Water*, *13*(4), 490.

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

Mitchell, V. G., Mein, R. G., & McMahon, T. A. (2002). Utilising stormwater and wastewater resources in urban areas. *Australasian Journal of Water Resources*, *6*(1), 31-43.

Mitlin, D., Beard, V. A., Satterthwaite, D., & Du, J. (2019). Unaffordable and undrinkable: Rethinking urban water access in the global south.

Montgomery, M. (2014). Water on an urban planet: Urbanization and the reach of urban water infrastructure. *Global environmental change*, *27*, 96-105.

Morgan, D. L. (2014). Pragmatism as a paradigm for social research. *Qualitative inquiry*, *20*(8), 1045-1053.

Morinville, C. (2012). *Beyond the pipe: Participation and alternative water provision in underserved areas of Accra, Ghana*. University of British Columbia, Columbia.

Morse, J. M. (2016). *Mixed method design: Principles and procedures* (Vol. 4). Routledge.

Mosley, L. M., & Sharp, D. S. (2005). The hydrogen sulphide (H2S) paper-strip test. *A simple test for monitoring drinking water quality in the Pacific Islands. South Pacific Applied Geoscience Commission (SOPAC) Technical Report*, *373*.

Mothetha, M., Nkuna, Z., & Mema, V. (2013). The challenges of rural water supply: a case study of rural areas in Limpopo Province.

Mouton, J (1996): Understanding Social Research. Pretoria: JL Van Schaik

Mukherjee, S., Sundberg, T., & Schütt, B. (2020). Assessment of water security in socially excluded areas in Kolkata, India: An approach focusing on water, sanitation and hygiene. *Water*, *12*(3), 746.

Murthy, S. L., Shemie, D., & Bichai, F. (2018). The role of adaptation in mobile technology innovation for the water, sanitation and hygiene sector. *Water Practice & Technology*, *13*(1), 143-156.

Mutsiwa, A. (2016). *Precedent, policy and possibility: a victimological orientation towards the protection of traditional knowledge in Africa*.

MWRWH (2014). National Water Policy. Ministry of Water Resources, Works and Housing, Government of Ghana, June2014.

National Academy of Sciences. (2008). Water Supply by vehicule. Retrieved January 7, 2020, from Safe Drinkign Water is Essential: http://www.drinking

Nations, U. (2016). *The Sustainable Development Goals 2016*. E Social Sciences.

Neto, S. (2016). Water governance in an urban age. *Utilities Policy*, *43*, 32-41.

Neuman, L. W. (2007). *Social research methods, 6/E*. Pearson Education India.

Neuman, W. L. (2011). Social Research Methods: Qualitative and Quantitative Approaches. USA: Allyn and Bacon

Nketiah-Amponsah, N., Woedem, A. P., Senadza, B. (2009): *Socio-economic Determinants of Sources of Drinking Wate*r: Some Insight from Ghana. Paper presented at the Conference on International Research on Food Security, Natural Resource Management and Rural Development, University of Hamburg, Germany.

NNEPA. (2010). *Guidelines for Hauling and Transporting Regulated Water for Human Consumption.* Navajo: Public Water Systems Supervision Program.

Nsiah-Gyabaah, K. (2001). The looming national dilemma of water crisis in peri-urban areas in Ghana. In *Proceedings of the Second Workshop on Peri-Urban Natural Resource Management Project at the Watershed Level, DFID, Kumasi, Ghana*.

Nsiah-Gyabaah, K. (2010). Human security as a prerequisite for development. *Global environmental change and human security*, 237-259.

Nwokoro, C. V., & Chima, F. O. (2017). Impact of environmental degradation on agricultural production and poverty in rural Nigeria. *American International Journal of Contemporary Research*, *7*(2), 6-14.

Nyamekye, E., Yarney, S., & Oppong-Mensah, S. B (2016). Women's Informal Water Vending as an Economic Activity and Its Effects on Household Bargaining Dynamics in Northern Ghana.

Nyarko, K. B., & Franceys, R. W. (2003). Delays and Challenges: Public Private Partnership (PPP) in Ghana Water Sector.

Odonkor, S. T., & Addo, K. K. (2018). Prevalence of multidrug-resistant Escherichia coli isolated from drinking water sources. *International Journal of Microbiology, 2018(1),*7204013.

OECD (Organisation for Economic Co-operation and Development) (2016). Water governance in cities. *OECD Studies on Water*. Paris: OECD.

OECD (2011). *Benefits of Investing in Water and Sanitation: An OECD Perspective*. OECD Publishing, Paris, France.

