“Untapped connections”: The impact of water (in) accessibility and distant water collection on women’s health and livelihoods in rural Northern Ghana

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By

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Author's declaration

This thesis comprises works that I have either authored independently or co-authored. Furthermore, I have completed this thesis under my supervisors' and advisory committee's guidance and supervision. The section following this one acknowledges the contributions made by various individuals. I affirm that this document accurately represents my thesis, including any suggested or recommended revisions as approved by my examiners. I am fully aware of and consent to the electronic or hard copy deposition of my thesis in a public repository for accessibility and utilization by the public.

Statement of contributions

Exemptions to sole authorship:

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I am the lead author in all the four manuscripts, and I wish to confirm that my role was multifaceted. It encompassed various responsibilities, including project conceptualization, drafting the manuscript, conducting an exhaustive literature review and analysis, and revising. At every project stage, I contributed to maintaining the manuscript's coherence, precision, and overall quality. The co-authors (primary supervisors: Drs. Corinne J Schuster-Wallace and Sarah Dickson-Anderson) not only took on supervisory roles but also made varied contributions. They played a crucial role in conceptualization, formal analysis, investigation, methods development, visualization, and revisions. They provided essential direction, ensuring that the manuscripts were well-written and met the standards expected of scholarly work.

Abstract

In sub-Saharan Africa, access to safely managed water remains low, particularly for rural residents who predominantly rely on decentralized water systems. The issue is exacerbated by the prevalence of non-functional and unsustainable hand pumps, compounding the chronic water challenges in rural areas. Access to safely managed water is a pressing concern connected with gender dynamics and power imbalances, closely linked to the socially constructed roles assigned to women in patriarchal African cultures and societies. This emphasizes the gendered and intersectional implications of water inaccessibility and distant water collection for rural women. However, scholarship examining the gendered experiences and consequences of women's water collection responsibility remains limited, particularly in Ghana, where water inaccessibility is a longstanding issue. Inadequate empirical research on critical aspects of water (in)accessibility and distant water collection could create missing links to advancing knowledge on and addressing the gender dimensions of water insecurity in diverse sociocultural and economic settings. This thesis aimed to address research gaps and advance knowledge by investigating the impact of water inaccessibility and distant water collection on the health and livelihoods of women in rural northern Ghana.

The research began by developing a comprehensive conceptual framework through a systematic review of the literature on water access and collection, focusing on gender and climate considerations aimed at alleviating water inaccessibility in rural sub-Saharan Africa. This work emphasized the reciprocal linkages between drivers (environmental, systemic, and individual factors) of water (in)accessibility, and the ensuing consequences (health, safety, nutritional, hygiene, and economic risks), and coping strategies (exit, loyalty, and voice or collective action) as well as the feedback loops that sustain water inaccessibility and exacerbate

difficulties in water acquisition. Building upon this framework, Ghana's 2014 Demographic and Health Survey was combined with meteorological records (1991-2021) and relationships were explored through binary logistic regression to explore and understand factors influencing the spatiotemporal dynamics of access to improved water sources among Ghanaian households. Results from the multivariable regression analyses revealed significant access inequalities influenced by intersecting environmental, systemic, and individual factors. Critical environmental factors showed that a unit increase in average rainfall range [OR 1.012; 95% CI (1.005 – 1.019)] was associated with improved water sources, as were urban residents [OR 1.469; 95% CI (1.233 – 1.750)]. Essential systemic factors revealed that high-income households [OR 6.875; 95% CI (5.748 – 8.223)] had far higher odds of accessing improved water sources. Critical individual factors showed that higher education levels [OR 1.212; 95% CI (1.069-1.373)] and smaller household size [OR 1.461; 95% CI (1.191 - 1.793)] associated better with access to improved water sources.

Building upon the groundwork laid by these broader regional and national studies and considering women's water collection responsibility in patriarchal African cultures, a case study was carried out within the Kologo rural community of Ghana to explore women's experiences collecting water off premises. This study involved surveys and focus group conversations, engaging an equal number of women and men to interrogate factors underlying women's challenges when collecting water, the health and economic impacts of this responsibility, and the various strategies women employ to address inadequate water access. Key findings from the statistical and thematic analyses revealed overlapping factors in women's water collection difficulties, including distance to water sources, seasonality, poverty, limited water facilities, and health issues. These factors exposed more than half of the women to complex deleterious consequences spanning physical and psychological injuries (>80%), animal attacks (≤12%), spousal violence (>40%), nutritional challenges (>30%), hygiene problems (>40%), and socioeconomic issues (>50%). Over half of the women encountered three to seven intersecting water-related problems, which disempowered them and created feedback loops that perpetuate water insecurity and exacerbate their difficulties in water acquisition. In response, these women employed exit (alternative water sources, purchasing water, collaborative sharing), loyalty (storage, conservation, treatment), and voice (community-driven actions, complaints to authorities) strategies to address access challenges simultaneously or interchangeably. However, specific coping mechanisms can be ineffective and even detrimental long-term, highlighting the double burden of enduring persistent water inaccessibility.

The significance of this research lies in its ability to illustrate how water inaccessibility, distant water collection, and entrenched gender norms intersect, leading to ripple effects on women's health and well-being. This study contributes to the ongoing discourse on the gender dimensions of water access and water collection responsibilities. The potential impact of this research extends beyond academia. By employing a multifaceted approach that enhances our understanding of the complexity and intersection of factors influencing rural women's water access challenges and coping strategies, this study sheds light on the multidimensional public health and socioeconomic challenges stemming from water insecurity and distant water collection. It underscores the urgent need for action, urging governments, policymakers, and stakeholders to prioritize initiatives to improve water security in rural areas and mitigate gender-related risks. It highlights the disproportionate burden placed on rural women due to deeply entrenched gender norms, underscoring the imperative to challenge and transforms these norms to promote a more equitable distribution of responsibilities and alleviate the burden on women.

Furthermore, this research advocates for innovative methods beyond conventional approaches to gather robust, evidence-based insights to engage policymakers to improve equitable water access effectively. While this study provides insights into the water-collection experiences of women in a specific locality, its findings hold the potential to inspire broader ideas, approaches, and actions. The studies emphasize the importance of integrated, cross-sectional approaches. Combining local community engagement strategies with understanding environmental, systemic, and individual factors highlighted at regional and national levels can create comprehensive strategies for diverse settings. This may include implementing comprehensive policies and frameworks beyond infrastructure development, incorporating community participation and accounting for socioeconomic and cultural contexts to ensure sustainable water improvements. This will be a crucial step toward promoting gender equity in water access, safeguarding the fundamental right to safe water, and advancing the Sustainable Development Goals, particularly Goals 6 (clean water and sanitation), 5 (gender equality), and 3 (good health and well-being). Overall, this study brings attention to the ongoing water insecurity in rural areas, calling on governments and policymakers to address sociocultural norms and power structures and the multifaceted factors influencing access through effective and gendered water management and planning in patriarchal African cultures and societies.

Keywords: SDGs**,** SDG 6: clean water and sanitation, SDG 5: gender equality, SDG 3: good health and well-being, gender, water access, water collection, water fetching, women, Africa, Ghana, Upper East Region, Kologo, Kassena-Nankana East Municipality, factors, consequences, coping strategies, coupled systems framework, rural areas

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Dedication

I dedicate this work to the Holy Trinity: God the Father (Supreme Being), God the Son (Jesus), and God the Holy Spirit (Holy Spirit).

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Glossary

Term	Definition
Cross-sectional design	Collecting data from a sample of participants at a single point in time (Wang & Cheng, 2020)
Gender	In this study, gender refers to man and woman (Harcourt, 2017)
Intersectionality	The interconnection of social categorizations such as race, class, gender, sexuality, ability, and other axes of identity and oppression (Crenshaw, 2021)
Disaggregated data	Data that has been broken down into smaller, more specific categories or subgroups (Balestra & Fleischer, 2018)
Mixed methods	In this research, the mixed-methods approach involves the integration of quantitative and qualitative data collection techniques in a single investigation (Creswell & Plano-Clark, 2017)
Rural area	In Ghana, rural is a geographical area of less than 5000 people (Ghana Statistical Service, 2013)
Place	Place refers to the biological, social, and physical attributes that determine people's lives (Cummins et al., 2007)
Coupled systems	Two or more components interacting with each other, influencing one another's behaviour and often leading to complex dynamics that will not be present in isolated systems (Holling, 2001)
Exit strategy	Identifying alternative ways to access sufficient water (Majuru et al., 2016)
Feedback loops	A system structure in which the output of a process is fed back into the system as input, potentially influencing the subsequent output (Bayer, 2004)
Loyalty strategy	Adopting accommodative plans to cope with persistent water inaccessibility (Majuru et al., 2016)
Voice strategy	Employing collective action and radical measures to lobby for the provision of sustainable water access (Majuru et al., 2016)
Space	The geographic context of place and the connectedness between these places (Andrews et al., 2012)
Scale	The spatial and temporal dimensions at which (health) phenomena occur (Bambra et al., 2019)
Deficit-based Approach	Narrow or constrained approach that may overlook important factors or perspectives in explaining phenomena (Saleebey, 1996)

List of Acronyms

Acronym	Meaning
SDGs	Sustainable Development Goals
SSA	sub-Saharan Africa
GDHS	Ghana Demographic and Health Survey
WHO	World Health Organization
UNICEF	United Nations International Children's Emergency Fund
WASH	Water, Sanitation, and Hygiene
ECMRWF	European Centre for Medium-Range Weather Forecasts
NGOs	Non-Governmental Organizations
UNDP	United Nations Development Programme
WWAP	World Water Assessment Programme
FGDs	Focus Group Discussions

CHAPTER ONE

1.0 Introduction

This thesis conducts a comprehensive and scholarly investigation into the difficulties of water inaccessibility and long-distance water collection in rural sub-Saharan Africa. As an academic endeavour, this research aims to systematically reveal the complexities of access dynamics and identify strategic intervention points for government entities, policymakers, and stakeholders. Given the fast-approaching 2030 Sustainable Development Goals, this research emphasizes the urgent need for a thorough understanding of water access and related issues.

This introductory chapter presents compelling empirical evidence of water inaccessibility and long-distance water collection, highlighting the profound and disproportionate impact on (rural) women because of deeply ingrained patriarchal sociocultural norms and structures in sub-Saharan Africa. This contextual background forms the basis for delineating objectives and research questions within the broader context of water accessibility challenges. The chapter also provides a thorough introduction to the research context, commencing with an exploration of the country under investigation, followed by an in-depth analysis of the particular region and community that have been the focus of the study. This approach serves to establish a strong basis for understanding the complex sociocultural and geographical factors that inform the research landscape. Additionally, the opening chapter critically engages with existing literature on gender and water, integrating it into the discipline of health geography. This integration elevates the scholarly rigour of the research. It provides a nuanced foundation for examining the intricate interplay between water dynamics, gender considerations, and health in rural sub-Saharan Africa. It further presents the structural roadmap of the thesis, providing a glimpse into how it is organized.

1.1 Background

Access to safely managed drinking water has long been recognized as a fundamental human right and is closely intertwined with the enjoyment of other essential human rights. The right to water entails that "every individual should have access to a sufficient, safe, acceptable, physically accessible, and affordable water supply for personal and domestic use" (United Nations, 2002). Consequently, world leaders introduced various instruments and policy frameworks over the years, including the Millennium Development Goals and the Sustainable Development Goals (SDGs), specifically target 6.1, to address the spatial disparities in equitable water access (UNICEF & WHO, 2015). At the core of these frameworks, basic access implies that everyone should have access to water from an improved or safely managed source that is conveniently available on their premises, accessible when needed, and free from contamination (UNICEF & WHO, 2023). Despite extensive efforts and initiatives aimed at achieving universal access to safely managed water, more work is still required because a significant portion of the global population still faces challenges related to inadequate, unreliable, scarce, and unaffordable access (UNICEF & WHO, 2023). Global statistics show that in 2017, approximately 785 million people lacked access to safely managed drinking water (WHO & UNICEF, 2021), and by 2022, this number had risen to 2.2 billion (UNICEF & WHO, 2023), highlighting a troubling trend suggesting that the world is not on track to meet SDG target 6.1, especially low-income countries.

While this is a global issue, it disproportionately affects sub-Saharan Africa, where an estimated 50% of the population is chronically underserved and faces significant disparities in access (UNICEF & WHO, 2023). These disparities manifest as pronounced gaps between urban and rural areas and across various regions (WHO & UNICEF, 2021), resulting from a complex interplay of factors, including climate change, population growth, and governance challenges (Apatinga et al., 2022; WHO & UNICEF, 2021). Rural areas, in particular, need more safely managed water services, defined as on-site, on-demand sources, and, most crucially, contamination-free. Rural coverage for these services remains low, standing at approximately 50%, in stark contrast to urban areas where coverage exceeds 70% (UNICEF & WHO, 2023). Even this 50% in rural areas primarily relies on decentralized systems like communal boreholes and standpipes, requiring most residents to expend significant time and effort traversing challenging terrains to access water sources. The ultimate solution, in-house piped water supply, is often unaffordable, or unavailable to rural communities (UNICEF & WHO, 2023). Thus, it is unsurprising that a growing body of literature links Africa's developmental challenges, disease burden, and persistent poverty to rural water insecurity (Prüss-Ustün et al., 2019; WWAP, 2019). This situation underscores the urgent need for governments, policymakers, and stakeholders to intensify their efforts and expand initiatives to improve equitable access to safely managed water in rural regions.

While water inaccessibility and distant water collection are persistent and severe challenges for rural communities, women and young adolescent girls bear a greater burden of these chronic problems (Apatinga et al., 2022; Graham, Hirai, & Kim, 2016; Jeil et al., 2020). This is due to the gendered nature of access to safely managed water, deeply rooted in the socially constructed roles of women in patriarchal African societies and cultures. Women are primarily responsible for household water supply, with households lacking in-house piped connections relying on women to provide water for drinking and domestic purposes (Apatinga et al., 2022; UNICEF & WHO, 2023). Traditional socio-cultural norms and practices further exacerbate this disparity by exempting men from water collection and other forms of domestic labour, reinforcing and justifying men's power and autonomy within households. Even as men engage in collecting water, they often perceive it as assistance to their spouses rather than taking direct responsibility for the chore (Asaba, 2013; Van Houweling, 2016). In this context, it becomes evident that rural women are disproportionately affected by the challenges and burdens associated with limited water availability and the distant retrieval of water compared to men.

Compounded by women's water collection responsibilities, economic, political, and social factors deeply influence material inequalities and water insecurity, determining who can access water, when, and at what cost (Crow, 2001; Jei et al., 2020; Van Houweling, 2016). In every mode of water access, whether through private land ownership with secure water sources, communal rights, open access, state-backed provisions, or market access, disparities exist (Crow, 2001), particularly when considering the differing circumstances of men and women, especially within the African context. The entitlement to water is shaped by social norms, thereby assigning rights based on one's position within the family and community (Crow & Sultana, 2002). The lack of property ownership, limited access to resources among women, and the uneven distribution of household assets can hinder their ability to access water and restrict their involvement in community water governance. In impoverished regions, women often find themselves in vulnerable positions, frequently having to negotiate with men-dominated and controlled water vendors (Pommells et a., 2018; Yerian et al., 2014). These realities underscore the intricate dynamics of gender and power in water access, highlighting the disproportionate burden women bear in terms of water unavailability and the challenging task of collecting water from distant sources. Women need help to access sufficient quantities and quality of water to fulfill their gendered responsibilities and meet household water needs, compelling them to develop potentially ineffective strategies to secure water during shortages (Apatinga et al., 2022;

Bisung, 2021; Bukachi et al., 2021). This responsibility poses an even more significant challenge for women with unique vulnerabilities, such as pregnant women (Geer & Cortobius, 2017). Beyond the diseases burden often associated with rural water insecurity in sub-Saharan Africa, there are other unforeseen complications stemming from poor water access and remote water retrieval for rural women. However, there is inadequate academic scholarship examining the gendered experiences and consequences of water inaccessibility and distant water collection for rural women, especially in Ghana, where water inaccessibility is a longstanding issue. To address these inequities and social justice issues in line with the Sustainable Development Goals, a comprehensive approach is necessary- one that recognizes the social and physical context and belief systems that undermine efforts to achieve equitable access. With the Sustainable Development Goals surpassing a midpoint, with goals 5 and 6 specifically emphasizing gender equality and universal access to safely managed water (UNICEF & WHO, 2023), it is crucial to investigate women's water-collection experiences in specific local contexts to inform context-specific water policies and programs aimed at women's empowerment and sustainable development goals related to drinking water access.

This study examined the vulnerabilities and burdens rural women experience in Ghana due to water inaccessibility and distant water collection. It specifically focused on the disproportionate threats to livelihoods and health resulting from poor water access and water collection from outside premises. By addressing this critical topic, the study contributes to the evolving body of literature exploring the intersections of water inaccessibility, gender inequality, and women's subordination, all rooted in cultural norms, gender roles, power dynamics, and social governance related to water use and control. The objectives addressed were:

1.2 Objectives of the study

1. To identify factors underlying limited access to safe water for domestic use among rural women in Northern Ghana
2. To examine the impact of inadequate water access and distant water collection on women in rural Northern Ghana
3. To explore the coping strategies against suboptimal water access among rural women in Northern Ghana.

1.3 Research questions

The following research questions guided the study:

1. What factors make it difficult for women in rural Northern Ghana to access potable water for domestic use?
2. What are the health, social, and economic implications of water collection for women in rural Northern Ghana?
3. How do women in rural Northern Ghana cope with domestic water supply unreliability?
4. What are the possible ways to make potable water more accessible to people living in rural Northern Ghana?

1.4 Research context (Ghana)

Data collection was conducted in Ghana (Figure 1.1) during the summer of 2022. Ghana is the first country in sub-Saharan Africa to achieve independence and is located along the Gulf of Guinea in West Africa. It has a population of approximately 32 million and is administratively divided into 16 regions, covering an area of roughly 238,533 square kilometres (Ghana Statistical Service, 2021). The country has a tropical climate and shares borders with Togo to the east, Ivory Coast to the west, Burkina Faso to the north, and the Atlantic Ocean to the south.

Once known as the Gold Coast, Ghana is known for its stable political climate and democratic governance. It gained independence from British colonial rule on March 6, 1957, and has since undergone multiple peaceful transitions of power through democratic elections. Ghana is a multiparty democracy, but its political landscape is dominated by two major parties: The New Patriotic Party (NPP) and National Democratic Congress (NDC). The country's governance structure follows a presidential system in which the president serves as both the head of the state and government. Regular presidential and parliamentary elections, held every four years, determine the nation's leadership. Ghana is often recognized as one of the more politically stable countries in West Africa. It is culturally diverse, with many ethnic groups contributing to its rich cultural tapestry, unique languages, and traditions.

Ghana possesses abundant natural resources such as gold, oil, gas, bauxite, and aluminum, and is a leading global producer of gold. Despite its wealth, Ghana faces economic challenges in the post-colonial era, including debt, inflation, and poverty. Significant economic disparities exist between rural and urban areas and across regions. Notably, approximately 38% of individuals in rural areas experience poverty, which is in stark contrast to the 11% poverty rate in urban areas (Cooke et al., 2016). The five northern regions—Upper West, Upper East, Northeast, Savannah, and Northern—are particularly affected and are significantly poorer than their southern counterparts. Despite the substantial water resources in Ghana, disparities in access to improved or safely managed water exist between regions and rural-urban areas (UNICEF & WHO, 2023). In rural areas, less than half of the residents have access to improved or safely managed water sources, often requiring them to travel long distances to remote locations to reach predominantly utilized hand pumps or boreholes. This highlights the need for improved access to water in rural areas.