Oke, M., & Oyebola, O. (2015). Assessment of rainwater harvesting potential and challenges in Ijebu Ode, southwestern part of Nigeria for strategic advice. *Analele stiintifice ale Universitatii" Alexandru Ioan Cuza" din Iasi-seria Geografie*, *60*(2), 17-39.

Olukanni, D. O., Ebuetse, M. A., & Anake, W. U. (2014). Drinking water quality and sanitation issues: A survey of a semi-urban setting in Nigeria. *International Journal of Research in Engineering and Science (IJRES)*, *2*(11),58-65.

Onwuegbuzie, A. J., Johnson, R. B., & Collins, K. M. (2009). Call for mixed analysis: A philosophical framework for combining qualitative and quantitative approaches. *International Journal of Multiple Research Approaches, 3*(2), 114-139.

Opare, S. (2012). Rainwater harvesting: an option for sustainable rural water supply in Ghana. *GeoJournal*, *77*, 695-705.

Opare, S. (2018). Adaptation to climate change impacts: coping strategies of an indigenous community in Ghana to declining water supply. *Climate and Development*, *10*(1), 73-83.

Oppenheimer, S. (2012). Out-of-Africa, the peopling of continents and islands: tracing uniparental gene trees across the map. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1590), 770-784.

Oppong, S. (2014). A critique of the philosophical underpinnings of mainstream social science research. *Academicus International Scientific Journal*, (10), 242-254.

Oteng-Ababio, M., Smout, I., & Yankson, P. W. (2017, June). Poverty politics and governance of potable water services: The core–periphery syntax in Metropolitan Accra, Ghana. In *Urban Forum* (Vol. 28, No. 2, pp. 185-203).

Owusu, K., & Kofi Teye, J. (2015). Supplementing urban water supply with rainwater harvesting in Accra, Ghana. *International Journal of Water Resources Development*, *31*(4), 630-639.

Owusu, P. A., Asumadu-Sarkodie, S., & Ameyo, P. (2016). A review of Ghana's water resource management and the future prospect. *Cogent Engineering*, *3*(1), 1164275.

Pahl-Wostl, C., Jeffrey, P., Isendahl, N., & Brugnach, M. (2011). Maturing the new water management paradigm: progressing from aspiration to practice. *Water Resources Management*, *25*(3), 837-856.

Panagopoulos, G. P., Bathrellos, G. D., Skilodimou, H. D., & Martsouka, F. A. (2012). Mapping urban water demands using multi-criteria analysis and GIS. *Water Resources Management*, *26*, 1347-1363.

Parmar, H. S., & Rana, A. (2003). Appropriating Images from Village Life. *Economic and Political Weekly*, 3236-3239.

Peloso, M., & Morinville, C. (2014). 'Chasing for Water': Everyday Practices of Water Access in Peri-Urban Ashaiman, Ghana. *Water Alternatives*, *7*(1),121-139

Pereira, L. S., Oweis, T., & Zairi, A. (2002). Irrigation management under water scarcity. *Agricultural water management*, *57*(3), 175-206.

Poehls, L. B. (2017). Energy assessment in early architectural design stages: framework and validation methodology for an architect-friendly computational energy assessment.

Popa, F. (2015). Motivations to contribute to public goods: beyond rational choice economics. *Environmental Policy and Governance*, *25*(4), 230-242.

Qadir, M., Sharma, B. R., Bruggeman, A., Choukr-Allah, R., & Karajeh, F. (2007). Non-conventional water resources and opportunities for water augmentation to achieve food security in water scarce countries. *Agricultural water management*, *87*(1), 2-22.

Radonic, L., & Jacob, C. (2021). Examining the cracks in universal water coverage: Women document the burdens of household water insecurity. *Water Alternatives*, *14*(1), 60-78.

Rahman, S., Khan, M. T. R., Akib, S., Din, N. B. C., Biswas, S. K., & Shirazi, S. M. (2014). Sustainability of rainwater harvesting system in terms of water quality. *The Scientific World Journal*, 2014(1),721357.

Rahut, D. B., Behera, B., & Ali, A. (2015). Household access to water and choice of treatment methods: Empirical evidence from Bhutan. *Water Resources and Rural Development*, *5*, 1–16. doi: 10.1016/j.wrr. 2014.09.003.

Rathnayaka, K., Malano, H., & Arora, M. (2016). Assessment of sustainability of urban water supply and demand management options: A comprehensive approach. *Water, 8*(12), 595. doi:10.3390/w8120595.

Reed, P. M., Hadka, D., Herman, J. D., Kasprzyk, J. R., & Kollat, J. B. (2013). Evolutionary multiobjective optimization in water resources: The past, present, and future. *Advances in water resources, 51*, 438-456.