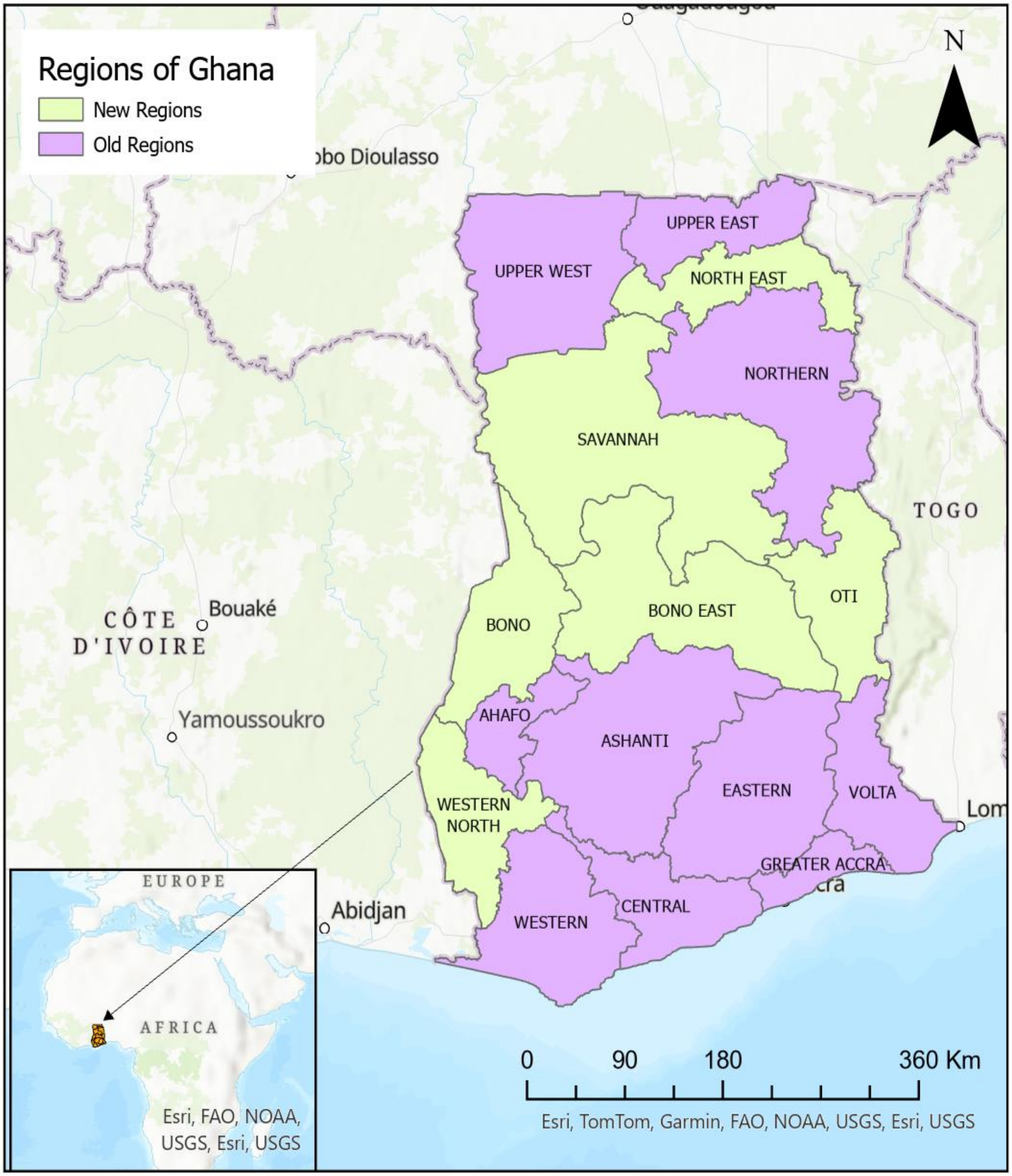


Figure 1.1: A regional map of Ghana Data source: ArcGIS Hub. (n.d.)

Gender disparities are also pervasive in many aspects of the Ghanaian society and deeply ingrained in cultural norms and structures that favour men and assign women secondary roles (Nartey et al., 2023). These norms affect decision-making power and control, resulting in men-dominated culture and women’s submission (Heise et al., 2019). These entrenched cultural norms perpetuate gender disparities in various aspects of society, such as leadership and decision-making roles (Sikweyiya et al., 2020). Typically, men hold household leadership and decision-making roles, whereas women are expected to submit and obey (Dako-Gyekye & Owusu, 2013). Women often conform to their assigned cultural roles and expectations (Dako-Gyekye & Owusu, 2013). For example, women dedicate at least 15% of their time to unpaid care and domestic work, including water collection, compared with 5% of men (World Bank, 2020). These societal norms intersect with issues such as water insecurity to hinder women's empowerment and perpetuate gender inequality in various societal spheres.

1.4.1 Region of study (Upper East Region)

The study was carried out in the Upper Eastern Region (Figure 1.2), which is located in Northern Ghana and is the country's third smallest administrative region, covering 8,842 square kilometres (2.7% of the total land mass). It shares borders with Burkina Faso to the north, Togo to the east, the Upper West Region to the west, and the Northern Region to the south. According to the 2021 Population and Housing Census, the region has a population of 1,301,226, representing 4.2% of the national population, with more women (51%) than men (49%) (Ghana Statistical Service, 2021). Despite being a significant contributor to the country's tax revenue, the Upper East Region is recognized as one of the most impoverished areas in Ghana, facing notable development challenges. The primary source of income is the central government's budget allocation, which is linked to its smaller population compared to other regions (Adugbire et al., 2010). This has resulted in a notable developmental challenge; an insufficient water supply and unsafe sanitation, which is compounded by inadequate funding for community water and sanitation agencies, leading to limited facilities for residents and common issues such as open defecation and littering (Ghana Statistical Service, 2014). In addition to socioeconomic barriers, environmental threats, such as extreme climate change and floods, pose risks to water availability and human life (Alhassan & Hadwen, 2017; Yaro, 2010). Past floods have resulted in casualties, displacement, and infrastructure damage (Alhassan & Hadwen, 2017), highlighting the need for proactive measures to prevent increased poverty and threats to development initiatives.

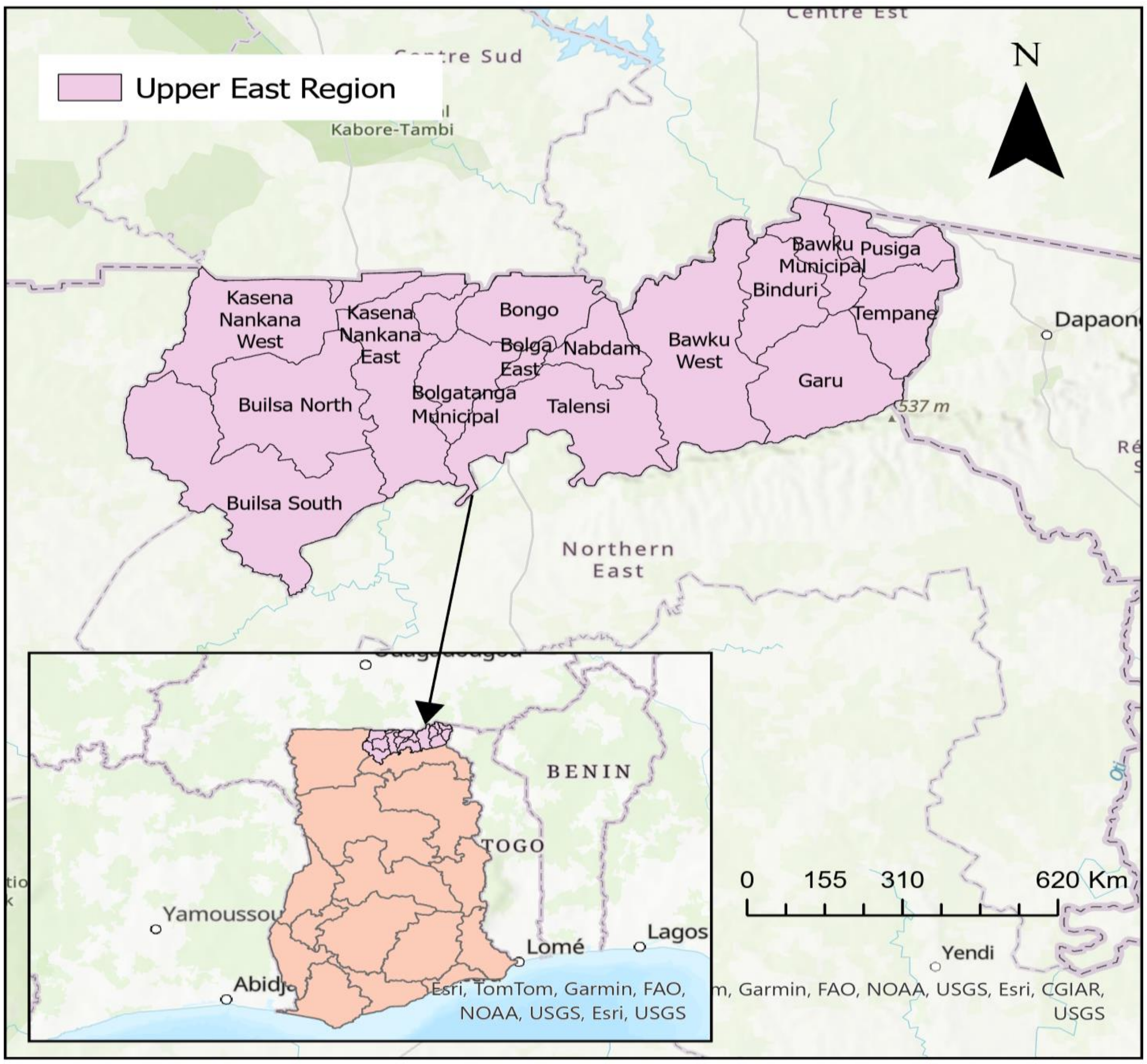


Figure 1.2: A map of the Upper East Region in Ghana

Data Source: Humanitarian Data Exchange (n.d.)

Climate predictions for the northern regions, including the Upper East Region, forecast rising temperatures and less annual rainfall (Alhassan & Hadwen, 2017). This is anticipated to affect the water cycle, availability, and access. With inadequate water infrastructure, many communities face water inaccessibility, especially in rural areas, requiring women and children to travel further distances to reach water sources. These sources pose health risks and livelihood challenges, failing to meet the WHO's drinking water guidelines. The widespread child mortality in the Upper East Region is due to water-borne diseases, and communities in this region also confront dental fluorosis linked to high fluoride concentrations in groundwater sources (Ganyaglo et al., 2019). The combination of water inaccessibility and unsafe sanitation threatens development initiatives in Ghana, potentially hindering progress towards achieving the Sustainable Development Goals. Thus, it was crucial to study the impact of water inaccessibility on rural women in this region to implement sustainable interventions to preserve lives and livelihoods, particularly for the poor and vulnerable populations.

1.4.2 District of study (Kassena-Nankana East)

The study specifically focused on the Kassena-Nankana East District (Figure 1.3), an area in the Upper East Region that experiences chronic water shortages. This administrative district, covering 1,674 square kilometres, was established in 1988 and upgraded to a municipal status in 2010, with Navrongo as its political and administrative capital (Oduro et al., 2012). The district is predominantly rural, with more than 80% of the population residing in rural areas. The 2021 census recorded a population of approximately 99,895, with more women (51,237; 51.2%) than men (48,658; 48.8%), and an average household size of 4.8 persons (Ghana Statistical Service, 2021). The inhabitants of the district include the Kassena (54%), the Nankana (42%), and the Buli-speaking people (4%), who share similar sociocultural and economic lifestyles.

Additionally, there are migrant tribes, such as Hausas, Akans, and Zambaramas. Most people are Christians (56%), with a smaller percentage identifying as Muslims (14.5%) and traditional believers (24.2%) (Ghana Statistical Service, 2014). Agriculture, particularly farming, is the primary economic activity, supplemented by common trading practices, mainly petty trading, owing to limited financial capital for larger businesses (Donkoh et al., 2013). The district is recognized as one of the poorest in Ghana (Ghana Statistical Service, 2013).

In the region of Kassena-Nankana, the patrilineal inheritance system favours the eldest male child, resulting in women not owning family assets. Women are primarily responsible for unpaid domestic tasks, such as water hauling, childcare, and firewood collection (Awumbila, 2006; Lugg, Morley, & Leach, 2007). Decision-making authority is mainly held by men, limiting women's autonomy and independence (Baiden et al., 2006), and creating significant sociocultural and economic barriers. In the vulnerable Upper East Region, the Kassena-Nankana East District faces irregular rainfall patterns, causing periodic water shortages (Donkoh, Ayambila, & Abdulai, 2013; Ghana Statistical Service, 2013). With an annual average rainfall of 850 mm between July and September, the municipality needs help with unequal potable water distribution. Although water pumping machines exist in major towns, such as Navrongo and Chiana, as well as boreholes and hand-dug wells, these sources are insufficient and often dry during the long dry season (Ghana Statistical Service, 2013). Many households need help accessing installed boreholes, which are frequently out of order owing to population pressure and mechanical issues. The piped water system is only affordable for the wealthy, while some residents rely on remote, unprotected sources, such as dug wells, dams, streams, and rainwater harvesting. Sanitation issues, including indiscriminate waste disposal, contribute to water pollution (Ghana Statistical Service, 2014). Women and girls, primarily responsible for caregiving and domestic water supply, face exacerbated consequences due to water inaccessibility. This marginalized district presents a compelling case for examining the impact of water scarcity and inaccessibility on women's health and socioeconomic activities.

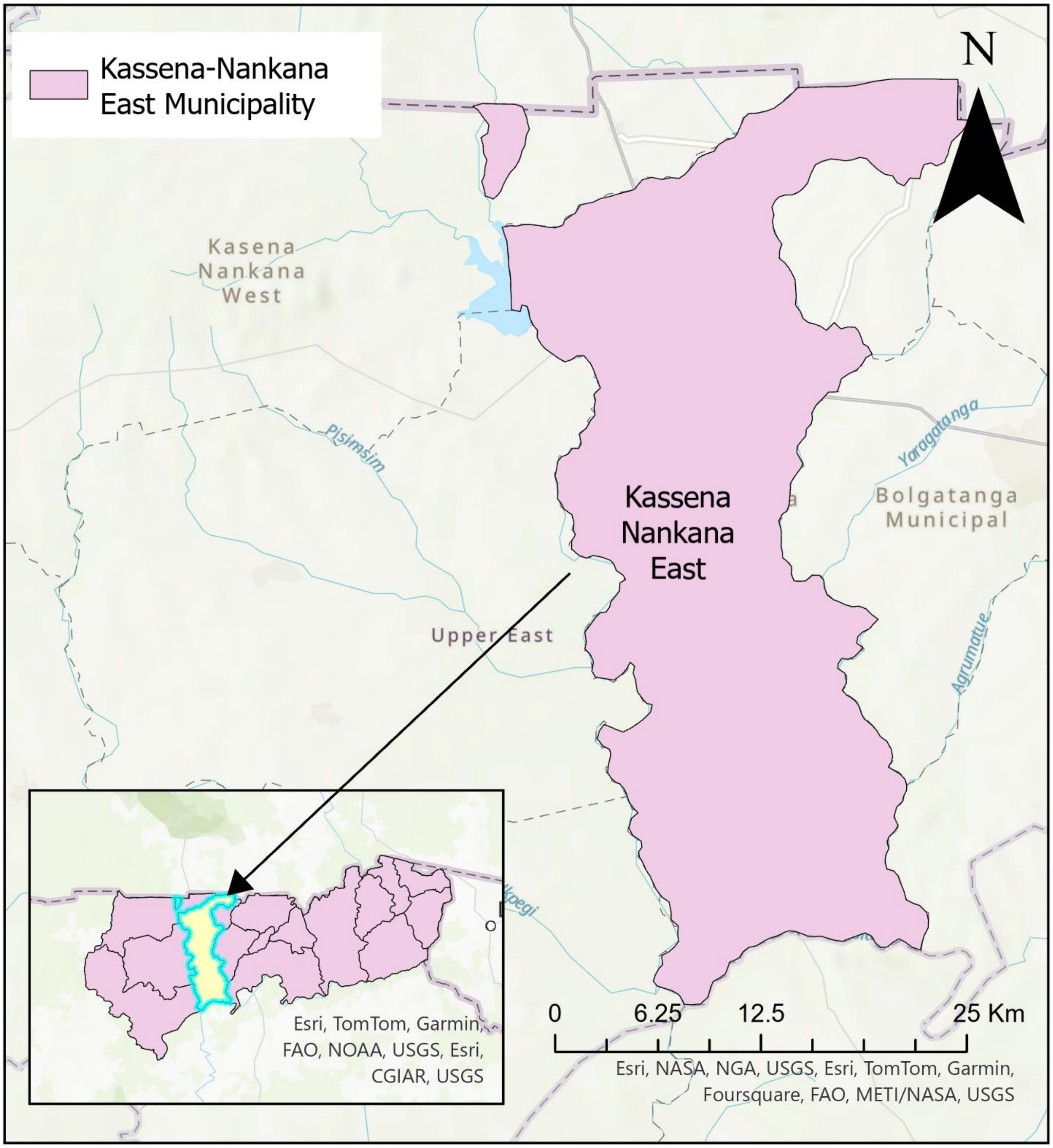


Figure 1.3: A map of the Kassena-Nankana East Municipality in the Upper East Region Data Source: Humanitarian Data Exchange (n.d).

1.4.3 Community of study (Kologo)

This study was conducted within the Kologo community (Figure 1.4) in the Kassena-Nankana East District of Ghana, an area characterized by pronounced water insecurity. The community is 14 kilometres from the municipal capital of Navrongo. Positioned between latitude 10º44'11" N and longitude 1º4'41" W, it shares borders with the district capital (Navrongo) to the north, the Atankwidi Forest Reserve to the east, the Wulugu community to the west, and the Naaga community to the south. With an approximate population of 2000 (Luabe et al., 2017), the community primarily consists of Nankane-speaking people (Osman, 2023). It has a diverse population of Christians, Muslims, and traditional believers. Governance is facilitated through the leadership of the chief and elders, who are responsible for maintaining order, settling disputes, and overseeing developmental initiatives.

Kologo is a rural community that features short, scattered trees and grasses. These vegetation types are susceptible to bushfires during the dry season (Naziru, 2018). The region experiences a single rainy season from May to October, with annual rainfall ranging from 800 to 1100 mm. During the dry season, which lasts from November to mid-February, the community experiences cold, dry, and dusty harmattan winds. The average temperatures during this period are 14°C at night and approximately 35°C during the day. Agricultural activities are the primary occupation for both men and women in the community, with crops such as cereals and legumes being grown for subsistence and commercial purposes. The community's soil is rich in savannah ochrosols, which are well-suited for agriculture (Osman, 2023). Additionally, the community has access to water from canals linked to the Tono Dam, allowing dry-season irrigation farming. There are two dams in the community that serve as a vital water reservoir for various purposes.

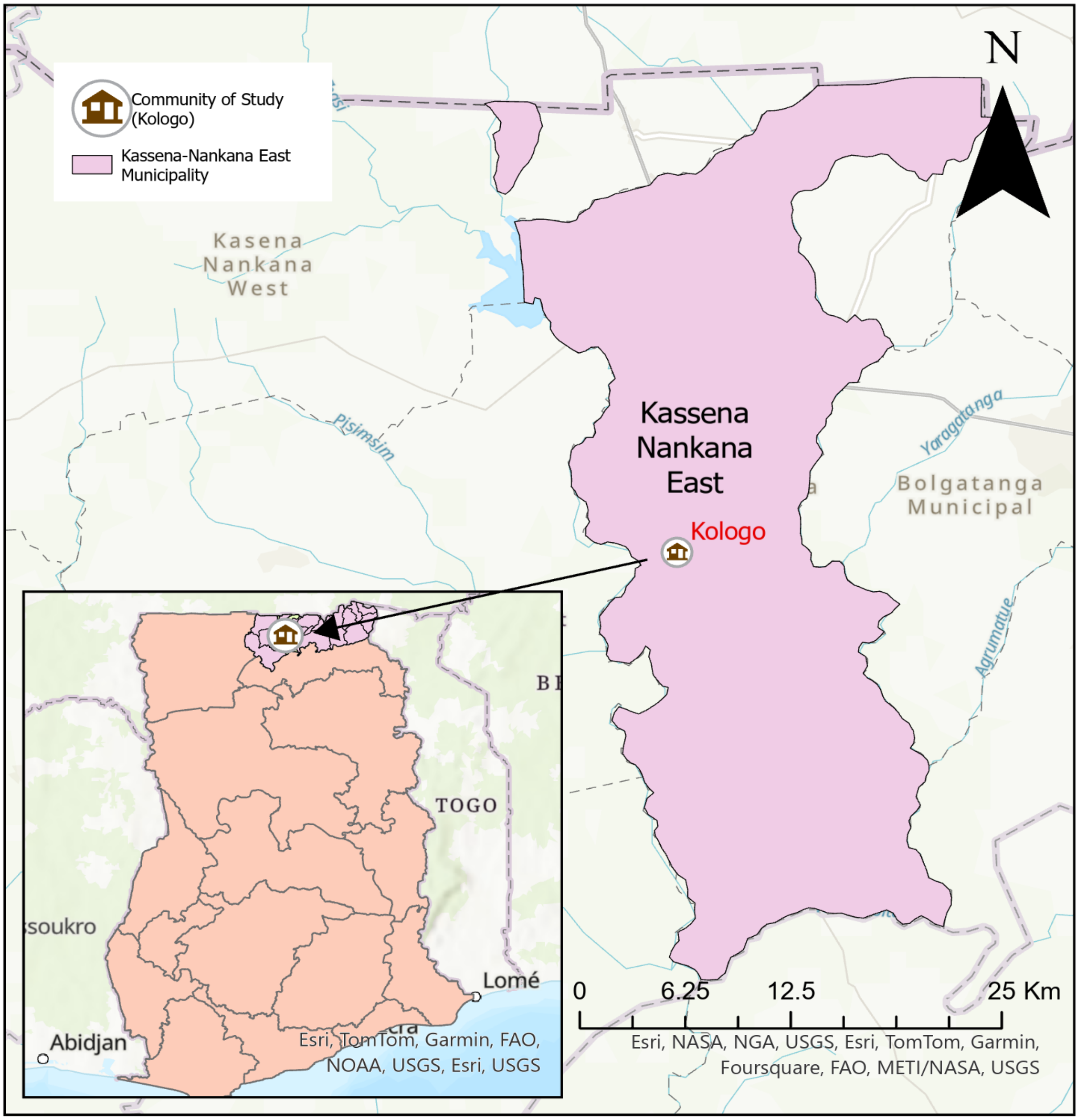


Figure 1.4: A map of the study community (Kologo) in Ghana

Data Source: Humanitarian Data Exchange (n.d.)

Kologo is a rural farming community that is economically disadvantaged and lacks basic amenities and infrastructure. The community has only one health center and three basic schools serving the entire population. Low literacy rates exacerbate educational challenges in the area. Residents face significant obstacles in accessing resources and opportunities, leading to widespread poverty, particularly affecting women. For instance, the lack of piped water is a persistent issue due to economic constraints and high connection costs. Water access relies on strategically placed boreholes to cater to rural residents' needs. Women, who adhere to gender norms, are primarily responsible for collecting water and often walk long distances through challenging terrains to reach these facilities. However, boreholes' unreliability, mechanical issues, and frequent malfunctioning due to population growth exacerbate the struggle. Moreover, some water sources dry up during the dry season, and water quality becomes questionable due to poor sanitation practices. The absence of toilet facilities has resulted in open defecation, which poses a significant health risk.

The Kologo community is divided into three distinct subdivisions: Kolwingo, Nayiire, and Zuo. Kolwingo, one of the major subdivisions, reflects the socioeconomic and cultural structures of the broader community. It is the first community you encounter upon entering Kologo, characterized by dispersed settlements. This area is home to the market square, where residents of Kologo and neighboring communities gather to conduct business. Residents primarily engage in subsistence and small-scale commercial farming activities. Kolwingo has one basic school and one dam. The social structures are characterized by extended family systems and communal living arrangements, common throughout the district. Water insecurity, which affects agricultural productivity and daily life, is a significant challenge. During fieldwork, it was noted that there were few boreholes and unprotected dug wells located far from many homes.

Nayiire is the second subdivision after Kolwingo when entering Kologo and is the residence of the chief, earning its name, which means "chief's area." Nayiire shares similarities with Kolwingo and Zuo, including an agrarian economy, dispersed settlements, traditional practices and beliefs, extended family systems, and communal living arrangements. The local lifestyle is largely influenced by natural vegetation, and residents depend heavily on seasonal rains for farming. Nayiire has a basic school and health center that serve the entire population of Kologo. A dam located adjacent to the chief's place is used for dry-season farming, but it experiences water depletion during this period, making farming difficult. This dam is vulnerable because it is not stable and has been breached multiple times. Like Kolwingo, Nayiire has limited water facilities, primarily boreholes, at strategic points. A water tank for the whole of Kologo is located here, but accessing water from this tank is difficult because of poverty, preventing many inhabitants from tapping it into their homes. Consequently, residents often rely on distant sources of water.

Zuo is situated next to Nayiire, about a 20 to 25-minute walk away. It shares characteristics with Kolwingo and Nayiire, including agricultural economy, extended family systems, scattered settlements, and communal living arrangements. The physical environment, including vegetation and climate, was consistent across all subdivisions, contributing to shared environmental and socioeconomic conditions. Zuo has one basic school but no dam. Members engage in dry season farming using dams in Kolwingo and Nayiire. Zuo also preserves the cultural heritage of the broader Kologo community through practices and traditions. Similar to Kolwingo and Nayiire, there are very few government-provided boreholes located at strategic points for community members to access.

Across all three subdivisions, common factors such as socioeconomic status, cultural practices, and environmental conditions influence residents' daily lives, including water access. Traditional gender norms are deeply ingrained in the social fabric of Kologo's surrounding communities, with women being primarily responsible for domestic chores and collecting water, despite the access challenges. Water insecurity is widespread in many rural communities within the Kassena-Nankana municipality, with Kologo being a particularly severe example. The dispersed nature of settlements, combined with decentralized water delivery systems, makes accessing and collecting water challenging, especially for women. This situation highlights the importance of studying women's experiences with water access and collection in Kologo for research and policy purposes.

1.5 The gender and water nexus

In Africa, gender is a binary construct, defined as the social construction of men’s and women’s characteristics (Harcourt, 2017). These distinctions are not intrinsic, essential, or biological; they emerge from sociocultural differences evolving through practices, policies, and actions (West & Zimmerman, 1987). As Harcourt (2017) emphasizes, gender is not a biologically determined category, but a socially constructed phenomenon perpetuated through daily interactions (Butler, 1990). These masculine and feminine categories arise from routine social interactions and processes (West & Zimmerman, 1987). Consequently, men and women are assigned specific behaviours and roles aligned with their gender identities. Deviation from these roles is often met with stigmatization and criticism to maintain and legitimize the existing gender system (West & Zimmerman, 1987). This underscores the continuous construction, reshaping, and contestation of gender subjectivities, ideologies, and identities across time and space (Fenstermaker & West, 2013). The rigidity of gender differentiation compels men and women to adhere to normative gender behaviours, reinforcing the subordinate roles of women in many sub-Saharan African countries, where men predominantly occupy superior positions and control resources.

In the context of water access, use, and control, these gender dynamics differentially impact men and women (Graham et al., 2016; Pommells et al., 2018). Unsurprisingly, scholars have increasingly advocated for a comprehensive examination of gender in the context of water, emphasizing the integration of power relations and subjectivities (Rocheleau et al., 2013; Elmhirst, 2015; Mollett & Faria, 2013). Gender is acknowledged as a critical factor influencing access, knowledge, control, and distribution of water resources (Nunbogu & Elliott, 2021). Several significant insights can be gleaned from the intersection of gender and water.

First, disparities in access to water to some extent stem from gender-based divisions of labour and power imbalances (Geere et al., 2018; Nunbogu & Elliott, 2021; Pommells et al., 2018). Mounting literature underscores that households in Africa rely on women and girls to supply water for drinking and domestic use (UNICEF, 2016; WWAP, 2019). Even when water is scarce within households, women often bear the burden as they prioritize men's and children's needs before attending to their own. This is partly due to the societal expectations placed on women as home managers, with any family issues often attributed to the woman's perceived inability to manage the household. Numerous studies have documented women's water collection, purification, and distribution responsibilities (Graham, Hirai, & Kim, 2016; Jeil et al., 2020; UNICEF & WHO, 2023). For instance, Geere et al. (2010) found that in six rural South African communities, adult women (56%) were the primary water carriers, followed by adolescent girls (31%), male children (10%), and adult males (3%). In contrast, adult men's involvement in water collection is infrequent due to deeply ingrained societal norms stigmatizing such actions (Asaba, 2013; Sommer et al., 2015).

Second, despite women's greater involvement in water-collection duties, their perspectives must be more adequately represented in water governance (Adams et al., 2018; Mandara et al., 2017). Men and women participate unequally and differently in water governance and institutions (Adams et al., 2018; Harris et al., 2017; Yerian et al., 2014). Cultural barriers and traditional gender roles often hinder women's participation (Roy & Crow, 2004; Sultana, 2007).

For instance, in some communities, cultural norms prevent women from attending committee meetings, or it may be socially unacceptable, with men often discouraging their involvement (Sultana, 2007). Even when women have opportunities to participate, they are typically relegated to the background, and societal norms may restrict their public speaking (Mitra & Rao, 2019). Despite water being considered a fundamental human right, women often have limited access compared to men and are frequently excluded from decision-making regarding resource management (Bennette et al., 2008). Gender and other social markers influence water allocation and access, as observed in India, where lower-caste women are often denied participation in water programs (Bennette et al., 2008). Disabled women may also face dual barriers to access (Geer & Cortobius, 2017) because of social stigma and taboos. Gender differences significantly shape water use priorities and water management. When men dominate decision-making processes, valuable information and experiences are lost, leading to inadequate planning and suboptimal water management, negatively impacting entire communities (Bennette et al., 2008; Sultana, 2007). Cultural and traditional barriers leave women uninformed and unqualified to participate in decision-making within water user associations, with their experiences and knowledge often disregarded in developing water policies. Within households and communities, power dynamics suggest that women rarely make independent decisions about water, potentially exacerbating their burden in water access and collection (Crow, 2001; Minoia, 2007; Sultana, 2007).

Furthermore, methods of accessing water vary significantly based on geographical location and gender. Social, technical, and physical conditions determine how individuals access water. For example, Crow (2001) identified five modes of access; private ownership of land with access to safe water, access via communal rights, open access, state-backed provision, and market access. Gender and material inequalities significantly influence how men and women access water, leading to differing access to resources and opportunities (Crow, 2002). Delegating water provision to private companies and local user groups, especially in developing countries, may not adequately consider the specific water needs of marginalized men and women. Inequalities in accessing water through private land ownership, market access, and communal access persist, with high-income bracket households enjoying better access than low-income bracket households. Women may face additional challenges in controlling these access modes, as they often lack land ownership, or resource access. In many African countries, men dominate land ownership, control, and management, granting them control over water resources (Fleifel et al., 2019). Thus, women's limited ownership and access to property resources and the unequal distribution of household resources directly impact their access to water and often exclude them from communal water decision-making organizations. These dynamics underscore how gender and power relations create inequalities in water resource ownership and access.

Finally, the gendered aspects of water access and governance and disparities in choices and opportunities have far-reaching consequences for women's health and overall well-being (Apatinga et al., 2022; Geere et al., 2018; Jeil et al., 2020). Water inaccessibility and poor governance can lead to health, economic, social, and political consequences. For instance, women and girls, especially in rural areas (Arku & Arku, 2010), face a higher burden resulting from gender norms, limited resource access, and the persistent degradation of water infrastructure (Sorenson et al., 2011). Women generally have less physical capacity than men to carry heavy water loads, making the task particularly arduous, especially when collecting water from distant sources. The challenging terrain in some geographic settings further compounds the difficulties in accessing water (Sorenson et al., 2011). The physically demanding and time-consuming task of walking long distances over challenging terrains and queuing for hours to collect water can result in physical injuries, fatigue, and pervasive water insecurity (Geere et al., 2018). These challenges, coupled with gender norms, may contribute to mental health issues such as depression, frustration, and anxiety among women (Crow, 2001; Minoia, 2007). Gender-based inequalities in resource access and opportunities often compound these adverse effects. Thus, water access, utilization, and governance are connected with broader social, political, and economic dynamics that evolve across different contexts and over time. The complexities of navigating these intricate relationships and processes are central to realizing women's entitlement to safe and affordable water. These multifaceted challenges underscore the tensions arising from social power imbalances, marginalization, gender-based disparities, and vulnerabilities deeply ingrained in water inaccessibility issues and prevailing gender norms.

The linkages between gender and water access, use and governance, especially in Africa, reveal a nuanced landscape where societal norms and power dynamics significantly influence the roles, opportunities, and experiences of men and women. Considering these gender dynamics and complexities in the context of water access is essential for promoting gender equity in water resource management and ensuring all individuals have equal access to this fundamental resource. This is a critical area with profound implications for policy development, research, practice, and women's empowerment.

1.6 Situating the gender and water nexus within health geography

The intersection of gender and water access can be situated within the field of health geography. Originating from human geography, health geography highly emphasizes the role of social, economic, cultural, political, and environmental elements in shaping health and well-being in space and time (Andrews & Moon, 2005; Andrews et al., 2012). This perspective broadly connects environmental, economic, political, and sociocultural dimensions to populations' overall health and well-being. A central theme in health geography discussions is the significance of "place" and "space" in health and well-being (Andrews & Moon, 2005; Andrews et al., 2012). Health geographers consider place and space as critical dimensions in understanding population health and well-being. They emphasize spatial relations and patterns in the occurrence of disease, health, and well-being (Luginaah, 2009; Luginaah & Bezner-Kerr, 2015). Health and well-being are inherently tied to the specific geographic locations where people live and exist. Some health geographers even argue that a mutually reinforcing relationship exists between people and their environments (Cummins et al., 2007, p.1825). "Place" is the biological and social attributes of individuals and the contextual factors that determine their lives, including socioeconomic structures, sociocultural features, and social cohesion (Cummins et al., 2007; Macintyre et al., 2002). The concept of place encompasses not only biological and social attributes, but also the physical environment that defines people's surroundings, which comprises various physical features such as water bodies, built structures, soil, climate, and natural vegetation. Space, on the other hand, is the geographic context of place and the connectedness between these places (Andrews & Moon, 2005; Andrews et al., 2012). These elements are not static, but dynamically interwoven, contributing significantly to the connection between health and place (Macintyre et al., 2002). Furthermore, it is crucial to recognize that understanding the relationship between health and place can further be understood through the concept of scale (Bambra et al., 2019; Rishworth and Elliott, 2019). In our increasingly interconnected world, the concept of "scale" is essential to understand the broader global context. Various units, or scales, local, or global, constantly interact and influence human behaviour and health patterns (Bambra et al., 2019; Macintyre et al., 2002). These interactions shape the intricate connection between human beings and their environments, ultimately impacting their health and well-being.

Health and well-being to a larger extent are influenced by gender dynamics, power relations, and access to resources, including water, in space and time (Dickin et al., 2017; Nunbogu et al., 2018; Sahoo et al., 2015; O'Reilly & Louis, 2014). Gender is a social construct that manifests locally through power dynamics between men and women, enforced and reinforced by social and cultural structures (Massey, 2013). The issue of gendered access to, and governance of, water resources is closely linked with how individuals and groups perceive their physical and social environments and how their interactions are sustained. For instance, in many patriarchal African societies, deeply rooted sociocultural norms and gender roles have traditionally assigned women the responsibility of collecting water exclusively (Graham et al., 2016; Jeil et al., 2020). This practice is considered essential for upholding their socially constructed identity. Despite ongoing water insecurity and access challenges, women continue to bear the burden of supplying household water due to long-standing social expectations and power imbalances within their communities.

At different geographic scales, factors further exacerbate this situation. At the local, or micro level, sociocultural norms marginalize vulnerable populations, restricting their access to resources, including water (Wilbur & Danquah, 2015; Geere & Cortobius, 2017). Some community leaders, such as chiefs, often dictate water resource access terms, excluding women (Chew et al., 2019). Poor sanitation practices in these communities, like open defecation, also render water sources unsafe (Owusu et al., 2016; Yeleliere et al., 2018). Widespread patriarchal norms hinder women from participating in decision-making processes related to water resources, leading to their experiences and perspectives being disregarded in water planning and programs (Sultana, 2007).

At the national, or meso level, political factors like corruption and partisan politics contribute to inadequate water infrastructure, particularly in rural areas (Debela et al., 2020; Matamanda et al., 2015; Wrisdale et al., 2017). Public policies and programs related to water access are often inaccessible to marginalized groups, limiting their ability to secure and maintain access (O'Reilly, 2016; Tutu & Stoler, 2016). This situation places a significant burden on women, who are primarily responsible for water access, resulting in physical and psychological health issues and livelihood challenges.

In the context of gender and water access, geographical scale becomes crucial, as it blurs the lines between local (micro) and global (macro) influences. Socio-politico-cultural and economic forces at the national and local levels are intricately connected to health and well-being by constructing and reconstructing gender and power dynamics and water insecurity. These forces are influenced by global-level (macro-level) factors, such as anthropogenic climate change and its impact on water quantity and quality (Adeyeye et al., 2016; Mukheibir, 2020). Climatic conditions like floods and droughts are vital in determining water access reliability and affordability (Abu et al., 2021; Kelly et al., 2018; Yillia et al., 2008). When combined with environmental factors and human actions, structural forces create conditions conducive to gender disparities and unequal water access, driven by poverty, marginalization, and government policies, especially in many African countries, which often occupy marginalized positions in the global economy (Hazen & Anthamatten, 2019; Luginaah & Bezner-Kerr, 2015). Unequal international trade relations and exploitation contribute to poverty and other dire conditions (Hazen & Anthamatten, 2019; Luginaah & Bezner-Kerr, 2015). These power imbalances significantly affect gender equality and the availability and access to water resources. Thus, gender and power dynamics are shaped within specific spatial contexts, impacting resource access, including water, within and beyond households. These complexities and societal meanings perpetuate patterns of gender-based exclusion and impoverishment, particularly affecting rural women and exposing them to complex health and well-being challenges.

1.7 Outline of thesis

This thesis comprises a collection of published and unpublished manuscripts, each with unique objectives and research methods. These manuscripts collectively contribute to a comprehensive understanding of water inaccessibility and distant water collection in rural sub-Sharan Africa. Chapter 1 began by introducing the research context, delineating the research objectives and questions, and describing the research setting. It also assessed pertinent gender and water literature, ultimately positioning it within the field of health geography. Chapter 2 delves into the specific research design and methods employed in papers 5 and 6 due to limitations in journal word counts.

Chapter 3 explains a systematic literature review concerning water access and retrieval in sub-Saharan Africa. This review focuses on integrating gender and climate considerations to address water inaccessibility in rural sub-Saharan Africa. This chapter emphasizes the interconnected nature of various drivers, particularly the interplay between climate, water resources, and gender, which can influence water access differently. In a broader context, this coupled systems framework in Chapter 3 helps elucidate the intricate connections between the drivers of water inaccessibility and the resulting outcomes and coping strategies.

Chapter 4 extends the discussion initiated in Chapter 3 by integrating social and meteorological data from Ghana. This integration uses the conceptual framework developed earlier to explore the factors that influence the spatiotemporal dynamics of drinking water access among households in Ghana. It reveals that access to drinking water in Ghanaian households is influenced by many factors arising from environmental conditions, systemic barriers, and individual experiences.

Chapter 5 focuses on the gendered experiences and consequences of women's responsibility for water collection in rural northern Ghana. Specifically, it examines the factors contributing to women's difficulties in accessing and collecting water and the impact of inadequate water access and distant water collection on women's health and economic status. Chapter 6 investigates rural women’s coping strategies to manage suboptimal water access and remote water collection. These chapters offer insights at the local level, utilizing the framework developed in Chapter 3.

Chapter 7 is a summary of the key findings from the four manuscripts. It explains their broader implications for policy, research, and practice, emphasizing the contributions of this research and suggesting avenues for future investigations.

CHAPTER TWO

Research Methods

2.0 Introduction

This thesis investigated the impact of water inaccessibility and distant water collection on the health and livelihoods of women the rural Kologo community of Ghana. A mixed-methods approach was adopted to achieve this objective, encompassing surveys and focus group discussions (FGDs). This chapter presents a comprehensive account of the research design, methods, and techniques, along with their justification. Additionally, this chapter offers an in-depth overview of community engagement and the data collection process. While certain aspects of these methods are covered in the main manuscripts, this chapter provides a unified and comprehensive methods encompassing the entire research, with a specific emphasis on chapters 5 and 6. The constraints imposed by journal word limits necessitated this extended elaboration on the research methods within this chapter.

2.1 Research design and ethics

This study employed a cross-sectional design to collect data from a sample of the Kologo population. Cross-sectional studies focus on collecting and analyzing data from individuals at a single point in time, rather than tracking changes over a period (Alexander et al., 2017; Wang & Cheng, 2020). This method provided a cost-effective and efficient means to assess the experiences of women with water collection in the Kologo community (Levin, 2006). In this design, a mixed-methods approach was utilized to achieve a comprehensive perspective, encompassing quantitative and qualitative methods for data collection and analysis (Creswell & Plano-Clark, 2017). Specifically, the study employed the convergent parallel mixed-methods, or concurrent triangulation design (Creswell, 2013). In this design, quantitative and qualitative data were collected simultaneously, with separate analyses conducted, and the results were subsequently combined and interpreted to address the research objectives (Creswell & Plano-Clarke, 2011). The integration of qualitative and quantitative strands within a single study was intended to provide a thorough and nuanced comprehension of women's subjective experiences related to water access and collection. This approach leveraged the strengths of one method to compensate for the limitations of the other (Creswell & Plano Clark, 2017; Tashakkori & Teddlie, 2010). Consequently, the qualitative strand complemented, corroborated, and elucidated the findings obtained through quantitative analysis. Ethics approval was received from the University of Saskatchewan, McMaster University and the University of Ghana. Details of approval and certificate numbers are captured in chapters 5 and 6.