Ritchie, J., Lewis, J., Nicholls, C. M., & Ormston, R. (Eds.). (2013). *Qualitative research practice: A guide for social science students and researchers*. Sage publication, New York.

Robeyns, I. (2005). The capability approach – A theoretical survey. *Journal of Human Development, 6*(1), pp.94–114.

Rowlands, B. H. (2005). Grounded in practice: Using interpretive research to build theory. *Electronic Journal of Business Research Methods*, *3*(1), 81-92.

Rubin, A., & Babbie, E. R. (2007). Survey research methods. *Pacific Grove, CA: Brooks/Cole*.

S. Arasmith (2011). Introduction to Small Water Systems

Saleth, R. M., & Dinar, A. (2000). Institutional changes in global water sector: trends, patterns, and implications. *Water Policy*, *2*(3), 175-199.

Sapkota, M., Arora, M., Malano, H., Moglia, M., Sharma, A., George, B., & Pamminger, F. (2015). An overview of hybrid water supply systems in the context of urban water management: Challenges and opportunities. *Water*, *7*(1), 153-174.

Sarantakos, S (2012).: Social Research. Palgrave Macmillan, Basingstoke.

Sarantakos, S. (2005). Social Research. Hampshire, Palgrave Macmillan.

Sarantakos, S. (2013). Social Research. 4th edition. Hampshire: Palgrave Macmillan.

Sarpong, D. (2013). World Water Week', Brief report on Ghana water Today. Radford University College, Accra.

Saunders, M. N., & Rojon, C. (2011). On the attributes of a critical literature review. *Coaching: An International Journal of Theory, Research and Practice*, *4*(2), 156-162.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. Pearson Education.

Schlosberg, D., & Carruthers, D. (2010). Indigenous struggles, environmental justice, and community capabilities. *Global Environmental Politics*, *10*(4), 12-35.

Schreck, P., van Aaken, D., & Homann, K. (2020). "There's Life in the Old Dog Yet": The Homo economicus model and its value for behavioral ethics. *Journal of Business Economics*, *90*(3), 401-425.

Scotland, J. (2012). Exploring the philosophical underpinnings of research: Relating ontology and epistemology to the methodology and methods of the scientific, interpretive, and critical research paradigms. *English language teaching*, *5*(9), 9-16.

Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach*. John Wiley & Sons.

Sen, A. (1999). The possibility of social choice. *American Economic Review*, *89*(3), 349-378.

Shannon, M. A., Bohn, P. W., Elimelech, M., Georgiadis, J. G., Marinas, B. J., & Mayes, A. M. (2008). Science and technology for water purification in the coming decades. *Nature*, *452*(7185), 301-310.

Sharma, A. K., Cook, S., & Chong, M. N. (2013). Monitoring and validation of decentralised water and wastewater systems for increased uptake. *Water Science and Technology*, *67*(11), 2576-2581. doi: 10.2166/wst.2013.168

Shevah, Y. (2015). Water resources, water scarcity challenges, and perspectives. *Water Challenges and Solutions on a Global Scale*, 185-219.

Shuster, W. D., & Garmestani, A. S. (2015). Adaptive exchange of capitals in urban water resources management: an approach to sustainability? *Clean Technologies and Environmental Policy*, *17*(6), 1393-1400.

Sieber, J. (2006). WEAP water evaluation and planning system.

Singh, J.P. (2003) 'Nuclearisation of household and family in urban India', *Sociological Bulletin*, 52(1), 53–72. doi: 10.1177/00380 22920030103.

Sitzenfrei, R., & Rauch, W. (2014). Investigating transitions of centralized water infrastructure to decentralized solutions–an integrated approach. *Procedia Engineering*, *70*, 1549-1557.

Siwar, C. and Ahmed, F. (2014) 'Concepts, dimensions and elements of water security', *Pakistan Journal of Nutrition*, 13(5), 281–286. doi:10.3923/pjn.2014.281.286.

Slavik, I., Oliveira, K. R., Cheung, P. B., & Uhl, W. (2020). Water quality aspects related to domestic drinking water storage tanks and consideration in current standards and guidelines throughout the world–a review. *Journal of water and health*, *18*(4), 439-463.

Songsore, J. (2008). Environmental and structural inequalities in Greater Accra. *Journal of the International Institute*, *16*(1),8-13.

Sood, A., Nicol, A., & Arulingam, I. (2019). *Unpacking the water-energy-environment-food nexus: Working across systems* (Vol. 186). IWMI.

Stewart, F. (2013). Capabilities and human development: Beyond the individual-the critical role of social institutions and social competencies. *UNDP-HDRO occasional papers*, (2013/03).