2.2 Methods

2.2.1 Quantitative data

2.2.1.1 Sample population, sampling procedure, and sample size

Before commencing the project, a community meeting was convened with the chief and elders. The purpose of this gathering was to provide them with information about the study's objectives, address any inquiries related to the research, and obtain their consent to approach the local residents. After consultations with community leaders and their approval, a few days were dedicated to establishing connections, acquainting the research team with the community's environment, and fostering rapport with the local residents.

Subsequently, in collaboration with community leadership, the research team identified and recruited a subset of local participants for the study. To facilitate recruitment, posters were designed and displayed in public areas throughout the three sub-communities, inviting interested individuals to participate. These recruitment posters were strategically placed at water sources, market squares, and community gathering spots. Additionally, announcements were made in the local dialect during market days, church services, and community events over two weeks to invite potential participants for the project. As a result of these efforts, some individuals voluntarily expressed their interest in participating in the study, while others were approached directly by the researcher due to their presence in the community.

In order to ensure diverse and complementary perspectives on water access and collection, an equal number of participants was recruited from each of the three sub-communities. Eligibility criteria encompassed adults aged 18 or older residing in the community for at least one year and provided informed consent to participate. These criteria were established given the primary focus of the investigation on water-related issues. Those residing in this water-scarce area were deemed in the best position to offer meaningful contributions to the study. Preferably, the study targeted married men and women to gain insights into the gender dynamics associated with household water access, considering differences in productive and reproductive responsibilities. Participants who did not meet these criteria were excluded from the study.

The quantitative survey randomly selected men and women from each community to participate. Quota sampling was utilized to ensure an equal representation of both genders across different age groups and socio-economic backgrounds, thereby ensuring the comparability of results. The total sample size for the quantitative survey consisted of 300 participants.

2.2.1.2 Data collection and instrument

Trained research assistants (man and woman) played a crucial role in the data collection process. The division of responsibilities was designed to enhance participants' comfort and encourage open sharing of their experiences and viewpoints regarding water access and collection. The man administered the survey to men, while the woman delivered the women's survey. This approach significantly enriched the study.

The survey instrument consisted of closed-ended questions, predefined response options, and short open-ended questions to gather more detailed information on specific responses. Although the survey was initially crafted in English, the research assistants delivered it in the participants' local dialects. This approach ensured that participants could fully comprehend the questions and contribute meaningfully to the study. The research assistants were highly proficient in the local dialects spoken by the participants, which greatly benefited the study. The translation of questions into local dialects and the one-on-one survey format were essential because a substantial portion of the participants faced literacy challenges, reflecting the prevailing high levels of illiteracy in the community. Moreover, the shared dialect between the researchers and participants facilitated effective communication, rapport-building, and in-depth information elicitation (Devereux & Hoddinott, 1993b; Grewal & Ritchie, 2006).

Before commencing the questionnaire, participants were guided through an informed consent process in the local dialect. This process included an explanation of the study's purpose, participants' rights to withdraw from the study or skip questions they found discomforting without facing the consequences, and a discussion of potential risks associated with participation. Participants affirmed their consent in one of three culturally appropriate ways, considering their literacy levels and customs. They could either voluntarily sign or thumbprint the consent sheet, or verbally provide consent in the presence of a witness, indicating their comprehension and willingness to participate. Participants were also given the flexibility to select a convenient time and location for the household survey, or reschedule, or relocate if needed, prioritizing their privacy and safety.

The survey instrument encompassed various topics, such as participants' backgrounds, livelihood assets and strategies, sources of drinking water and associated problems, gender roles in water supply, health and livelihood consequences of inadequate water supply, and household responses to water scarcity. Specific questions included inquiries about the primary source of drinking water, its location, the time taken for water collection, the frequency of visits to the water source, and who was responsible for collecting water. Participants were asked about their experiences with back and body pain from carrying water containers over long distances, encounters of attacks during water collection, reduced water usage, postponed activities due to inadequate water access, and instances where they cooked less or avoided cooking desirable foods because of water scarcity. They were also asked about whether water collection activities impacted their own or their household members' work.

The interviews were conducted at different times of the day, accommodating participants' preferences and prioritizing their privacy and safety. Prior to administering survey, a reliability assessment of the questionnaire instrument was conducted through pre-testing with five participants (two men and three women) at the study site. This allowed for adjustments to thematic areas, integration of community insights, and refinement of the research questions' feasibility. On average, each survey took approximately an hour to complete, with 300 surveys administered after adhering to ethical protocols and securing participants' consent. Subsequently, the data were meticulously cleaned, scrutinized for missing values and incomplete questionnaires (none were found), and entered into Excel. The data were subsequently transferred to Canada for analysis using SPSS version 21—chapters 5 and 6 offer comprehensive accounts of the quantitative data analysis and the resulting findings.

2.2.2 Qualitative data

2.2.2.1 Sample population, sample procedure and sample size

Recruiting participants for the qualitative data collection closely mirrored the approach used in quantitative data collection, with a strong emphasis on community engagement protocols. Recruitment posters were prominently displayed in public spaces, including water points and market areas. Additionally, local announcements were made during market days, church services, and community events, inviting individuals to participate in the study. Working in collaboration with community assembly members, the research team purposively selected a subset of the population at market squares and community meeting points. To be eligible for participation, individuals had to be at least 18 years old and have resided in the community for at least one year.

For the qualitative data collection phase, three distinct groups of participants were conveniently recruited across the three communities. Each group consisted of eight participants, comprising both men and women. These groups included young men or women (≤30), adult men or women (31-50), and older men or women (≥51) from various socioeconomic backgrounds. This recruitment strategy aimed to ensure diverse perspectives and ideas related to the research topic, promoting a rich and comprehensive understanding.

2.2.2.2 Data collection and instrument

Empirical data for this study was collected through a series of FGDs. This qualitative data collection method allowed the research team to interactively gather collective and contrasting opinions and a wealth of information on water access from individuals with similar backgrounds within a group context (Krueger, 2000). In total, eighteen FGDs were conducted, involving young men and women, adult men and women, and older men and women. To create a comfortable environment for participants to share their experiences and perspectives on poor water access and water collection outside their premises, the man moderated the FGDs with adult and young men, while the woman facilitated those with adult and young women.

The discussions commenced with informal exchanges, building rapport, and engaging in general conversations about the community, life in Ghana, and rural living. Participants expressed their excitement that the researcher was in their community to address their water issues. Before delving into the main discussion, participants often voiced phrases like "help us," underscoring the severity of water access challenges in the community.

Before active participation, participants were informed about the study's objectives and the potential benefits it could bring to the community. It was emphasized that their involvement was entirely voluntary, and they had the right to withdraw from the study if they encountered difficulties or chose not to respond to questions, they found distressing. The informed consent process was conducted in the local dialect, as most participants were not proficient in English. This ensured that participants fully comprehended the research's purpose and gave their informed consent. Participants confirmed their consent and pledged their honesty in one of three culturally appropriate ways: voluntary signing, thumbprinting, or providing oral consent in the presence of a witness.

Discussion locations were selected jointly by the researcher and the participants, prioritizing convenience, privacy, and a tranquil environment free from noise and disturbances. The discussions were conducted informally and flexibly, with a script designed in English, but translated into the local dialect to ensure comprehension and accurate representation of water-collection experiences and perspectives. The script covered various aspects, including socio-demographic characteristics, household water sources, decision-making related to water management, time spent collecting water, health and socio-economic challenges tied to water collection, and strategies to improve water access. Specific questions included inquiries about household drinking water sources, who was responsible for collecting water, participants' livelihood activities, challenges faced during water collection, and risks associated with carrying water.

On average, the discussions lasted about an hour and were scheduled during times when participants were less occupied and could concentrate fully on sharing their water-collection and access experiences and perspectives. These discussions were held in both morning and afternoon sessions. With the participants' permission, all discussions were recorded using a digital recorder and later transcribed verbatim by the research assistants from the local dialect into English.

The transcripts and audio recordings were uploaded to a secure cloud data repository at the University of Saskatchewan for analysis, using NVivo version 12 software. Chapters 5 and 6 comprehensively explain the data analysis and the resulting findings. These qualitative findings were integrated with the quantitative results to understand the research topic better.

2.3 Situating myself within the research

Growing up in the impoverished village of Nogsenia in northern Ghana, I bore witness to harsh realities that defy imagination. From a tender age, I laboured in the fields, contributing to my family's noble endeavours. In our community, education was considered a luxury reserved for the privileged few, and the prevailing mindset centred on acquiring land, marriage, and raising large families to gain social reputation. Women faced marginalization, a persistent issue that continues to this day, leaving them without authority and often subjected to violence and accusations of witchcraft. Consequently, many were/are banished to isolated camps devoid of access to justice. These challenges, coupled with other chronic issues, compounded the disempowerment of women, exacerbating gender inequalities and heightening their vulnerability to socioeconomic hardships.

While the plight of women and their discrimination deeply troubled me, water access remained a persistent issue throughout my upbringing and even now. This concern piqued my interest because, much like the air we breathe, access to water is an indispensable necessity for meeting other fundamental human needs, including sustenance. Ghana is blessed with abundant water resources, yet a significant portion of its population, particularly those in rural areas like my own, grapple with the arduous task of securing safe and well-managed drinking water. My formative years were marked by the sight of numerous individuals in rural Nogsenia and neighbouring communities living without access to clean drinking water. Some were/are compelled to share unprotected water sources with animals and birds. Traditionally entrusted with the responsibility of procuring domestic water, women were/are compelled to embark on long journeys to collect water. Many commenced these water-collection expeditions in the middle of the night to evade long queues, and it is/was not uncommon for young women to face the threat of sexual assault, including rape, during these arduous trips and at water points.

As I embarked on this project, I brought a multitude of identities and a spectrum of experiences and perspectives. Despite being a heterosexual male and having been socialized within a predominantly masculine framework, I actively participated in water collection from distant sources, undertook nighttime treks to reach water sources, and endured lengthy queues to collect water during my formative years. I even faced disciplinary measures at school due to tardiness resulting from time-consuming water-collection endeavours. To some degree, I empathize with rural women's challenges in their quest for clean water access. I had the privilege of comprehending their experiences concerning inadequate access to safe water, or the necessity of collecting water far from their homes.

My commitment to researching this subject matter was not solely driven by personal experiences, but also by an inherent responsibility to offer these women a platform to articulate their experiences and viewpoints regarding the hardships they face in accessing clean water. Rural women bear the brunt of water collection responsibilities and often find themselves disadvantaged compared to men. As a researcher and engaged academic, I wholeheartedly adhere to the principles of gender equity, anti-oppression, respect for human dignity and diversity, and promoting social justice and sustainable development. I also recognize that many challenges, including gender-based oppression, are inextricably linked to water insecurity in various countries. Consequently, my interest in this topic transcends personal inclination; it represents a calling rooted in the aspiration to gain insights into the subjective experiences of rural women, with the aim of fostering positive change.

My diverse experiences and identities played a pivotal role in establishing trust and rapport with rural women facilitating open and candid discussions. For instance, my status as a Ghanaian who shares cultural and belief systems with these women fostered a deeper connection and a greater willingness to open up for fruitful discussions. Simultaneously, my outsider status as a man addressing an issue predominantly affecting rural women encouraged them to freely articulate their perspectives on poor water access in rural areas. Unsurprisingly, research suggests that individuals tend to identify more closely with those who share similar experiences and commonalities (Fries-Britt & Turner, 2002). Mindful of my insider/outsider status and my mission to study and document an issue that profoundly affects rural women, my goal was to amplify the voices that have long been silenced and neglected within the existing body of evidence.

CHAPTER THREE

Preamble

Chapter 3 delves into the exploration of water access and retrieval in rural sub-Saharan Africa, using a systematic literature review approach. The primary objective of this chapter is to incorporate gender and climate considerations into the discussion on water inaccessibility in this region. Through thematic analysis, the literature was distilled to deepen our understanding of the drivers, consequences, and adaptive strategies linked to water inaccessibility in these communities. Consequently, a conceptual framework was developed to enhance our comprehension and assessment of research gaps and points of intervention. This framework specifically addresses integrating gender and climate considerations into mitigation strategies to reduce the negative impacts of water inaccessibility in rural sub-Saharan Africa. The findings illuminate the complex nature of the factors affecting water inaccessibility and highlight the intricate responses adopted by rural women in sub-Saharan Africa. While building on previous scholarship focusing on water, sanitation, and hygiene (WASH), this chapter emphasizes the complex interconnections between climate change, water dynamics, and gender dynamics. In this context, the chapter advocates for a more comprehensive and integrative research approach encompassing vulnerability, impacts, and grassroots solutions, while identifying co-benefits. This integrated approach is envisioned to provide a foundation for creating policies, initiating planning efforts, and implementing practical interventions to address the challenges associated with water inaccessibility in rural sub-Saharan Africa.

This chapter has been reformatted from the original version for inclusion in this thesis.

Manuscript #1: A conceptual framework for gender and climate mainstreaming to mitigate water inaccessibility in rural sub-Saharan Africa

Apatinga, G. A., Schuster-Wallace, C. J., & Dickson-Anderson, S. E. (2022). A conceptual framework for gender and climate mainstreaming to mitigate water inaccessibility in rural sub-Saharan Africa. *Wiley Interdisciplinary Reviews: Water*, *9*(4), e1591. [Reprinted with permission from journal].

Abstract: Evidence underscores that water inaccessibility in rural sub-Saharan Africa (SSA) disproportionately affects women due to patriarchal gender norms and practices. In the context of Sustainable Development Goals 5 (Gender Equality) and 6 (Water and Sanitation), globally driven efforts and initiatives are set against a backdrop of empowering women, improving rural water accessibility, and reducing water-related risks. Furthermore, climate change is altering spatiotemporal patterns of water availability and quality. A thematic analysis of the literature was conducted through Scopus and Web of Science to identify drivers and consequences of as well as coping strategies for water (in)accessibility in rural SSA. A conceptual framework was developed to better understand and assess research gaps and points of intervention for gender and climate mainstreaming in mitigation strategies that reduce the impacts of water inaccessibility in rural SSA. Findings show that complex intersecting factors underlie water inaccessibility—and responses—among rural women in SSA. The complex socio-ecological interlinkages among climate change, water, and gender are discussed, and a case is made for more integrative research (including dimensions of vulnerability, impacts, and effective grassroots strategies and co-benefits) to inform policy, planning, and practice.

Keywords: climate mainstreaming, gender mainstreaming, rural water access, sub-Saharan Africa, SDGs 5 and 6

3.1 Introduction

Reliable access to potable water has been demonstrated to improve public health, community resilience, food security, and empower women (Butler et al., 2017; Krishnan, 2019; Schuster et al., 2020; Sorenson et al., 2011; Wolf et al., 2018). Basic access to water is defined as an improved source of water within 30-min round trip of a dwelling, including queuing time (WHO & UNICEF, 2021). However, even basic access to water can be unsafe, unreliable, scarce, inaccessible, or unaffordable for many individuals and families (Brewis et al., 2019; Geere & Cortobius, 2017; Luker & Harris, 2019; Wrisdale et al., 2017), which may result in household water insecurity (Wutich, 2020; Young et al., 2019). Accessibility, affordability, sufficiency, and quality (Jepson et al., 2017) along with reliability and safety are identified as significant components of household water security. To this end, Young et al. (2019) describe household water insecurity as "the inability to access and benefit from adequate, reliable, and safe water for well-being and a healthy life" (p. 2). This underscores the significance of providing and improving access to affordable, reliable, and safe supplies of water, that is, achievement of Sustainable Development Goal (SDG) 6. Although progress has been made to provide potable water to populations, adequate access is still lacking for millions of people, the majority of whom live in sub-Saharan Africa (SSA) (WHO & UNICEF, 2021), a reality underscored by the current COVID-19 pandemic (Adams et al., 2021; Amin et al., 2020; Howard et al., 2020; Stoler et al., 2021). In 2020, just over 700 million people lacked basic access to drinking water, with the majority living in rural areas and half living in SSA, where the greatest disparity between urban and rural access exists (WHO & UNICEF, 2021). Furthermore, eight out of nine countries with less than 50% basic access in 2020 were located in SSA and only 30% of people living in SSA had access to safely managed water supplies (WHO & UNICEF, 2021).

Although access to drinking water is a human right (United Nation, 2010), provision in rural SSA can be challenging, often linked to the dispersed nature of rural settlements, small population sizes, a lack of political will and accountability, and inadequate resources to build and maintain infrastructure (Collaborative Africa Budget Reform Initiative, 2019; Schuster-Wallace & Dickson, 2017). Poor water access in rural SSA disproportionately affects women. In SSA, men and women occupy different social and political positions at the household and community levels, leading to differences in water use, water management, water rights, and water access. In many of these cultures and societies, there is unequal involvement in domestic work and care between men and women (Jeil et al., 2020; Owoo & Lambon-Quayefio, 2021). Women are more involved in household chores and care because their involvement underpins their socially constructed identity and bargaining power in intrahousehold interactions (Cerrato & Cifre, 2018; Owoo & Lambon-Quayefio, 2021). In contrast, men occupy positions of power, and their traditionally constructed gender identity has been associated with paid work outside the domestic sphere. They are generally described as wage earners and disciplinarians (Owoo & Lambon-Quayefio, 2021; Schmitz, 2016), although this role has become, or is becoming a collaborative task in many households in the current epoch because of socioeconomic pressures and the erosion of the predominant gender system (Cherlin et al., 2013; Harcourt, 2017). Men and women often feel pressured to conform to their socially constructed and expected gender roles to gain and maintain social acceptance and avoid social stressors (Koenig, 2018; Owoo & Lambon-Quayefio, 2021; Skinner et al., 2018). This underscores that men are more likely to participate passively in domestic chores and care compared to their female counterparts and maintain the unequal gender order to continue to benefit from the patriarchal dividend (Connell, 2009; Connell & Messerschmidt, 2005). Thus, it is not surprising that accumulating literature underscores that women and girls in SSA generally acquire, purify, and distribute water for household use (Graham et al., 2016; Jeil et al., 2020; Van Houweling, 2016). Participation of adult men in water collection and purification in many patriarchal African cultures and societies is uncommon (Sommer et al., 2015), and in some contexts considered shameful, degrading, and unethical (Asaba, 2013). Water inaccessibility and associated water collection from distant sources is more likely to expose women and girls to intersecting vulnerabilities and security threats such as physical injuries, psychosocial problems, and socio-economic challenges (Cooper-Vince et al., 2017; Cooper-Vince et al., 2018; Geere, 2015; Geere et al., 2018; Geere, Cortobius, et al., 2018; Nounkeu et al., 2019; Venkataramanan et al., 2020), particularly in rural regions (Arku & Arku, 2010). These intersecting vulnerabilities are exacerbated by a lack of access to and control of resources and opportunities, poverty, persistent degradation and failure of water infrastructure, and climate change (Brewis et al., 2019; Cook & Bakker, 2012; Geere & Cortobius, 2017; Luker & Harris, 2019; Wrisdale et al., 2017).

In the context of SDGs 5 (Gender Equality) and 6 (Water and Sanitation), globally driven efforts and initiatives are being implemented to empower women, improve rural water accessibility, and reduce water-related risks. Although researchers have increasingly developed different methods and tools over the past decade for assessing, or measuring household water insecurity (Aboelnga et al., 2020; Brewis, et al., 2020; Octavianti & Staddon, 2021; Schuster-Wallace et al., 2019), such perspectives do not adequately explain and address the intersecting drivers of rural water inaccessibility, the feedback loops, and the ensuing consequences. Dominant approaches such as a biocultural perspective (Brewis et al., 2020), political ecology (Truelove, 2019), and human capabilities (Jepson et al., 2017) are deficit-based and argue for increased understanding of the complex, intersecting determinants of socially differentiated and unequal gendered experiences of water (in)accessibility and, therefore, household water insecurity (Jepson et al., 2017), especially in rural areas. Water inaccessibility is multifaceted and multifactorial suggesting that, if not considered comprehensively, critical dynamics such as mediating social and cultural processes that also affect the implementation of effective interventions can be overlooked (Kujinga et al., 2014; Nganyanyuka et al., 2014; Obeng-Odoom, 2012). For instance, a coupled-systems approach to private drinking water wells in the Canadian context revealed important interlinkages between private groundwater contamination and human behavior (Di Pelino et al., 2019). Specifically, the inclusion of human behavior as part of the exposure pathway recognized the importance of private well stewardship in maintaining and testing wells. Furthermore, it provided a coupled systems framework for guiding transdisciplinary research and combining physical and behavior interventions in solutions to reduce public health risks. Similarly, examining water (in)accessibility through an integrated and cross-sectional lens can help to disentangle inherent complexities to increase sustainable water access in rural SSA.

The primary objective of this paper is to present a conceptual framework that identifies the drivers and consequences of, and coping strategies for, water inaccessibility in rural SSA. The goal is to better understand pathways, and assess research gaps, for gender and climate mainstreaming in reducing impacts of water inaccessibility at individual, household, and community levels. A key strength of this framework is that it facilitates better accounting of multi-level and structural influences and their impact on water inaccessibility across contexts. Furthermore, while used here to explore drivers of inaccessibility, the framework can be used to examine drivers of accessibility (denoted by the use of (in)accessibility), that is, strength-based analyses that are currently under-emphasized. Moreover, given the recent attention to relational frameworks in water research such as coupled social-ecological systems and the hydrosocial cycle (Boelens et al., 2016; Linton & Budds, 2014; Liu et al., 2007; Scown et al., 2017) and climate resilient adaptation strategies (Howard et al., 2021), this framework advances critical analysis, knowledge, gaps, and dialogue through an integrative and cross-sectoral perspective. More generally, this novel framework will help inform and support research, policy, and practice in SSA and other regions by providing critical insights into pathways and synergies among environmental, systemic, and individual drivers of water inaccessibility and how this translates into adverse health, social, political, and economic outcomes for rural women and populations. Although specific drivers within categories and, therefore, the outcomes may differ between regions, broad categories, pathways, and responses are transferrable.

3.2 Methods

An initial conceptual framework identifying the determinants and consequences of, and coping strategies for, water inaccessibility (Figure 3.1) was used to determine the search parameters for a thematic analysis of the literature. This method involves looking for and analyzing patterns in a set of identified literature to develop themes (Braun & Clarke, 2013).

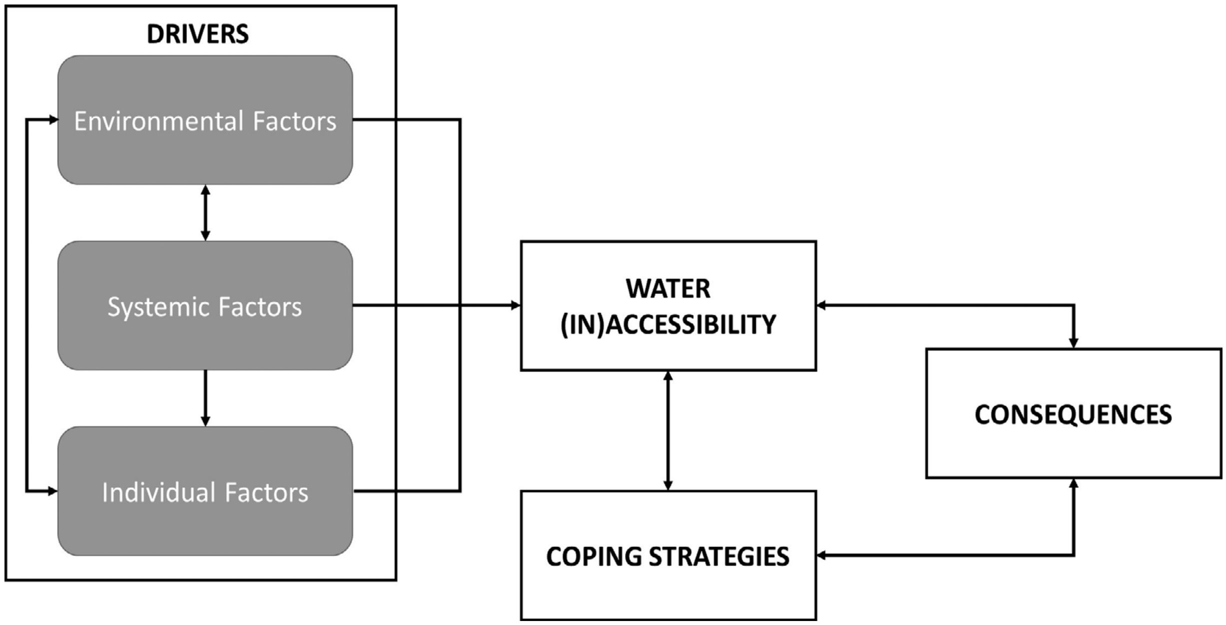


Figure 3.1: Conceptual integration of drivers of water inaccessibility with consequences and coping strategies

The thematic analysis was based on a systematic review of peer-reviewed literature published in English from 2000 to present. This timeframe was considered appropriate to obtain much of the emerging literature relevant to the study topic. Between April and November 2021, a systematic review of the peer-reviewed literature was undertaken through Scopus and Web of Science, using a combination of keywords, including “water,” “WASH,” “Africa,” and “gender” (Table 3.1). A total of 5025 articles were returned across all search terms and databases (Figure 3.2). The returned articles were screened using their titles, leading to the exclusion of 3511 records. These records were then exported to Excel© for removal of duplicates (1143 records removed) and further screening. Abstract screening resulted in the exclusion of an additional 219 articles, primarily due to not being peer reviewed journal articles or that focused on methods, a disease, urban water access, agriculture, general health and wellbeing, sanitation, and hygiene without consideration of water, or marine environments. A full text review was undertaken on the remaining 152 articles using the following inclusion criteria: (1) peer-reviewed journal articles relating to rural water access that included a gender dimension; (2) undertaken, at least in part, in SSA or Africa; and (3) published between 2000 and 2021. An additional 16 articles were removed at the full text review due to a focus on methods, general livelihoods, or water institutions, or an insufficient focus on water, resulting in 136 articles included for analysis. Relevant information from the final articles was extracted under the drivers, coping strategies, and consequences categories comprising the conceptual framework (Apatinga et al., 2022A). Although some themes for each category were identified a priori (climate, social drivers, political drivers, gender, age, health, nutrition, violence), others were developed iteratively as new themes emerged from the extracted information. Articles with content that supported themes developed a priori were coded directly into the extraction matrix. New content was added in an "other" column in the extraction matrix. If similar content was extracted across more than two articles, a new theme was added to the extraction matrix through an iterative process. Content reflecting a single article remained in the "other" category. The themes were used to further develop the conceptual framework presented in the results (Figure 3.3). Primary identification was undertaken by a single author, screening and eligibility by all authors and data extraction by a single author with quality assurance checks by the remaining authors. Subsequently, the information extracted was analyzed, and sub-themes were generated, within the broad domains of the original conceptual framework.

Table 3.1: Search terms

Search terms	Number of articles returned
Water AND Africa AND gender	976
“Water security” AND Africa	120
“Water access” AND Africa	384
WASH AND gender AND Africa	76
“Drinking water” AND sanitation AND hygiene AND gender AND Africa	55
Rural AND “sub-Saharan Africa” AND “water security” AND (“environment” OR “climate” OR “drought” OR “rainfall” OR “water quality” OR “econom*” OR “soci*” OR “politic*” OR “age” OR “women” OR “gender” OR “health” OR “nutrition” OR “food” OR “well-being”)	984
“Rural sub-Saharan Africa” AND “water insecurity” AND (“climate change” OR “drought” OR “rainfall” OR“econom*” OR “soci*” OR “politic*” OR “age” OR “women” OR “gender” OR “health” OR “nutrition” OR “food” OR “well-being”)	279
“Rural sub-Saharan Africa” AND “water access” AND (“environment” OR “climate” OR “flood” OR “drought” OR “rainfall” OR “water quality” OR “econom*” OR “soci*” OR “politic*” OR “age” OR “women” OR “gender” OR “health” OR “consequence” OR “nutrition” OR “food” OR “well-being” OR“violence”)	1573
“Rural sub-Saharan Africa” AND “water fetching” AND (“environment” OR “water quality” OR “econom*” OR “soci*” OR “women” OR “gender” OR “health” OR “food” OR “well-being”	55
“Rural sub-Saharan Africa” AND “water collection” AND (“environment” OR “climate” OR “flood” OR“drought” OR “rainfall” OR “water quality” OR “econom*” OR “soci*” OR “age” OR “women” OR “gender” OR “health” OR “food” OR “well-being”)	517

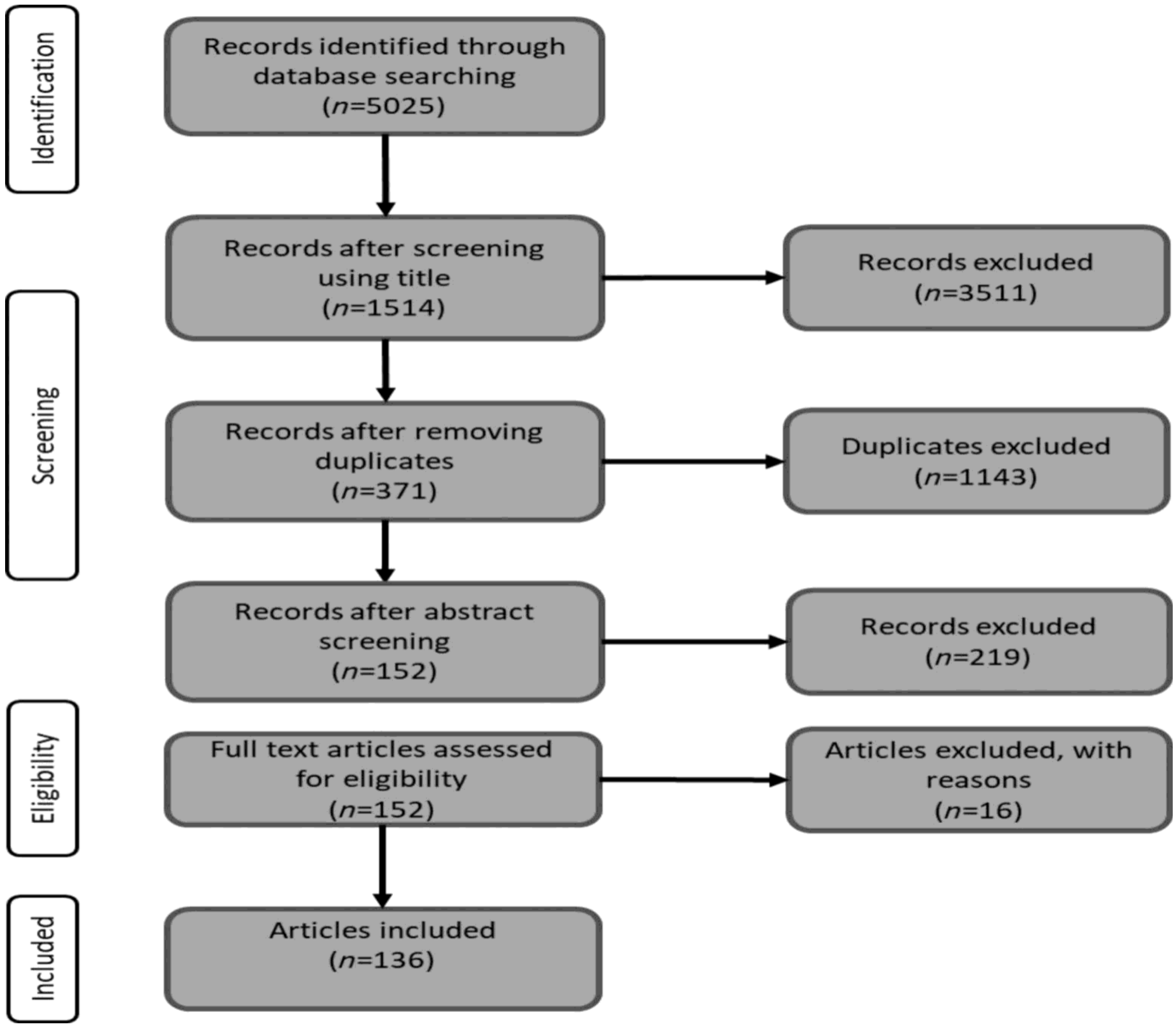


Figure 3.2: Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) representation of the systematic literature review process (after Moher et al., 2009)

3.3 Results— Climate change, water, and women: Complex interlinkages

The thematic analysis identified many complex and intersecting factors that drive local water (in)accessibility in rural communities in SSA (Figure 3.3). It is important to recognize that water inaccessibility in rural SSA can be a permanent state, cyclical, or periodic, depending on the specific drivers. Coping strategies have been classified based on the type of response as exit, loyalty, or voice (Hirschman, 1970; Majuru et al., 2016). The exit strategy involves identifying alternative ways to access sufficient water, the loyalty strategy involves adopting accommodative plans to cope with persistent water inaccessibility, and the voice strategy involves using collective action and radical measures to lobby for the provision of sustainable water access. Understanding the gendered impacts of water inaccessibility is particularly important for rural women and girls in SSA, as they are underprivileged from a water access perspective and many live in communities and regions where water insecurity is a known problem (Jeil et al., 2020; WWAP, 2019). The interplay within and between identified drivers, coping strategies, and consequences (Figure 3.3) demonstrates that: (1) household water inaccessibility results from complex interacting factors such as political, ecological, and social conditions, and these driving forces overlap and are mutually reinforcing; (2) when rural women find it difficult to access adequate and reliable supplies of water, they are likely to employ coping mechanisms to meet their water needs; (3) these coping strategies are determined by complex reciprocal relationships among social, economic, political, and ecological factors, some of which may be ineffective and unsustainable; (4) household water inaccessibility together with ineffective and maladaptive coping strategies leads to adverse consequences for rural women's livelihood activities, health, and well-being that reinforce lack of access and maladaptive strategies (Figure 3.4); and (5) water access confers positive health, nutritional, safety, and socio-economic states.

The availability of water in the environment is driven by climatic factors such as seasonal and interannual temperatures and rainfall amounts as well as extreme weather events such as floods and droughts (Abu et al., 2021; Adeyeye et al., 2016; Foster, 2013; Kelly et al., 2018; Mukheibir, 2020a, 2020b; Quinn et al., 2011; Twisa & Buchroithner, 2019; Yillia et al., 2008). Seasonality can reduce water availability and affect access, for example by impairing travel or facilitating access through rainwater harvesting in the wet seasons (Bernard & Joyfred, 2020; Kelly et al., 2018; Neufeld et al., 2021; Ritchie et al., 2021; Twisa & Buchroithner, 2019; Van

Houweling, 2016; Yillia et al., 2008). Long dry seasons are more likely to make water sources such as streams, springs, and wells dry up, and consequently make access difficult (Van Houweling, 2016). Prolonged dry seasons (i.e., droughts) are a common problem in SSA (Calow et al., 2014; Ojo et al., 2004). In Mozambique, long dry seasons often reduce available water in nearby streams and wells, making residents travel long distances to access alternative sources (Van Houweling, 2016).

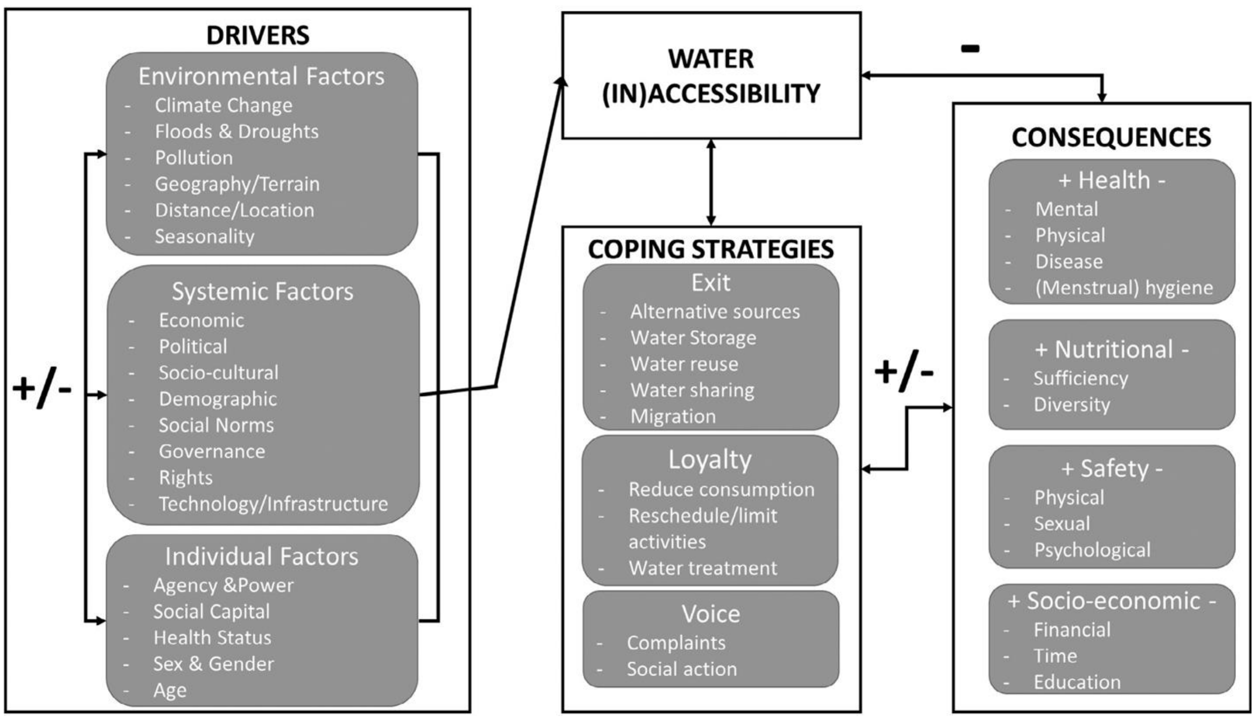


Figure 3.3: A conceptual framing of water inaccessibility affecting rural women, with + and – representing beneficial and adverse consequences, respectively, as a result of positive or negative feedback loops

Climate change will continue to shape water availability and, therefore, affect access in SSA. Climate change is altering the frequency and timing of events, affecting the amounts and quality of water available in the short and long term (De Wit & Stankiewicz, 2010; Hosea & Khalema, 2020; Kisakye & Van der Bruggen, 2018; Mukheibir, 2020a, 2020b; Ojo et al., 2004; Patrick, 2021; S´anchez & Rylance, 2018). Although this can have a positive effect in some regions, high intensity rainfalls can be difficult to capture for use, with most of it being lost through runoff. Africa is one of the most vulnerable regions to climate change impacts globally (Intergovernmental Panel on Climate Change (IPCC), 2021; Niang et al., 2014). Land surface temperatures have been increasing faster than the global average, but different regions are experiencing, or are projected to experience differing impacts on water resources. Decreases in average precipitation are already being experienced in central, north-eastern, and southern Africa. The Sahara, central, northeastern, south- eastern, and east southern regions are projected to experience increases in heavy precipitation and flooding, while western and west southern regions are projected to experience increases in droughts (Intergovernmental Panel on Climate Change (IPCC), 2021). Variability and change are already being experienced. For example, Ghana, Cote D'Ivoire, and southern Nigeria have experienced 10%–30% decreases in annual runoff (Schewe et al., 2013). In 2019, rainfall was above average in many areas in East Africa, causing floods and landslides (Wainwright et al., 2021). The increasing frequency of extreme climatic events will affect the quality and quantity of both groundwater and surface water sources (Kelly et al., 2018; Malley et al., 2007; Ojo et al., 2004).

Even when sufficient water is physically available, water may still be inaccessible (Akinyemi et al., 2005; Alexander et al., 2015; Armah et al., 2018; Asoba et al., 2019; Atangana Ondoa, 2017; Busari, 2002; Cole et al., 2015; Debela et al., 2020; Dinko et al., 2018; Dugard & Mohlakoan, 2009; Dungumaro, 2007; Emenike et al., 2017; Engel et al., 2007; Fisher et al., 2015; Foster, 2013; Gondo & Kolawole, 2013; Hamlet et al., 2021; Hope et al., 2020; Hope & Rouse, 2013; Marcatelli, 2013; Marcatelli, 2014; Marson & Savin, 2014; Miller, Frongillo, et al., 2021; Mosimane & Kamwi, 2020; et al., 2006; Sjöstedt, 2009; Smiley et al., 2020; Swatuk & Kgomotso, 2007; Yang et al., 2013). Economic water scarcity is defined as a lack of infrastructure, or poor water resources management (Busari, 2002; Noemdoe et al., 2006; Swatuk & Kgomotso, 2007), and is a factor in SSA that increases distance required to collect water (Egbinola, 2017). For example, at any given time hand-pumps in rural SSA are non-functional and unsustainable (Fisher et al., 2015; Foster et al., 2018; Peter & Nkambule, 2012).