Stoler, J., Tutu, R. A., & Winslow, K. (2015). Piped water flows but sachet consumption grows: The paradoxical drinking water landscape of an urban slum in Ashaiman, Ghana. *Habitat International*, *47*, 52-60.

Stoler, J., Weeks, J. R., & Fink, G. (2012). Sachet drinking water in Ghana's Accra-Tema metropolitan area: past, present, and future. *Journal of Water, Sanitation and Hygiene for Development*, *2*(4), 223-240.

Sturm, M., Zimmermann, M., Schütz, K., Urban, W., & Hartung, H. (2009). Rainwater harvesting as an alternative water resource in rural sites in central northern Namibia. *Physics and Chemistry of the Earth, Parts A/B/C*, *34*(13-16), 776-785.

Sulemana, M. (2019). Urbanization, Urban Poverty and Urban Livelihoods in Tamale Metropolis, Ghana. *ADRRI Journal (Multidisciplinary)*, *28*(8), 23-58.

Sušnik, J., Jussah, O., Orabi, M.O., Abubakar, M.C., Quansah, R.F., Yahaya, W., Adonadaga, J.A., Cossa, C., Ferrato, J., Cossa, C.A. and Hadi, W. (2021). Comparative assessment of alternative water supply contributions across five data-scarce cities. *International Journal of Water Resources Development*, 38(6),985-1008.

Syme, G. J., Shao, Q., Po, M., & Campbell, E. (2004). Predicting and understanding home garden water use. *Landscape and Urban Planning*, *68*(1), 121-128.

Tecco, N. (2008). Financially sustainable investments in developing countries water sectors: What conditions could promote private sector involvement? *International Environmental Agreements: Politics, Law and Economics*, *8*(1),129-142.

Trevett, A. (2003). Household water security–the quality component. *Waterlines*, 23(1),2-4.

Tutu, R. A., & Stoler, J. (2016). Urban but off the grid: The struggle for water in two urban slums in greater Accra, Ghana. *African Geographical Review*, *35*(3), 212-226.

Twerefou, D. K., Tutu, K. A., Botchway, E., & Darkwah, S. (2015). Willingness-to-pay for potable water in the Accra-Tema metropolitan area of Ghana. *Modern Economy*, *6*(12), 1285-1296.

Ulman, A. (2019). *Expanding Conceptions of Water Security and Health: A Case Study in Anacostia, DC* (Doctoral dissertation).

UN. (1977). Report of the United Nations Water Conference. *Mar del Plata*, March 1977: United Nations Publications, No. *E/CONF* (Vol.70. p. 29)

UN-DESA. (2015). World population prospects: The 2015 revision, key findings and advance tables. Working Paper No. ESA/P/WP.241.

UNDP (2017). United Nations Development Programme. In *Human Development Report 2016*. http://hdr.undp.org/sites/default/files /2016_human_development_report.pdf. Accessed December 05, 2022.

UNDP (United Nations Development Programme) (2013). *User's guide on assessing water governance*. Oslo (NO): UNDP.

UNEP. (1998). Water Conveyance by Tanker Trucks. Retrieved April 3, 2014, from United Nations Environment Programme: http://www.unep. or.jp/ietc/Publications/TechPublications/TechPub8f/B/Conveyance3.as p 54-66

UNESCO-IHE, 2009. Research Themes. Water Security. http://www.unesco-ihe.org/ Research/Research-Themes/Water-security (accessed on 15/09/2022)

Un-Habitat. (2016). World cities report 2016: Urbanization and development–emerging futures *United Nations Human Settlements Programme*.

UN-Habitat/UNECA. 2015. *Towards an African Urban Agenda*. Nairobi: bijHabitat

UNICEF & WHO. (2014). Progress on drinking water and sanitation 2015 update. New York and Geneva

UNICEF, W. (2012). WHO, World bank. *Levels and trends in child malnutrition: UNICEF-WHO-World Bank joint child malnutrition estimates. UNICEF, New York*.

UNICEF. (2006). *Progress for children: a report card on water and sanitation* (No. 5). UNICEF.

UNICEF/WHO (2015) Progress on sanitation and drinking water 2015 update and MDG assessment. World Health Organization, Geneva

United Nations (2012). Water Survey on Integrated Approaches in the Development, Management sand Use of Water Resources Governance.

United Nations Environment Programme. Ozone Secretariat. (2006). *Handbook for the Montreal protocol on substances that deplete the ozone layer*. UNEP/Earthprint.

United Nations Environmental Program-DTIE-EITC/Sumida City Government/People for Promoting Rainwater Utilization (2002). Rainwater harvesting and utilization; an environmentally soundly approach for sustainable urban water; an introductory guide for decision makers.