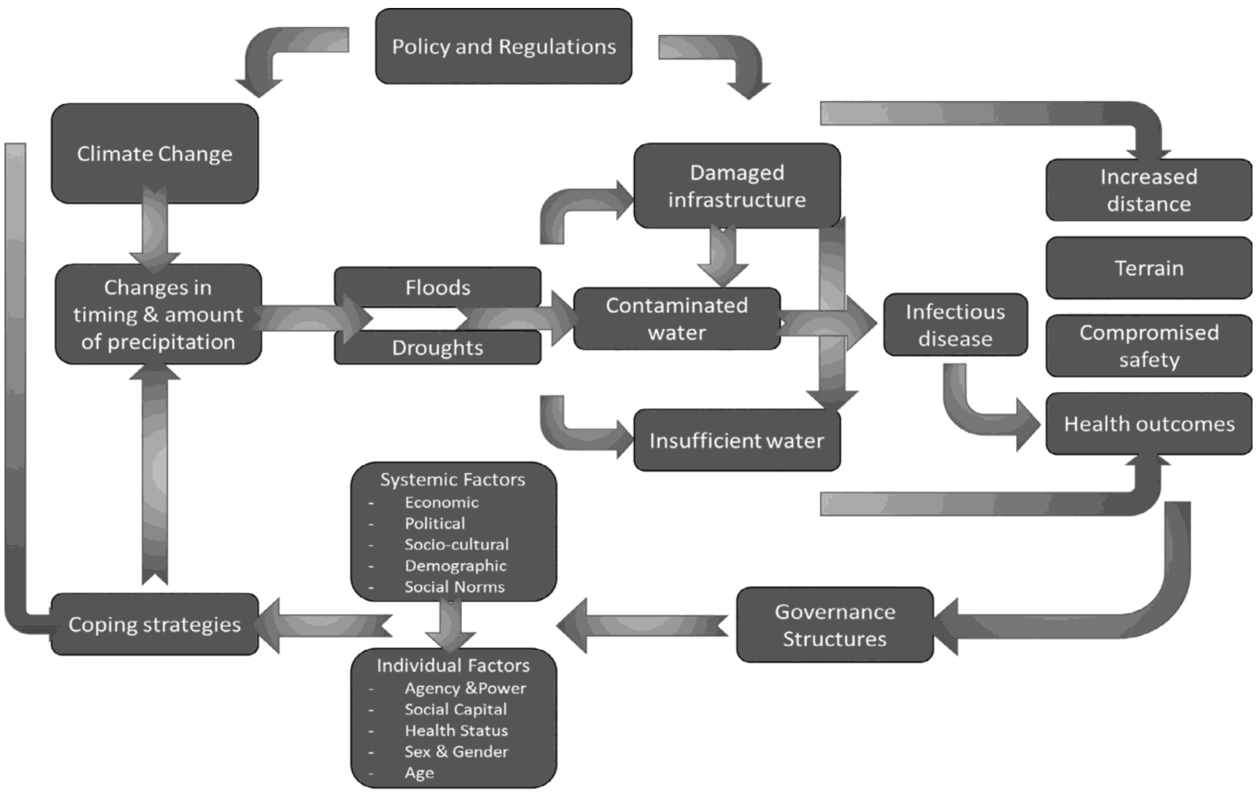


Figure 3.4: Climate change and water access—drivers, pathways, and impacts

As well as putting pressure on limited water supplies, increasing populations, poor sanitation, urbanization, industrial and agricultural activities, and energy production pollute water sources, thereby reducing the availability of potable water (Atipoka, 2009; Cronk et al., 2021; Dungumaro, 2007; Foster et al., 2018; Galaitsi et al., 2001; Kelly et al., 2018; Mapulanga & Naito, 2019; Quinn et al., 2011; Rankoana, 2021; Swatuk & Kgomotso, 2007; Tantoh et al., 2021). For example, in Ghana, some authors found that many water bodies were polluted, preventing access to potable water for affected households (Owusu et al., 2016;

Yeleliere et al., 2018). Coupled with this, deforestation may affect water resources through changes to local climatic conditions, reduced infiltration and, therefore, decreased filtration, and increased soil erosion (Filoso et al., 2017; Mapulanga & Naito, 2019). These can increase sediments and turbidity in surface water sources (Filoso et al., 2017; Kateb et al., 2013), which reduces water quality and increases water treatment cost for households with differential impacts on disadvantaged families (Mapulanga & Naito, 2019; Zongo et al., 2017). In Malawi, using the assumption that local communities will invest in piped water infrastructure when high quality water sources are available, Mapulanga and Naito (2019) report that a percentage point decrease in the forest cover decreases access to piped water by 0.93 percentage points, demonstrating the importance of healthy forest ecosystem services for drinking water provisioning. Heavy rainfall and flood events can mobilize microbiological and chemical contaminants into water sources, particularly in the absence of adequate sanitation and wastewater facilities (Atipoka, 2009; De Wit & Stankiewicz, 2010; Neufeld et al., 2021; Ojo et al., 2004; Rankoana, 2021), and after prolonged droughts when the overburden is dry and cracked (Levy et al., 2016). In addition to limiting the amount of water available, droughts can concentrate contaminants (Kelly et al., 2018; MacDonald et al., 2019; Malley et al., 2007; Myeni & Wentink, 2020).

The political system impacts water inaccessibility through, for example, corrupt bureaucratic procedures, ineffective decision-making, and the absence of transparency in public offices and institutions to develop and manage water resources and infrastructure, which lead to poor construction, inappropriate technologies, and incomplete projects and programs (Debela et al., 2020; Hofstetter et al., 2008; Matamanda et al., 2015; Morinville & Rodina, 2013; Noemdoe et al., 2006; Swatuk & Kgomotso, 2007; Wrisdale et al., 2017). Ineffective governance and weak institutional frameworks also create persisting poverty and unemployment, which can make it challenging for low-income households to pay for water services, or buy water from alternative sources during periods of water inaccessibility (Busari, 2002; Galaitsi et al., 2001; Hailu et al., 2021; Jiwani & Antiporta, 2020; Kativhu et al., 2017; Miller et al., 2020; Monteith et al., 2020; Noemdoe et al., 2006; Osei et al., 2015; Wrisdale et al., 2017). Alongside this, prevailing patriarchal socio-cultural norms and practices and differential power structures often neglect pro-poor initiatives and marginalize and exclude vulnerable populations such as women and people with disabilities from being involved in water-related decision-making, design, and access (Busari, 2002; Dungumaro, 2007; Geere & Cortobius, 2017; Kativhu et al., 2017; Mushavi et al., 2020).

Climate-related extreme events can also compromise water and sanitation treatment processes and infrastructure. This will be exacerbated in regions of economic water scarcity, not only through the destruction of inadequate infrastructure, but also by the lack of resources to manage water under future uncertainties. Incomplete, poorly constructed, and inappropriate infrastructure will further increase susceptibility to extreme events. Floods, droughts, pollution, or infrastructure failure can require travel over longer distances to find sufficient water or water that is not contaminated (Kelly et al., 2018). For example, in Ghana, floods and heavy storms compromised water and sanitation facilities, forcing women to travel further distances to access water (Alhassan & Hadwen, 2017). However, climate events such as floods may also have positive consequences. For instance, floods can recharge and replenish groundwater sources, return nutrients to soils, and renew wetlands with freshwater for healthy water supplies, especially in hyper-arid environments (El Gayar & Hamed, 2017).

When water is not available on site, local geography can also be a barrier to accessing drinking water (Deshpande et al., 2020; Engel et al., 2007; Foster, 2013; Gon et al., 2016; Hosu et al., 2018; Katsi et al., 2007; Kusiluka et al., 2004; Marcatelli, 2013; Mazvimavi & Mmopelwa, 2006; Mushavi et al., 2020; Osei et al., 2015; Oyekale, 2018; Sinyolo et al., 2009; Sorenson et al., 2011; Stevenson et al., 2012). This is dependent on the terrain and distance between households and water points and can vary between wet and dry seasons (Jeil et al., 2020; Van Houweling, 2016). For example, muddy paths can be more difficult to traverse than dry ones (Drafor & Jones, 2008; Wilbur & Danquah, 2015; Wrisdale et al., 2017), and ephemeral rivers and lakes can impede travel, or provide a closer water source that can also be contaminated (Day et al., 2019; Wekesa et al., 2020). Steep slopes, varying relief of the physical terrain, and long distances particularly impact people who are young, elderly, pregnant, sick, or with a disability (Jeil et al., 2020; Mushavi et al., 2020; Pommells et al., 2018; Stevenson et al., 2012; Van Houweling, 2016; Wrisdale et al., 2017). More generally, physical disability, age, sex, gender, and social status can make it difficult for water fetchers to access or carry water (Akinyemi et al., 2005; Assefa et al., 2018; Bisung & Dickin, 2017; Bukachi et al., 2021; Dugard & Mohlakoan, 2009; Geere & Cortobius, 2017; Graham et al., 2016; Osei et al., 2015; Oyekale, 2018; Sinyolo et al., 2009; Tantoh et al., 2021; Twisa & Buchroithner, 2019; Wapenaar & Kollamparambil, 2019).

Gender and material inequalities as well as social and class differences are highly pervasive in SSA, causing inequities in water access, use, and management between men and women and between women in different circumstances (Fleifel et al., 2019; Harris et al., 2017). In many rural and marginalized regions, especially in SSA, men and women have unequal rights to water and have different roles and responsibilities associated with water provisioning and use because of cultural barriers and traditional gender roles (Jeil et al., 2020; Van Houweling, 2016). Most households, especially those without in-house piped connection systems, depend on women and girls to acquire water for domestic use, with most having to obtain water from nearby, or distant sources such as standpipes, rivers, springs, and dams (Jeil et al., 2020; Van Houweling, 2016; Wrisdale et al., 2017). On the other hand, men are exempted from such unpaid activities to reinforce and justify male power in intra-household relations. Even when men participate in water acquisition for the household, they believe they are helping their wives rather than taking responsibility for the chore (Van Houweling, 2016). Entrenched gender roles and norms indicate that women and girls predominantly bear the associated hardships of local water insecurity (Arku & Arku, 2010).

It has been well established that poor access to water exposes rural populations to water-related diseases, including cholera, malaria, and dengue (Arku et al., 2015; Asoba et al., 2019; Cronk et al., 2021; Denton, 2019; Deshpande et al., 2020; Marcantonio, 2009; Mazvimavi & Mmopelwa, 2006; Ntouda et al., 2013; Nyong & Kanaroglou, 2013; Onabolu et al., 2011; Owolabi, 2007; Schlamovitz & Becker, 2021; Sevilimedu et al., 2018; Stevenson et al., 2012; Yillia et al., 2008). Moreover, emerging evidence demonstrates an association between water collection and adverse musculoskeletal and mental health impacts and women's safety in SSA. These health impacts can destabilize the economic and social activities of women (Geere, Cortobius, et al., 2018; Sommer et al., 2015), and lead to out-of-pocket payments for drinking water and medical costs (including medications and transportation to and from healthcare facilities). Climate-induced scarcity and associated water quality degradation can only exacerbate health-related impacts. However, women with social networks, high social status, and better financial capital are more likely to be able to access water than those who are not similarly privileged (Sinyolo et al., 2009; Yerian et al., 2014).

Carrying heavy containers of water or walking long distances may cause fatigue, bone, and soft tissue damage, chronic back injuries, and macronutrient deficiencies, all of which adversely impact the health and development of water fetchers (Bisung & Elliott, 2015; De Jongh et al., 2008; Geere et al., 2010; Geere & Hunter, 2020; Miller, Workman, et al., 2021; Mushavi et al., 2020; Nounkeu & Dharod, 2019; Stevenson et al., 2012; Venkataramanan et al., 2020). During certain life stages, for example, pregnancy, there can be greater impacts on physical health (Schuster-Wallace & Watt, 2015; Sommer, Shandra, et al., 2015). For example, women need more calories during pregnancy and breastfeeding (Schuster et al., 2020). Moreover, women generally have less physical capacity to carry heavy loads than adult men, suggesting that physical impacts might be greater, especially over very long distances (Sorenson et al., 2011), or more difficult terrain. Water is also required for agriculture, which is critical for local food security, particularly in communities where subsistence agriculture is prevalent. In this context, in addition to increasing energy expenditures on water collection, water scarcity exacerbates food insecurity through preparation of less food, consumption of fewer calories, availability of lower-quality calories, or less dietary diversity (Brewis et al., 2020; Held et al., 2001; Jagals, 2006; Keino et al., 2014; Mazvimavi & Mmopelwa, 2006; Ngwenya & Kgathi, 2006; Nounkeu et al., 2021). The synergistic adverse consequences of water and food insecurity have also been associated with lower rates of breastfeeding and poorer levels of caregiving (Geere & Hunter, 2020; Ngwenya & Kgathi, 2006) as well as adverse mental health (Miller, Frongillo, et al., 2021; Workman & Ureksoy, 2017).

Inadequate water access further places a hygienic burden on people that affects women and girls more than men and boys (Alexander et al., 2014; Åstrøm & Mbawalla, 2011; Gon et al., 2016; Keino et al., 2014; MacDonald et al., 2019; Morgan et al., 2017; Phillips-Howard et al., 2016; Tegegne & Sisay, 2014). Lack of access to sufficient water and privacy has been demonstrated to result in social stigma and shame for women and girls, girls missing school to avoid physical and psychological discomfort associated with menstrual hygiene management, and increased susceptibility to urogenital infections (Duby et al., 2020; Morgan et al., 2017; Padmanabhanunni et al., 2018; Sommer & Sahin, 2013; Torondel et al., 2018). Adverse mental health consequences of water insecurity more broadly have also been identified, backed by a growing body of evidence (Bisung & Elliott, 2015; Marcantonio, 2009; Mosley et al., 2015; Ngwenya & Kgathi, 2006; West et al., 2013; Wutich et al., 2020). For example, in Lesotho, water scarcity was associated with increased psycho-emotional stress, with poor access and water quality significantly correlated with depression, anxiety, and overall levels of distress (Workman & Ureksoy, 2017).

A growing body of literature has associated water inaccessibility in rural SSA with compromised safety for women, exposing them to increased risk of violence and conflict (Asoba et al., 2019; Dugard & Mohlakoan, 2009; Katsi et al., 2007; MacDonald et al., 2019; Monteith et al., 2020; Pearson et al., 2021; S´anchez & Rylance, 2018; Sommer et al., 2015; Venkataramanan et al., 2020). Violent acts associated with poor water access may take different forms, including physical violence, sexual violence, psychological/mental violence, and verbal violence (Geere, Cortobius, et al., 2018; Jeil et al., 2020; Mushavi et al., 2020; Sommer et al., 2015; Stevenson et al., 2012). A few studies report physical injuries and pain as a result of physical attacks and altercations during water acquisition (Asaba et al., 2014; Monteith et al., 2020). This is often a result of arguments among water fetchers over who has the right to collect first (Pearson et al., 2021), especially if the water source is likely to run dry before everyone's needs are met. Prolonged droughts, exacerbated by climate change, could be expected to aggravate this issue. This could also mean that women need to walk further to collect water. It has already been documented that women are at risk of sexual violence traveling to, and from water sources, particularly when they are pubescent or traveling alone (Monteith et al., 2020; Sommer et al., 2015; Van Houweling, 2016), in part due to the predictable routes and times associated with water collection (Pommells et al., 2018). As travel distances increase, this risk could also increase. Increasing queue times and increasing distances mean that water collection takes longer and may not be sufficient to satisfy household needs. Physical and verbal assaults by partners and in-laws have been documented when women fail to bring sufficient water into the household (Mushavi et al., 2020; Sommer et al., 2015). Women survivors of violence can suffer from psychosocial problems such as psychosis, depression, sleep disruptions, and eating disorders (Geere et al., 2018; Stevenson et al., 2012). Sharing water sources and pathways with animals creates another dimension of physical insecurity as fetchers have been attacked by animals while collecting water (Dugard & Mohlakoan, 2009; Swatuk & Kgomotso, 2007; Van Houweling, 2016). Climate change alters animal territories, while floods and droughts can drive people and animals into closer proximity as they seek higher ground and water resources, respectively (Abrahms, 2021). This could increase the likelihood of animal attacks when collecting water.

Time spent collecting water (walking to a water source, queuing to draw water, and returning home) among women has been associated with reduced ability to participate fully in social, educational, and economic activities (Agol & Harvey, 2018; Bisung & Elliott, 2015; Dugard & Mohlakoan, 2009; Garn et al., 2013; Geere, Cortobius, et al., 2018; Graham et al., 2016; Kiendrebeogo, 2012; Makoni et al., 2004; Nauges & Strand, 2017; Sommer et al., 2015; Winter et al., 2021). The economic burden of water inaccessibility encompasses time and opportunity losses (Cooper- Vince et al., 2017; Denton, 2019; Dickin et al., 2011; Katsi et al., 2007; Kiendrebeogo, 2012; Komarulzaman et al., 2019; MacDonald et al., 2019; Makoni et al., 2004; Monteith et al., 2020; Stevenson et al., 2012; Winter et al., 2021), particularly during periods of physical water stress. These losses will increase if periods of water stress increase with changing climate, further hindering women's opportunities, for example, educational attainment, and exacerbating poverty (Jeil et al., 2020; MacDonald et al., 2019; Mazvimavi & Mmopelwa, 2006; Nauges & Strand, 2017; Njoh et al., 2020; Robson et al., 2013; Van Houweling, 2016; Yillia et al., 2008). These direct and indirect economic consequences can perpetuate a vicious cycle of poverty, femininization of poverty, and gender inequities (Krumdieck et al., 2016; Sinyolo et al., 2009; Stevenson et al., 2012). This is exacerbated by gendered land tenure rights, water governance, and water management in many SSA countries. As a result, water-related decisions are primarily made by men, to the exclusion of women despite their domestic water responsibilities (Bennett et al., 2008). This can result in decisions favoring men's water interests and needs over women's (Crow, 2001; Harris et al., 2017). Without gender-sensitive approaches in the water sector, water projects risk not adequately meeting women's needs (Arku & Arku, 2010), which reinforces inequities and has implications for water-related climate change adaptation.

Coping strategies can vary considerably between households and locations (Venkataramanan et al., 2019). When examined in terms of voice, loyalty, and exit, these strategies can be assessed with respect to the individual and systemic conditions that facilitate their implementation. For example, voice strategies take the form of complaints, demonstrations, and the formation of associations to help address water supply challenges. They include engaging in collective action (Bisung, 2021; Bukachi et al., 2021; Bulled, 2018; Kelly et al., 2017; Patrick, 2021). For this to occur, individuals need to hold sufficient agency, power, and social capital. In Usoma, Kenya, Bisung et al. (2014) found that the effects of sporadic water supply led to the formation of water and sanitation committees to mobilize resources to support the efforts of international organizations to supply water. Similarly, in Ghana, Kenya, and Zambia, Kelly et al. (2017) found that social capital and a sense of ownership were crucial elements in the sustainability of water systems. However, Bisung et al. (2016) assert that such strategies require attention be paid to the mechanism and level of engagement so that all voices are heard.

In some cases, households remain loyal to the system ("loyalty strategy") by changing behaviors and practices to cope with persistent water shortages or adverse water quality. Some strategies include reducing household water use, water treatment, reprioritizing (stopping or rescheduling) domestic activities, and substituting food types that require less water for preparation (Amoah et al., 2018; Dickin et al., 2011; Jeil et al., 2020; Myeni & Wentink, 2020; Ngarava et al., 2019; Nyong & Kanaroglou, 2013; Quinn et al., 2011; Rankoana, 2021; Schlamovitz & Becker, 2021; Venkataramanan et al., 2019). In Ghana, Jeil et al. (2020) found that chronic water shortages forced women to change their livelihood strategy of brewing pito (local drink made from fermented millet) to trading cereals. Women only brew pito when there is sufficient water to do so. Also, in rural Botswana, Ngwenya and Kgathi (2006) report that because of chronic water scarcity, families had to cook less food, postpone laundry, and reduce the number of bathing times per day, the latter of which is particularly problematic for the sick and infirmed. These studies suggest that employing such strategies requires households to be more flexible and efficient in water allocations. However, it should be noted that many of these loyalty strategies are only effective over the short term and can have adverse consequences over longer periods of time (Abubakar, 2018; Hutton & Chase, 2016; Majuru et al., 2016). As such, many of these coping strategies are maladaptive, that is, they are ineffective, unsustainable, or pose additional risks (Graham et al., 2016; Magnan et al., 2016; Ngwenya & Kgathi, 2006). For example, reducing water use and rescheduling domestic activities such as washing and bathing contribute to social and health risks by compromising sanitation and hygiene practices, and affecting nutritional practices (Abubakar, 2018; Majuru et al., 2016).

Households can also adapt to water inaccessibility through "exit strategies" by finding, and potentially treating, alternate water sources. Some of these include water sharing, recycling water, using alternative sources, including bottled/sachet water, and migrating to meet their needs (Arku et al., 2015; Asoba et al., 2019; Bernard & Joyfred, 2020; Brewis et al., 2019; Bukachi et al., 2021; Dickin et al., 2011; Emenike et al., 2017; Hamlet et al., 2021; Hofstetter et al., 2008; Jeil et al., 2020; Majuru et al., 2018; Marcatelli, 2013; Mushavi et al., 2020; Newcomer et al., 2017; Ngwenya & Kgathi, 2006; Nounkeu et al., 2019; Patrick, 2021; Pearson et al., 2017; Pearson et al., 2021; Schlamovitz & Becker, 2021; Twisa & Buchroithner, 2019; Venkataramanan et al., 2019; Walker, 2019; Yillia et al., 2008). Unsurprisingly, in Mozambique, Van Houweling (2016) found that during the long dry season, nearby wells and streams often dry up, forcing water fetchers to travel greater distances to alternative sources to obtain water. In Abuja, Nigeria, recycling of domestic water is common among households (Abubakar, 2018). A similar finding was reported in Dar es Salaam, Tanzania (Nganyanyuka et al., 2014). Some other scholars report that in rural Uganda, households respond to rainfall variability by employing rooftop rainwater harvesting systems such as plastic tanks and jerrycans to harvest and store water (Bernard & Joyfred, 2020). Note that some of the loyalty strategies are also maladaptive. For example, households that adopt labour, or time-intensive coping strategies such as collecting water from alternative sources may experience adverse health consequences, time loss for income-generation, poor school attendance, and poor participation in social activities (Geere, Bartram, et al., 2018; Geere, Cortobius, et al., 2018; Graham et al., 2016; Schuster et al., 2020). Furthermore, sustainable interventions such as rainwater harvesting, or purchasing additional storage tanks, have financial implications that put these solutions out of the reach of many, or require access to financing programs.

3.4 Addressing research gaps

Given current and future impacts of climate change on household water access, a gender-sensitive approach to policies, programs, and practice needs to engage with both the water and climate crises. The nexus between the water and climate crises is complex and has a disproportionate effect on the lives of women in SSA, especially those living rural and marginalized regions. Furthermore, given the interlinkages between climate change, water, gender, and sustainable development, enhancing adaptation capacity is instrumental to managing and building resilience. Governments at all levels should develop gender-sensitive water and climate adaptation plans and measures. Equitable and sustainable strategies to cope with water access during water shortages as well as during and in the aftermath of extreme weather events should be considered in these adaptation plans. These require the full and equal participation of all genders, as well as abilities, ages, and socio-economic status, to ensure effective planning.

Understanding the complex interlinkages of climate, water, and gender to mitigate rural water inaccessibility includes addressing crucial research gaps in the literature (Figure 3.5).

Although water inaccessibility is a common problem globally, its occurrence is diverse and complex, with substantial disparities within and across geopolitical boundaries. There has been a proliferation of formative research on water inaccessibility across countries and communities in SSA, especially in areas experiencing severe water insecurity. Although some scholars have documented the degree of water inaccessibility in specific regions (Alaci et al., 2013; Pickering & Davis, 2012; Ritchie & Roser, 2017), others concentrated on the etiology of this problem (e.g., Chew et al., 2019; Geere & Cortobius, 2017; Wrisdale et al., 2017; Yerian et al., 2014). The most commonly cited drivers shaping water inaccessibility in SSA include environmental issues, governance, market forces, some socio-cultural norms, and population growth (Figure 3). However, gaps remain in the literature with respect to the roles that the various factors play in access water. Of the studies included, the greatest focus was on systemic (102 occurrences) and environmental (72 occurrences) drivers (Apatinga et al., 2022A).

Individual drivers were identified far less frequently (25 occurrences) (Apatinga et al., 2022A). More specifically, economic (32 occurrences), political (26 occurrences), and climate change (19 occurrences) were the drivers most frequently discussed. Conversely, four environmental drivers had five or fewer occurrences, with terrain being the lowest (2 occurrences); three systemic drivers had five or fewer occurrences, with rights being the lowest (3 occurrences); and all individual factors, except sex and gender, had five or fewer occurrences, with agency and power being the lowest (2 occurrences) (Apatinga et al., 2022A).

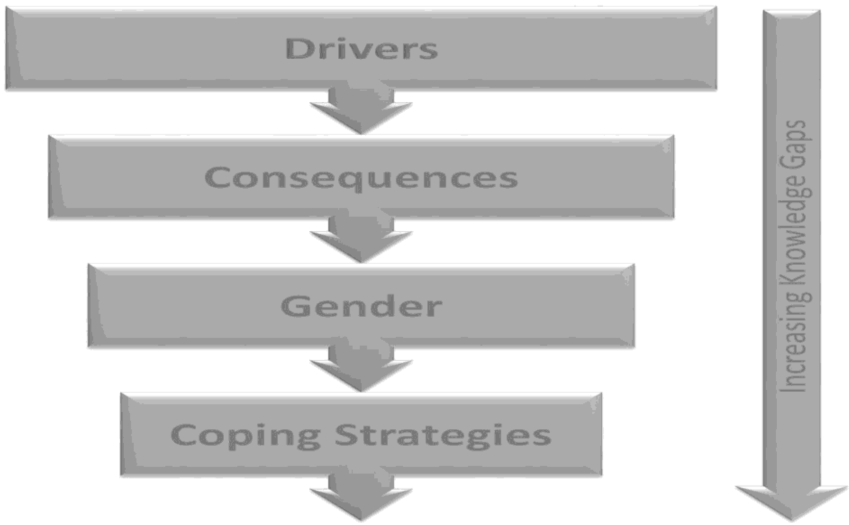


Figure 3.5: Increasing gaps in knowledge within a coupled systems approach to water inaccessibility

Other scholars have documented the complex and intersecting consequences associated with water inaccessibility (Asaba et al., 2014; Collins et al., 2019; Geere, Bartram, et al., 2018; Geere et al., 2018; Pommells et al., 2018;Rosinger, 2018; Rosinger & Brewis, 2020; Schuster-Wallace et al., 2019; Sommer, Ferron, et al., 2015; Sommer, Shandra, et al., 2015). The most frequently identified consequences categories include health impacts (48 occurrences), socio-economic (31 occurrences), and safety (24 occurrences) (Apatinga et al., 2022A). More specifically, most commonly identified consequences were disease (18 occurrences), mental health (13 occurrences), and physical violence, including animal attacks (12 occurrences). Gaps still remain regarding evidence of causal relationships between household water insecurity and adverse impacts on human biology throughout the life course (Rosinger & Young, 2020). Furthermore, distal impacts such as nutrition (14 occurrences) and gendered financial implications (7 occurrences) have been examined to a lesser degree within the context of water (in)accessibility (Apatinga et al., 2022A).

Another group of scholars has identified coping strategies that households employ to respond to water inaccessibility (Abubakar, 2018; Amit & Sasidharan, 2019; Bisung et al., 2014;

Cook et al., 2016; Etongo et al., 2018; Majuru et al., 2016; Venkataramanan et al., 2020). Dominant coping strategies identified include alternative sources (15 occurrences), water storage (9 occurrences), and water reuse (8 occurrences). The least identified coping strategy category was voice (6 occurrences), while consumption reduction (loyalty) (3 occurrences), and migration (exit) (3 occurrences) were the least identified strategies in their categories (Apatinga et al., 2022A). In addition to the need for more research on specific coping strategies, perhaps more important is the need to understand the determinants of, or factors influencing, water users' choice of coping strategies and their effectiveness, as well as unintended consequences. It should be noted that evidence-based sustainable, beneficial, equitable coping strategies should inform broader adaptation strategies and supports.

Examination of causal relationships requires a rethinking of research scope and methods in individual initiatives. There are limitations associated with various research methods and designs, and some are more culturally and practically appropriate in different contexts. For example, chosen methods must be inclusive of all levels of literacy and internet or mobile phone connectivity, and research should be embedded within local institutional structures and organizations. Some methodological tools are reductive, which can be useful when targeting a specific problem, but can overlook more distal drivers as well as climate, water, and gender-related complexities. Community-based participatory research can inform data collection instrument design and provide insights to local context and issues to be included in research, while longitudinal and multi-country assessments can provide evidence of more systemic drivers, responses, and consequences. Additionally, critical global issues, such as water access, which span physical and social systems, require a mixed methods approach using quantitative and qualitative research methods to understand the "what" and the "why" alongside climate, water quantity, and water quality data (Barber et al., 2018; Lucero et al., 2018).

Combining social and environmental datasets along with innovative use of big data, remote sensing datasets, and models can augment ground-based observations (Confalonieri & Schuster-Wallace, 2011; Schuster-Wallace & Sandford, 2015). In addition, understanding the interconnections between the socio-econo-politico-cultural and the environmental dimensions of water access requires collaboration among disciplines (e.g., Di Pelino et al., 2019). Furthermore, it requires the engagement of stakeholders and communities in research teams (Caldwell et al., 2015; Oetzel et al., 2018). Thus, adopting multidisciplinary and transdisciplinary research approaches in climate-and-water based analysis is required to understand and address complex, intersecting water-related challenges and inform resilient-adaptation strategies.

A significant barrier to more gender-inclusive climate and water-related policies and programs is the lack of comparable data on gender and sex indicators. Consideration of demographic data is critical in research design in order to be able to disaggregate data and account for intersectionality in terms of gender, age, socio-economic status, ability, and ethnicity. Moreover, in regions where it is safe to do so, sex and gender should be examined on a continuum, rather than as binary. Failure to incorporate these dimensions affects the formulation and implementation of policies at all scales, hinders measurements on national development progress, and leads to over-generalizations and lost voices on water challenges and solutions.

The redressing of these research gaps and use of appropriate and innovative data collection and analysis methods (e.g., disaggregated data) will facilitate a better understanding of and evidence base for future trends in water inaccessibility to inform policy, planning, and practice, including dimensions of vulnerability, impacts, and effective grassroots strategies and co-benefits. In particular, the increasing impacts of climate change call for research to examine the links between climate change, water (in)accessibility, and gender. An enhanced understanding of these complex interlinkages and their consequences has the potential to provide the basis for incorporating both gender and climate components in water-related policies, programs, and practices to reduce inequalities and enhance resilience and sustainability. However, it is imperative to translate knowledge and empirical evidence generated through transdisciplinary research and community engagement into policy and action to improve equitable and sustainable water access. Collectively, these support enhanced empowerment of women and the successful realization of SDGs 5 and 6.

3.5 Conclusion

Although it is evident that multiple drivers underpin water inaccessibility and individual and household coping strategies, it is important to note that these do not exist in isolation. Interaction among drivers, particularly the connection between climate, water, and gender, can impact water access in different ways. Collectively, the literature assessed reinforces the knowledge that water inaccessibility has far-reaching implications for the health, livelihoods, and well-being of rural women. This coupled social and ecological systems approach underscores the significance of mainstreaming gender and climate and provides the conceptual framing to: (1) better understand the complex interlinkages among drivers, consequences, and coping strategies; (2) identify potential research gaps; and (3) serve as a blueprint to design gender-sensitive indicators and interventions. Although research exists regarding the drivers and consequences of, and coping strategies for, rural water inaccessibility, numerous gaps still exist in the literature. Evidence of differential impacts and benefits along with understanding how and why grass roots solutions are successful will begin to shape appropriate solution envelopes for improving sustainable water access. A critical strength of this framework is that it helps in understanding the reciprocal linkages that exist between the drivers of rural water inaccessibility and the resulting consequences and coping strategies. In particular, this framework provides critical insights and synergies by establishing what drives water (in)accessibility and how local water inaccessibility translates into adverse health, social, and economic outcomes for women in rural SSA. This supports comparative analytical assessments of the burden of local water inaccessibility and grass roots solutions towards achieving SDGs 5 and 6. Translating knowledge into action requires this type of broad, critical framework that recognizes the ripple effects of water (in)accessibility, as drinking water access, climate change, and gender are multifaceted, intersectional, and overlapping issues. Part of the solution is to account for gender and climate change in all water-related planning and management. Implementing evidence- informed gender-sensitive and climate-resilient adaptation strategies specific to local contexts is no longer optional, but rather an imperative.

CHAPTER FOUR

Preamble

This chapter presents and discusses the impact of environmental and social factors on the spatiotemporal dynamics of access to improved or safe water sources in Ghana, which represents a significant research gap in the existing literature. By utilizing data from the 2014 Ghana Demographic and Health Survey (GDHS) and integrating it with meteorological records, this chapter provides a nuanced exploration of the factors influencing access to improved water sources. The 2014 GDHS is a comprehensive initiative conducted by the Ghana Statistical Service (GSS), Ghana Health Service (GHS), and the National Public Health Reference Laboratory (NPHRL) of the GHS. It is a nationally representative survey that followed a cross-sectional design protocol, aiming to comprehensively understand the demographic landscape, health dynamics, and socioeconomic factors across the nation. The 2014 GDHS was executed through a two-stage sampling design, with the first stage involving careful selection of sampling points (clusters) comprising enumeration areas (EAs). Four hundred and twenty-seven clusters were selected consisting of 216 urban and 211 rural areas. The second stage encompasses systematic sampling of households. The survey was conducted by trained enumerators between early September and mid-December 2014 and included a household listing operation for all selected EAs. Households for inclusion in the survey were then randomly selected from this list, with approximately 30 households chosen from each EA, culminating in a sample of 12,831 households. Through multivariable analysis, this study argues that disparities in access to improved water sources among households stem from environmental, systemic, and individual factors. This research not only enriches our understanding of access inequities, but also clarifies ambiguities in previous studies on the determinants of improved water access in Ghana.

Manuscript #2: "A closer look": Examining factors influencing the spatiotemporal dynamics of drinking water access in Ghana

Apatinga, G. A., Dickson-Anderson, S. E., & Schuster-Wallace, C. J. (2024) "A closer look": Examining factors influencing the spatiotemporal dynamics of drinking water access in Ghana (Under review in the International Journal of Water Resources Development)

Abstract: This study examined the impact of environmental, systemic, and individual factors on access to improved drinking water sources in Ghana, using a coupled systems framework. The study integrates the 2014 Ghana's Demographic and Health Survey data with meteorological records from 1991 to 2021, revealing environmental, geographic, socioeconomic, and cultural disparities. For instance, increased average rainfall range, urban residence, higher education levels and smaller household size were associated with better access to improved water sources. The study highlights the complexities of addressing water access disparities and underscores the need for nuanced and inclusive strategies that integrate climate and gender perspectives to achieve SDG 6.1 in Ghana.

Keywords: SDG: clean water and sanitation, Ghana, factors, coupled systems framework, climate change

4.1 Introduction

Basic drinking-water services are defined as improved water sources within a 30-minute round-trip, including queueing time (WHO & UNICEF, 2021). Despite global efforts, many areas, particularly in sub-Saharan Africa, continue to face challenges in accessing improved water sources (Weststrate et al., 2019; WHO & UNICEF, 2021). In Ghana, rural households fall behind compared to urban areas, with many relying on time-consuming water collection methods (Ablo & Yekple, 2018; Dongzagla et al., 2022). Lack of access to improved water sources poses significant public health and socioeconomic challenges. In Ghana, these consequences include increased disease burden, emotional distress, time and opportunity loss, conflicts, and spousal violence (e.g., Achore & Bisung, 2022; Apatinga et al., 2022; Nordström & Widman, 2022). Thus, identifying local drivers of improved drinking water access is crucial for achieving universal access.

While research has acknowledged the prevalence and adverse consequences of water inaccessibility in Ghana, studies on its drivers have been limited. Previous studies have produced mixed results and failed to adequately consider the complexity and interconnections between factors influencing drinking water access (Adams et al., 2016; Agbadi et al., 2019; Oppong et al., 2022). Cross-sectional household surveys have been used to examine the relationship between factors such as education and income and drinking water access, but findings have been inconsistent. Some researchers have reported a significant relationship between these factors and improved water access (Agbadi et al., 2019; Mahama et al., 2014), while others have found no strong relationship (Nketiah-Amponsah et al., 2009; Osei-Asare, 2005). Furthermore, little to no attention has been paid to environmental drivers, despite the importance of, for example, natural water resources and terrain (Apatinga et al., 2022). To design effective and sustainable solutions, policymakers and practitioners need to understand the different drivers of water inaccessibility, their interactions, and their scales of operation. Ignoring the impact of climate change on water demands and precipitation events could further undermine efforts to provide sustainable drinking water access (Bernard & Joyfred, 2020; Patrick, 2021).

This study applied a coupled systems framework (Apatinga et al., 2022) to the Ghanaian context to identify drivers of improved drinking water access and their relative importance. This framework emphasizes that inequalities in access to improved water sources results from complex, interwoven, and mutually reinforcing factors at various levels of the social-ecological system, comprising environmental, systemic, and individual driver types. These different sets of drivers interact directly or indirectly to affect improved water access at the individual, household, and community levels. This study provides a new perspective on drivers limiting access to improved water sources, which is different from previous scholarship. It is argued that sustainable solutions for universal access to improved water sources require recognizing the complex and intersecting determinants, which must be addressed to minimize risks and vulnerabilities, ultimately informing local and national policies for integrated water resources management and provisioning.

4.2 Methods

4.2.1 Geographical context

Ghana is located in the Gulf of Guinea (West Africa). During the period of study (2014), it consisted of ten administrative regions: Ashanti, Eastern, Western, Greater Accra, Northern, Brong Ahafo, Central, Volta, Upper East, and Upper West Regions. In 2014, Ghana's population was estimated to be approximately 27 million, with a significant majority, over 70%, inhabiting the southern regions of the country (Ghana Statistical Service et al., 2015). Population densities are highest in the coastal areas, the Ashanti Region, and the major cities such as Accra and Kumasi. The Akan ethnic group formed the majority of the population (48%), followed by the Mole-Dagbani (17%), Ewe (14%), Ga-Dangme (7%) and others (13%) (Ghana Statistical Service et al., 2015). Ghana is predominantly Christian (71%), with Muslims (20%) and traditional believers (3%) (Ghana Statistical Service et al., 2015). Agriculture drives the economy, but diverse natural resources, including gold and timber, and tourism contribute to wealth generation. Despite this, foreign aid is still needed for development due to chronic issues like poverty, unemployment, water insecurity, and illiteracy that affect all regions (Cooks et al., 2016).

Ghana encompasses five ecozones (Figure 4.1), which include the transitional, evergreen, deciduous forest, savannah, and coastal savannah zones (Harvest Choice, 2005). As a result, temperature and rainfall variations exist across the country. For instance, the savannah zone, which is a semi-arid and less developed region, has a single rainy season (April to September), while the other ecological zones experience two rainy seasons (April to July and September to November). These variations impact water resource availability, both spatially and temporally, leading to implications for water management and access to drinking water.