UN-Water (2013). What is Water Security? Infographic. Available online: https://www.unwater.org/publications/water-security-infographic/ (accessed on 5 July 2022).

UN-Water., 2018. Fact Sheet on water scarcity. United nations. Available on: http://www.iwmi.cgiar.org/News_Room/pdf/Understanding_water_scarcity.pdf. (accessed on 15/08/2022).

van Beek, E., & Arriens, W. L. (2013). *Water Security: Putting the Concept into Practice*. Sweden: Global Water Partnership.

Van de Meene, S. J., Brown, R. R., & Farrelly, M. A. (2011). Towards understanding governance for sustainable urban water management. *Global environmental change*, *21*(3), pp.1117-1127.

Vaske, J. J. (2019). *Survey research and analysis*. Sagamore-Venture. 1807 North Federal Drive, Urbana, IL 61801.

Vásquez, W. F., & Adams, E. A. (2019). Climbing the water ladder in poor urban areas: Preferences for 'limited'and 'basic'water services in Accra, Ghana. *Science of the Total Environment*, *673*, 605-612.

Vásquez, W. F., Mozumder, P., Hernandez-Arce, J., & Berrens, R. P. (2009). Willingness to pay for safe drinking water: Evidence from Parral, Mexico. *Journal of Environmental Management*, *90*(11), 3391-3400.

Vormawor, P. (2017). *Household's choice of water sources for domestic consumption in the Shai Osudoku district, Ghana*. University of Cape Coast, Cape Coast.

Walski, T. M., Chase, D. V., Savic, D. A., Grayman, W., Beckwith, S., & Koelle, E. (2003). Advanced water distribution modeling and management. *Civil and Environmental Engineering and Engineering Mechanics Faculty Publications.* 18(1),1-60.

Ward, P. J., Strzepek, K. M., Pauw, W. P., Brander, L. M., Hughes, G. A., & Aerts, J. C. J. H. (2010). Partial costs of global climate change adaptation for the supply of raw industrial and municipal water: A methodology and application. *Environmental Research Letters*, 5(4), 044011. https://doi.org/10.1088/1748-9326/5/4/044011.(Accessed: 20/05/2022)

Water Resource Commission Ghana (2015) Basins. Retrieved December 2022, from http://www.wrc-gh.org/basins/

Water, U. N. (2015). Water, Food, and Energy. *United Nations. Retrieved from https://www. unwater. org/water-facts/water-food-and-energy*.

Webber, M. E. (2016). *Thirst for power: Energy, water, and human survival*. Yale University Press.

Whittington, D., Sadoff, C. W., & Allaire, M. (2013). The economic value of moving to a more water-secure world. *Global Water Partnership, Stockholm*.

WHO (World Health Organization) (2011). *Water safety in buildings.* Geneva, WHO.

WHO (2005), *Delivering Safe Water by Tanker (Technical Note for Emergencies No. 12)*, World Health Organization, Geneva, available at: www.searo.who.int/LinkFiles/List_of_Guidelines_for_Health_Emergency_Delivering_safe_water.pdf (accessed: 4 July 2022)

WHO. (2007). Preventing disease through healthy environments. The contribution of water, sanitation and hygiene. World Health Organization, Geneva.

WHO/UNICEF Joint Monitoring Programme (JMP) (2017). Report on water supply and sanitation www.wssinfo.org/data-estimates/table/

WHO/UNICEF. (2012). *Progress on drinking water and sanitation, 2012 update*. Geneva: World Health Organization.

Wilcox, J., Nasiri, F., Bell, S., & Rahaman, M. S. (2016). Urban water reuse: A triple bottom line assessment framework and review. *Sustainable Cities and Society*, *27*, 448-456.

Williams, D. R. (2018). Stress and the mental health of populations of color: Advancing our understanding of race-related stressors. *Journal of Health and Social Behavior*, *59*(4), pp.466-485.

Williams, M. R., Buda, A. R., Elliott, H. A., Hamlett, J., Boyer, E. W., & Schmidt, J. P. (2012). Groundwater flow path dynamics and nitrogen transport potential in the riparian zone of an agricultural headwater catchment. *Journal of Hydrology*, *511*, 870-879.

Wong, C. Y., Teo, F. Y., Goh, B. H., & Mah, Y. S. (2021). Simulating Rainwater Harvesting System Performance for a Campus University in Malaysia. In *Water Management and Sustainability in Asia*. Emerald Publishing Limited.

World Bank. 2009. *World Development Report 2009: Reshaping Economic Geography*. Washington, DC

World Health Organization (WHO)/United Nations Children's Fund (UNICEF). *Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines*; World Health Organization: Geneva, Switzerland, 2017.

World Health Organization. (2006). *Core questions on drinking water and sanitation for household surveys*. World Health Organization.

Wouters, P., Vinogradov, S., & Magsig, B. O. (2009). Water security, hydrosolidarity, and International Law: A river runs through It…. *Hydrosolidarity, and International Law: A River Runs Through It*, 97-134.

Wutich, A., & Jepson, W., (2019). *Household Water Insecurity: Uncertainty around the Tap*. SSRC. Available on https://items.ssrc.org/chancing-the-storm/household-water-insecurityuncertainty-around-the-tap/. (accessed 25/09/2022)

Wutich, A., Budds, J., Eichelberger, L., Geere, J., Harris, L.M., Horney, J.A., Jepson, W., Norman, E., O'Reilly, K., Pearson, A.L. and Shah, S.H., (2017). Advancing methods for research on household water insecurity: Studying entitlements and capabilities, socio-cultural dynamics, and political processes, institutions and governance. *Water Security*, *2*, 1-10.

Yahaya, W. (2019). *Assessment of the potential contribution of alternative water supply systems to urban water security. Case study*. MSc Thesis, IHE Delft

Yamane, Taro (1967). Statistics An introductory Analysis. 2nd ed. New York: Harper Press.

Yannopoulos, S., Giannopoulou, I., & Kaiafa-Saropoulou, M. (2019). Investigation of the current situation and prospects for the development of rainwater harvesting as a tool to confront water scarcity worldwide. *Water*, *11*(10), 2168.

Yates, D., Meldrum, J., & Averyt, K. (2013). The influence of future electricity mix alternatives on southwestern US water resources. *Environmental Research Letters*, *8*(4), 045005

Yates, D., Sieber, J., Purkey, D., & Huber-Lee, A. (2005). WEAP21—A demand-, priority, and preference-driven water planning model: part 1: model characteristics. *Water*

Yeboah, I. (2006). Subaltern strategies and development practice: urban water privatization in Ghana. *Geographical Journal*, *172*(1), 50-65.

Yeleliere, E., Cobbina, S. J., & Duwiejuah, A. B. (2018). Review of Ghana's water resources: the quality and management with particular focus on freshwater resources. *Applied Water Science*, *8*, 1-12.

Yidana, S. M. (2010). Groundwater classification using multivariate statistical methods: Birimian Basin, Ghana. *Journal of environmental engineering*, *136*(12), 1379-1388.

Young, M. D., & Esau, C. (2013). Investing in water for a green economy. *Services, infrastructure, policies and management. UNEP*.

Zakaria, I. (2011). *Appropriate rainwater harvesting and domestic water quality: A case study of*

Zeitoun, M., Lankford, B., Krueger, T., Forsyth, T., Carter, R., Hoekstra, A. Y., ... & Matthews, N. (2016). Reductionist and integrative research approaches to complex water security policy challenges. *Global Environmental Change*, *39*, pp.143-154.

Zohrabi, M. (2013). Mixed method research: Instruments, validity, reliability and reporting findings. *Theory and practice in language studies*, *3*(2), 254-262.

Zuberi, M. J. S., Khan, A. A., & Akintug, B. (2013). Rainwater Harvesting System for Dormitories of Metu-Northern Cyprus Campus. Seventeenth International Water Technology Conference, IWTC17.

APPENDIX A: INTERVIEW SCHEDULE FOR HOUSEHOLD

Introduction

Dear respondents, this household survey is conducted by Asante Opare Enoch. I am researching on the topic '*Alternative Water Supply Systems and Household Water Security in the Krowor Municipality of Greater Accra Region'* as a requirement for MPhill in Development Studies at the University of Cape Coast. Kindly help by responding as many questions as you feel comfortable with. This study is strictly for academic purposes and all responses would be anonymous and handled with the strict confidentiality. Responding to all questions will require maximum of 15 minutes. Thank you.

SECTION A: **Demographic Characteristics**

1. Sex i. Male [ ] ii. Female [ ]
2. Age……………….
3. Marital status i. Single [ ] ii. Married [ ] iii. Separated [ ] iv. Divorced [ ]

   v. Widowed [ ]
4. Household size (number of people) …………
5. Who is head of the household? i. Male [ ] ii. Female [ ] iii. Other [ ]
6. Years of stay in the area……………………………
7. What is your monthly expenditure on water?...........................

SECTION B: SOURCES OF ALTERNATIVE WATER SUPPLY SYSTEMS FOR HOUSEHOLD WATER SECURITY.

8. What is main source (s) of water for your household water security in the community? Tick all that apply

   (a) Pipe borne water from GWCL [ ]

   (b) Rain water [ ]

   (c) Ground water [ ]

   (d) River/stream [ ]

   (e) Other, specify **[ ]**

9. Which of the source(s) of water do you rely on your household water security?

(a) Pipe borne water from GWCL via Public standpipe [ ]

(b) Rainwater [ ]

(c) Groundwater [ ]

(d) River/stream [ ]

(e) Other, specify ………………….

10.Have you ever used alternative water supply systems for your household water security?

i. Yes [ ] ii. No [ ]

11**.**If yes, what type of alternative water supply systems do you use for your household water security? Tick all that apply

i. Tanker water [ ]

ii. Public Standpipe [ ]

iii. Wells [ ]

iv. water reservoirs [ ]

v. rainwater harvesting [ ]

vi. Other, Specify…….

12. If No, what alternative water supply systems do you use for your household water security?

……………………………………………………………………………………

……………………………………………………………………………………

13.How often do you use the alternative water supply systems for your household water security?

i. Daily [ ]

ii. Weekly [ ]

iii. Monthly [ ]

iv. Others, specify……….

14. What purpose(s) do you use water from the alternative water supply systems for your household water security? Kindly Tick all that apply.

i. Drinking [ ]

ii. Bathing [ ]

iii. Cooking [ ]

iv. Washing [ ]

v. Other, specify ……………

SECTION C: PREFERENCE OF ALTERNATIVE WATER SUPPLY SYSTEMS FOR HOUSEHOLD WATER SECURITY

15. How many alternative water supply systems are available for household water security? Tick all that apply

i. water tank [ ]

ii. Wells [ ]

iii. Reservoirs [ ]

iv Rainwater harvesting [ ]

v. Other, specify……………………….

16. Which alternative water supply system do you prefer for your household water security?

(a) Wells [ ]

(b) Reservoirs [ ]

(c) Tankers [ ]

(d) Ground water [ ]

(e) Other- please specify………………….

17. Does your income level have influence on your preferred alternative water supply systems for your household water security?

i. Yes [ ] ii. No [ ] iii. Not sure [ ]

18. Which water security indicators would influence your preference for an alternative water supply system(s)? Tick all that apply

i. Availability [ ]

ii. Quality [ ]

iii. Affordability [ ]

iv. Accessibility [ ]

v. Safety [ ]

vi. Other, Specify…………

19. Do you think the location of alternative water supply system(s) a reason for your choice of an alternative water supply system for your household water security?

i. Yes [ ] ii. No [ ] iii. Not sure [ ]

20. Does time spent in water collection a reason your preferred an alternative water supply system for your household water security?

i. Yes [ ] ii. No [ ] iii. Not sure [ ]

21. Would you consider seasonal changes as a reason before choosing your preferred alternative water supply system for your household water security?

i. Yes [ ] ii. No [ ] iii. Not sure [ ]

22. Do you consider cost of water supply as a reason before choosing your preferred alternative water supply system for your household water security?

i. Yes [ ] ii. No [ ] iii. Not sure [ ]

23. if yes, why?

…………………………………………………………………………………

…………………………………………………………………………………

SECTION D: **BENEFITS OF ALTERNATIVE WATER SUPPLY SYSTEMS FOR HOSEHOLD WATER SECURITY**

24.What was the reason for using alternative water supply system for your household water security?

i. Cost saving [ ]

ii. Improved water quality [ ]

iii. Increased water accessibility [ ]

iv. Improved water availability [ ]

v. Other (please specify) ……

25. Has using alternative water supply systems reduced water shortage for your household water security? i. Yes [ ] ii. No [ ]

26. If No, why?

…………………………………………………………………………………

…………………………………………………………………………………

27. Has using alternative water supply system reduced stress and vulnerabilities for your household water needs?

i. Yes [ ] ii. No [ ] iii. Not sue [ ]

28. Has using the alternative water supply system reduced issues of water scarcity your household water security need?

i. Yes [ ] ii. No [ ] iii. Not sure [ ]

29. Has using alternative water supply systems for your household water security affected the following productive activities? Tick all that apply

(a) Getting to work early [ ]

(b) House chores [ ]

(c) Ready for school [ ]

(d) Improve household welfare [ ]

30. Has using relying on alternative water supply systems decreased the dependency on conventional water supply systems?

i. Yes [ ] ii. No [ ] iii. Not sure [ ]

SECTION E: CHALLENGES OF ALTERNATIVE WATER SUPPLY SYSTEMS FOR HOSUEHOLD WATER SECURITY

With the following statements below, kindly show your level of agreement to each statement.

No.	Statements	Strongly agree	Agree	Neutral	Disagree	Strong Disagree
31.	Alternative water supply systems are not usually safe for household water security					
32.	Treatment systems for alternative water supply systems are usually unavailable					
33.	Alternative water supply systems produce poor water quality for household water security					

34.	Maintenance of alternative water supply systems for household water security is often low					
35.	Carrying/transporting water from alternative water supply systems are usually energy intensive					
36.	Household spends too much time in collecting water from alternative supply systems					
37.	Alternative water supply is usually expensive					
38.	Alternative water supply systems are usually not safe for household's drinking purposes					

SECTION E: RECOMMEDATIONS FOR IMPROVING ALTERNATIVE WATER SUPPLY SYSTEMS FOR HOUSEHOLD WATER SECURITY.

39. Does your household recommend using certain alternative water supply systems for your household water security?

i. Yes [ ] ii. No [ ]

40. If yes, which type of alternative water supply systems?

(i) Wells [ ]

(ii) Reservoirs [ ]

(iii) Tankers [ ]

(iv) Rainwater harvesting system [ ]

(v) All of them [ ]

41. What is the reason given to the recommendation?

……………………………………………………………………………………

……………………………………………………………………………………

42.Would you recommend the Alternative water supply system to others for their Household water security?

i. Definitely [ ]

ii. Probably [ ]

iii. Neutral [ ]

iv. Definitely not [ ]

v. Probably not [ ]

43. How satisfied are you using alternative water supply system(s) for your household water security?

i. Very satisfied [ ]

ii. Somewhat satisfied [ ]

iii. Neutral [ ]

iv. Very dissatisfied [ ]

vi. Somewhat dissatisfied [ ]

44. If no, what can be done to improve alternative water supply systems for your household water security?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

Thank You

APPENDIX B: INTERVIEW GUIDE FOR WATER VENDORS

SECTION A

Can you please tell me about how long you have stayed in this community and the part you play in the supply of water to household?

SECTION B: SOURCES AND BENEFITS OF ALTERNATIVE WATER SUPPLY SYSTEMS TO HOUSEHOLD WATER SECURITY

1. What type(s) of alternative water supply systems do you operate in the community?
2. What is the main source(s) of water supply for the community?
3. Which of these available sources of water are used by household in the community?
4. How often does household use this alternative water supply system for their household water security in the community?
5. How have alternative water supply systems influenced household water security in the community? (Probe for reasons).
6. How would you consider using alternative water supply system to affect the following household productive activities in the community?

i. Getting to work early

ii. House chores

iii. Going to school

v. Livelihood support

7. How have alternative water supply systems improved water shortages, water scarcity, stress and vulnerabilities for their household water security in the community?

8. How has using alternative water supply systems impacted household dependency on conventional water systems in the community?

SECTION C: **PREFERENCE OF ALTENATIVE WATER SUPPLY SYSTEMS FOR HOUSEHOLD WATER SECURITY.**

9. Which alternative water supply systems are available for household water security in the community? (Probe for reasons)

10. What preferred alternative water supply system(s) would households consider useful for their household water security in the community? (Probe for reasons)

11. Would you consider that income level of household influenced their choice of alternative water supply systems for household water security in the community? (Probe for reasons).

12. Why do households consider these household water security indicator(s) for their preferred alternative water supply systems in the community? (Quantity, quality of water, accessibility of water, affordability, availability and safety). (Probe for reasons)

13. How has the preferred alternative water supply system improve household water security in the community?

14. Would you have the impression that household do consider time spent, location, cost of water before opting for an alternative water supply system for their household water security in the community?

SECTION D: **CHALLENGES OF ALTERNATIVE WATER SUPPLY SYSTEMS TO HOUSEHOLD WATER SECUIRTY.**

15.What are the primary challenges households face when accessing alternative water supply systems in the community? (Probe for reasons)

16. Have alternative water supply systems affected the safety of water for household water security in the community? (Probe for reasons)

17. How has alternative water supply systems affected the quality of water for household water security in the community? (Probe for reasons)

18. Does the maintenance of alternative water supply systems affected water for household water security in the community? (Probe for reasons)

19. Would you consider that the cost of water from alternative water supply systems to affect household water security in the community? (Probe for reasons)

20. Would consider that untreated stored water from alternative water supply systems affect household well-being in the community? (Probe for reasons).

SECTION E: **RECOMMENDATIONS FOR IMPROVING ALTERNATIVE WATER SUPPLY SYSTEMS FOR HOUSEHOLD WATER SECURITY**

21. What ways can alternative water supply systems be useful for household water security in the community? (Probe for reasons).

22. In your opinion, how can alternative water supply systems be improved for household water security in the community?

23. Please is there anything you would like to share with me?

Thank you