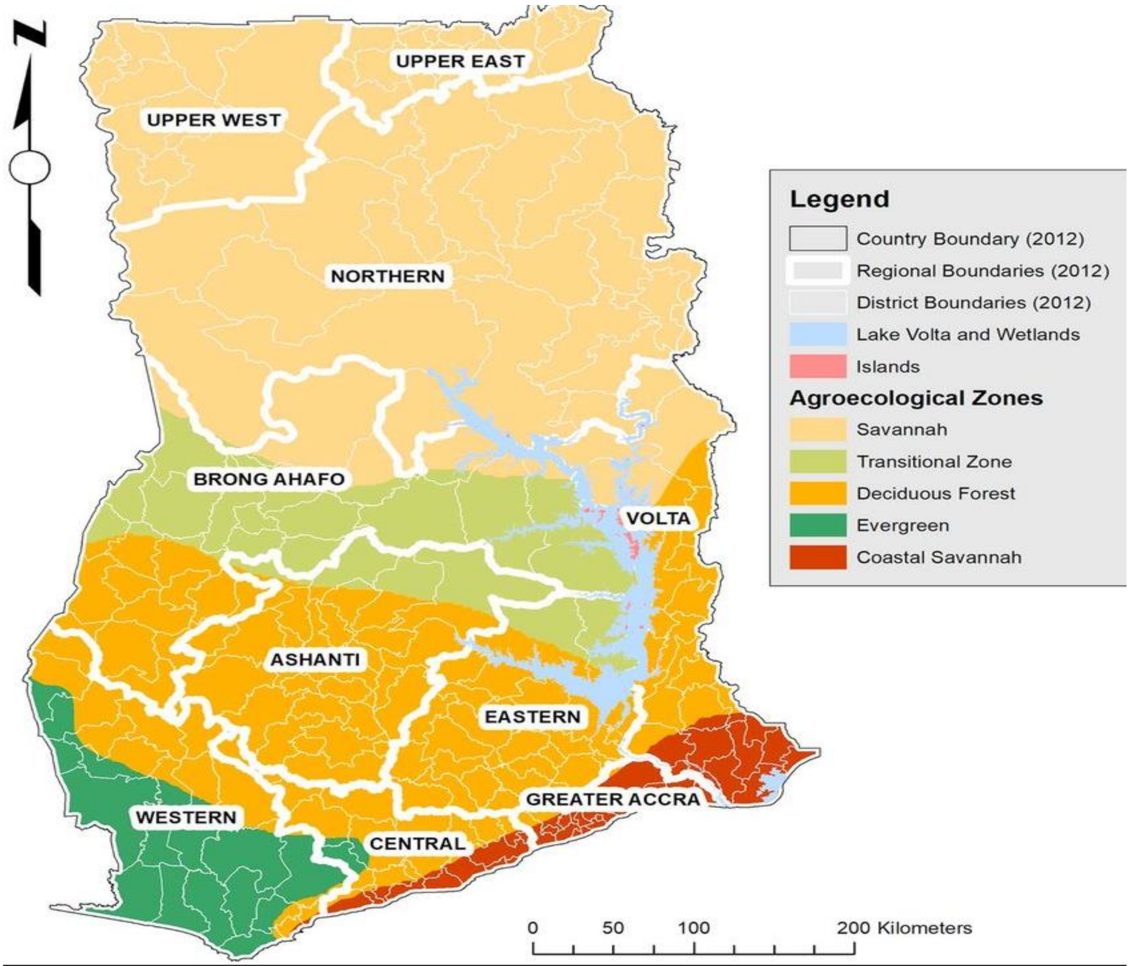


Figure 4.1: Agroecological zones of Ghana Source: Harvest Choice (2005)

4.2.2 Data and Variables

Data for this study were obtained from the European Centre for Medium-Range Weather Forecasts (ECMRWF) and the 2014 Ghana Demographic and Health Survey (GDHS). ECMRWF is a repository for Ghana's climate data (www.climate-data.org). Records of annual rainfall, monthly maximum and minimum rainfall, and monthly maximum and minimum number of rainy days were extracted for all meteorological stations in Ghana between 1991 and 2021 (Supplementary file 1, Appendix IV). Stations were organised by administrative region and average values calculated across all stations in each region. Additional variables calculated from the data included average total annual rainfall, average monthly maximum rainfall, average monthly minimum rainfall, average rainfall range, average maximum rainy days in a month, average minimum rainy days in a month, and average rainy days range (Supplementary file 1, Appendix IV). A two-tailed Pearson correlation test was performed to check for multi-collinearity ($p<0.01$). Most of the variables exhibited correlation and were thus excluded from the study. However, the variables representing the average rainfall range, average maximum rainy days in a month, and average minimum rainy days in a month were found to be uncorrelated and were included in the study (Table 4.1).

Table 4.1: Correlation matrix of climate variables

Variables	Average Total Annual Rainfall (mm)	Average Monthly Maximum Rainfall (mm)	Average Monthly Minimum Rainfall (mm)	Average Rainfall Range (mm)	Average Maximum Rainy Days in a month	Average Minimum Rainy Days in a month	Average Rainy Days Range
Average Total Annual Rainfall (mm)	1	0.431**	0.753**	0.071**	0.790**	0.652**	-0.496**
Average Monthly Maximum Rainfall (mm)	0.431**	1	0.189**	0.890**	0.688**	0.201**	-0.002
Average Monthly Minimum Rainfall (mm)	0.753**	0.189**	1	-0.279**	0.641**	0.974**	-0.922**
Average Rainfall Range (mm)	0.071**	0.890**	-0.279**	1	0.376**	-0.255**	0.426**
Average Maximum Rainy Days in a month	0.790**	0.688**	0.641**	0.376**	1	0.610**	-0.375**
Average Minimum Rainy Days in a month	0.652**	0.201**	0.974**	-0.255**	0.610**	1	-0.963**
Average Rainy Days Range	-0.496**	-0.002**	-0.922**	0.426**	-0.375**	-0.963**	1

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

No or negligible correlation (0.0 to 0.2)

The GDHS contains detailed information on socio-economic variables, health variables, and water and sanitation services. It consists of 11,835 survey responses across the country.

Details of the dataset available at https://dhsprogram.com/pubs/pdf/FR307/FR307.pdf.

Explanatory variables representing environmental, systematic, and individual level factors were identified and categorized according to the conceptual framework and informed by insights from prior literature, ensuring alignment with the research objective and relevance to the phenomenon under study (Table 4.2). Source of drinking water was used as the main outcome or dependent variable, categorized as improved and unimproved following the WHO's (2015) categorization of drinking water sources (Table 4.2). The following DHS survey responses were categorised as improved water sources for this study; piped water, piped into dwelling, piped to yard/plot, public tap/standpipe, tube well water, tube well or borehole, protected well, protected spring, bottled water, sachet water, and rainwater. All other responses were categorised as unimproved water sources; dug well (open), unprotected well, surface water, unprotected spring, tanker truck, cart with small tank, river/dam/lake/ponds/stream/canal/irrigation channel, other. Once uncorrelated environmental variables were identified (average rainfall range, average maximum rainy days in a month, and average minimum rainy days in a month), they were integrated with other selected independent variables from the DHS data and used in the data analysis (Table 4.2).

Table 4.2: Description of dependent and independent variables

<table>
<tr><th>Variables</th><th>Description</th><th colspan="2">Collinearity Statistics (Independent Variables)</th></tr>
<tr><th>Dependent Variable</th><th></th><th>Tolerance</th><th>VIF</th></tr>
<tr><td>Sources of drinking water</td><td>This variable describes the sources from which individuals access drinking water. In the DHS dataset, various drinking water sources were reported, which were then recoded into a binary variable according to the WHO's (2015) classification of drinking water sources.
(0) Unimproved water sources: Households have access to unimproved sources if they accessed the following sources; dug well (open), unprotected well, surface water, unprotected spring, river/dam/lake/ponds/stream/canal/irrigation channel, tanker truck, cart with small tank, other.
(1) Improved water sources: Households have access to improved water sources if they accessed the following sources; piped water, piped into dwelling, piped to yard/plot, public tap/standpipe, tube well water, tube well or borehole, protected well, protected spring, bottled water, sachet water, rainwater</td><td></td><td></td></tr>
<tr><td>Independent Variables</td><td colspan="3"></td></tr>
<tr><td>Environmental Variables</td><td></td><td></td><td></td></tr>
<tr><td>Average Rainfall Range</td><td>This variable was calculated by subtracting average monthly maximum rainfall from average monthly minimum rainfall</td><td>0.504</td><td>1.985</td></tr>
<tr><td>Average Maximum Rainy Days in a month</td><td>The average maximum rainy days in a month were calculated by summing the maximum number of rainy days for each month and dividing by the number of months in a year</td><td>0.311</td><td>3.211</td></tr>
<tr><td>Average Minimum Rainy Days in a month</td><td>The average minimum rainy days in a month were calculated by summing the minimum number of rainy days for each month and dividing by the number of months in a year</td><td>0.367</td><td>2.724</td></tr>
<tr><td>Location of Residence</td><td>The location of the primary residence of a survey respondent. It is taken directly from the DHS database and is categorized as:
(i) Rural (ii) Urban</td><td>0.606</td><td>1.650</td></tr>
<tr><td>Time to get to water sources</td><td>The time taken to access water sources, especially those who do not access water on premises.</td><td>0.897</td><td>1.115</td></tr>
<tr><td>Ecological Zone</td><td>Areas with similar environmental attributes (Harvest Choice (2005). Originally, it was labeled as "region" in the DHS dataset, with categories such as Western, Central, Greater Accra, Volta, Eastern, Ashanti, Brong Ahafo, Northern, Upper East, and Upper West. However, for this study, it was reclassified into ecological zones:
(i) Transitional Zone (ii) Evergreen Zone (iii) Savannah Zone (iv) Deciduous Forest Zone (v) Coastal Savannah Zone</td><td>0.759</td><td>1.317</td></tr>
</table>

Systemic and Structural Variables			
Religion	The religious group to which the respondent associates himself or herself at the time of the survey. In the original DHS dataset, it was reported and categorized as Catholic, Anglican/Methodist/Presbyterian, Pentecostal/Charismatic, Other Christian, Muslim, Traditional/Spiritualist, No religion, and Other. However, for this study, it was recoded into: (i) Christian Religion (ii) Islamic Religion (iii) Traditional Religion (iv) No religion	0.932	1.072
Occupation	The respondent's employment status at the time of the survey. In the DHS dataset, it was originally categorized as not working, professional/technical/managerial, clerical, sales, agricultural - self-employed, agricultural - employee, services, skilled manual, and unskilled manual. For this study, it was recoded into: (i) Unemployed (ii) Formal Work (iii) Informal Work	0.857	1.167
Income Status	Household income status at the time of the survey. Initially, in the DHS dataset, it was classified as poorest, poor, middle, richer, and richest. However, for this study, it was recoded as: (i) Poor (ii) Rich	0.514	1.947
Health Insurance Coverage	This variable indicates whether respondents had health insurance coverage. It is taken directly from the DHS database and is categorized as: (i) No/Unsure (ii) Yes	0.894	1.118
Ethnicity	The ethnic group to which respondents belong. It is directly taken from the DHS database and is coded as: (i) Akan, (ii) Ga/Dangbe, (iii) Ewe, (iv) Guan, (v) Mole-Dagbani, (vi) Grusi, (vii) Gurma, (vii) Mande, (viiii) Other	0.979	1.021
Individual Variables			
Household Size	The number of people living in a household at the time of the survey. Initially coded in the DHS dataset with values ranging from 1 to 25, it was recoded into: (i) 1-3 members (ii) 4-6 members (iii) 7+ members	0.744	1.344
Age of Household Head	The age of the household head at the time of the survey. Initially reported in the DHS dataset as age groups 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49, it was recoded for this analysis into: (i) 15-24 years (ii) 25-35 years (iii) 35-49 years	0.787	1.270

Having Pregnancy	This variable indicates whether there was a pregnant woman in a household at the time of the survey. In the DHS dataset, it was reported and coded as: (i) No (ii) Yes	0.923	1.083
Sex of Household Head	The sex of the household head. In the DHS dataset, it was reported and coded as: (i) Male (ii) Female	0.670	1.492
Number of Women in Household	The number of women in a household during the survey period. Originally coded in the DHS dataset with values ranging from 1 to 6, it was subsequently recoded into: (i) 1-2 women (ii) 3-4 women (iii) 5+ women	0.919	1.088
Currently Breastfeeding	This variable indicates whether there was a breastfeeding woman in the household at the time of the survey. In the DHS dataset, it was reported and coded as: (i) No (ii) Yes	0.781	1.280
Household Means of Transport	This variable described whether households owned or possessed any means of transportation such as bicycles, cars, or motorcycles. In the DHS dataset, it was reported and coded as: (i) No (ii) Yes	0.801	1.249
Access to Media	This variable described whether households had access to or listened to any of the media outlets. In the DHS dataset, this was reported and coded as: (i) No (ii) Yes	0.723	1.383
Marital Status	The marital status of the survey respondent. Initially reported in the DHS dataset with categories such as never in union, married, living with partner, widowed, divorced, and no longer living together/separated, it was recoded into: (i) Never married/Single (ii) Married (iii) Ever married	0.821	1.219
Educational Status	The educational status of respondents at the time of the survey. Initially reported in the DHS dataset with categories such as no education, primary education, secondary education, and higher education, it was subsequently recoded into: (i) Uneducated (ii) Educated	0.851	1.175

Descriptive analysis of the data (Table 4.3) shows that among the environmental variables, the average rainfall range exhibited a mean of 188.09 mm with a standard deviation of 38.009 mm. The average maximum rainy days in a month amounted to 18.73 ± 1.053 days, while the average minimum rainy days stood at 3.48 ± 3.613 days. Additionally, the ecological distribution of the population showcased varying proportions across different zones, with the savannah zone hosting the highest concentration at 32.7% (7,571). The urban-rural divide was apparent, with 60.3% (13,946 individuals) residing in rural areas and 39.7% (9,172 individuals) in urban areas.

In terms of systemic variables, characteristics revealed that 39% of respondents identified as Akan ethnicity (8,986), while 70% identified as Christians (16,390). Just under half of the respondents engaged in the informal sector (11,461, 49%), with 55% falling within the low-income bracket (12,792) (Table 4.3). Among individual variables, the majority of survey respondents were single (16,677, 75%), and approximately 35% (4,713) had not received formal education. Household composition showed that 49% (11,365) of households comprised between four and six members, 33% (7,697) had seven or more members, and 17% (4,057) consisted of one to three members. Notably, 28.6% (6,620) of households were headed by women, while 71.4% (16,498) were headed by men.

Table 4.3: Background Information

Socio-demographic, economic and environmental characteristics	**Mean±SD or Frequency (%)**
Environmental Variables	
Average Rainfall Range	188.09 ± 38.009
Average Maximum Rainy Days in a month	18.73 ± 1.053
Average Minimum Rainy Days in a month	3.48 ± 3.613
Location of Residence	
Rural	13946 (60.3)
Urban	9172 (39.7)
Time to get to water sources (in minutes)	152.14 ± 333.8
Ecological Zone	
Transitional Zone	4428 (19.2)
Evergreen Zone	2295 (9.9)
Savannah Zone	7571 (32.7)
Deciduous Forest Zone	4722 (20.4)
Coastal Savannah Zone	4102 (17.7)
Systemic and Structural Variables	
Religion	
No Religion	1056 (4.6)
Christian Religion	16390 (70.9)
Islamic Religion	4657 (20.1)
Traditional Worshippers	1015 (4.4)

Occupation	
Unemployed	2405 (10.4)
Formal Work	9215 (39.9)
Informal Work	11461 (49.7)
Income Status	
Poor	12792 (55.3)
Rich	10326 (44.7)
Health Insurance Coverage	
Health Insurance: Yes	15036 (65.1)
Health Insurance: No/Unsure	8076 (34.9)
Ethnicity	
Ethnicity: Other	388 (1.7)
Akan	8986 (38.9)
Ga/Dangbe	1143 (4.9)
Ewe	2488 (10.8)
Guan	641 (2.8)
Mole-Dagbani	6100 (26.4)
Grusi	1007 (4.4)
Gurma	2077 (9.0)
Mande	278 (1.2)
Individual Variables	
Household Size	
7+members	7697 (33.3)
1-3 members	4057 (17.5)
4-6 members	11365 (49.2)
Age of Household Head	
15-24 years	1509 (6.5)
25-35 years	6952 (30.1)
35-49 years	14657 (63.4)
Age of Household Head	44.21 ± 11.362
Having Pregnancy	
Yes	1551 (6.7)
No	21567 (93.3)
Sex of Household Head	
Female	6620 (28.6)
Male	16498 (71.4)
Number of Women in Household	
1-2 women	20883 (90.3)
3-4 women	2077 (9.0)
5+ women	158 (0.7)
Currently Breastfeeding	
No	15499 (67.0)
Yes	7619 (33.0)
Access to Media	
No	5687 (24.9)
Yes	17136 (75.1)
Household Means of Transport	
No	11717 (51.3)
Yes	11106(48.7)
Marital Status	
Ever Married	1024 (4.6)
Never Married	16677 (74.5)
Married	4689 (20.9)
Educational Status	
Uneducated	4713 (35.4)
Educated	8601 (64.6)
Sources of water	
Unimproved water sources	3703 (16.2)
Improved water sources	19120 (83.8)

4.2.3 Data Analysis

The selected independent and dependent variables were managed and analyzed using SPSS version 27. A multi-collinearity test was first performed using tolerance and variance inflation factor (VIF) to check for possible significant correlations between the selected independent variables (Chatterjee & Simonoff, 2013). This step was crucial in confirming that the variables were not correlated, which could potentially impact the accuracy of the regression analysis outcomes. Following the standards of tolerance (N< 0.1 indicates severe multi-collinearity) and VIF (N>10 indicates severe multi-collinearity) (Chatterjee & Simonoff, 2013), all variables demonstrated independence from each other (Table 4.2).

Regression analyses were then performed to understand and highlight potential relationships between the predictors and categorical response variables. Specifically, binary logistic regression was used to generate models (Harris, 2021; Wilson et al., 2015). A key assumption of this technique is that the dependent variable must be binary. The application of the binary logistic regression technique made it possible to estimate the relationship between the independent and dependent variables. Constructing models commenced with a bivariate analysis to explore relationships between the dependent variable and each independent variable. Conducting bivariate analysis is a crucial step for selecting variables for inclusion in a multivariable model. It allows for the exclusion of variables that do not demonstrate a significant bivariate relationship with the outcome, thereby simplifying the model (Bursac et al., 2008). This analysis revealed that all selected independent variables, except for household means of transport (excluded from subsequent multivariable analysis), were significantly associated with access to improved water sources (Table 4.4).

Subsequently, a multivariable analysis was conducted using the enter method in binary logistic regression. Unlike the forward and backward modeling methods, the enter method simultaneously includes all significant independent variables in the model, allowing the evaluation of their collective impact on the dependent variable (Halinski, & Feldt,1970; Stevens, 2002). The enter method evaluates each predictor as if it were added last, assessing its individual contribution to predicting the dependent variable, beyond what has already been predicted by other variables in the model (Pedhazur,1997). Importantly, the enter method mitigates biases by incorporating all variables, regardless of their significance, in contrast to methods like stepwise regression (Gary, 2018; Thompson, 1995;1989). It ensures the generation of unbiased estimates of the effects of predictor variables on the outcome, aligning with the objectives of the analysis. The enter method is relevant in logistic regression when researchers seek a straightforward and comprehensive approach to modeling the relationship between multiple predictor variables and a binary outcome (Halinski, & Feldt,1970; Stevens, 2002).

The modeling process adhered to a hierarchical approach, beginning with significant environmental variables, followed by systemic, and lastly, individual variables. This approach ensures a thorough exploration of different levels of influence on the dependent variable. Aligned with the adapted conceptual framework and previous research, this systematic progression enhances interpretability and robustness by providing a clear framework for variable selection and interpretation (Gary, 2018). The bivariate and multivariable logistic regression results were reported as odds ratio (OR) and 95% CI, with statistical significance established at 0.05.

4.3 Results and Discussion

4.3.0 Multivariable regression analysis of factors influencing access to improved water sources

The multivariate regression analysis, a comprehensive examination of factors influencing access to improved water sources, showed significant associations between environmental, systemic, and individual variables and the outcome of drinking water access levels (Table 4.4).

Table 4.4: Bivariate and multivariable logistic regression results of dependent and independent variables

Independent Variables	Bivariate analysis				Multivariable analysis		
	Odds Ratio	95% C.I.for EXP(B)			Odds Ratio	95% C.I.for EXP(B)	
		Lower	Upper			Lower	Upper
Environmental Variables							
Average Rainfall Range	0.995 *	0.994	0.995		1.012 *	1.005	1.019
Average Maximum Rainy Days in a Month	0.794 *	0.769	0.820		0.845 *	0.734	0.974
Average Minimum Rainy Days in a Month	0.962 *	0.953	0.971		0.665 *	0.596	0.742
Location of Residence							
Rural (ref)	1.00				1.00		
Urban	4.187 *	3.818	4.593		1.469 *	1.233	1.750
Time to get to water source	1.001 *	1.001	1.001		1.000 *	1.000	1.001
Ecological Zone							
Transitional Zone (ref)	1.00				1.00		
Evergreen Zone	0.946	0.833	1.074		18.901 *	6.800	52.537
Savannah Zone	1.217 *	1.105	1.340		0.248 *	0.136	0.449
Deciduous Forest Zone	1.310 *	1.175	1.460		2.982 *	1.711	5.198
Coastal Savannah Zone	2.197 *	1.935	2.494		5.263 *	2.974	9.314
Systemic Variables							
Religion							
No Religion (ref)	1.00				1.00		
Christian Religion	1.734 *	1.501	2.005		1.233	0.914	1.663
Islamic Religion	2.244 *	1.907	2.641		1.154	0.796	1.671
Traditional Worshippers	1.557 *	1.259	1.924		3.024 *	1.684	5.431
Occupation							
Unemployed (ref)	1.00				1.00		
Formal Work	1.320 *	1.142	1.525		1.070	0.852	1.343
Informal Work	0.452 *	0.396	0.517		0.802 *	0.643	1.000
Income Status							
Poor (ref)	1.00				1.00		
Rich	7.769 *	7.003	8.620		6.875 *	5.748	8.223
Health Insurance Coverage							
Health Insurance: Yes (ref)	1.00				1.00		
Health Insurance: No/Unsure	0.635 *	0.591	0.682		0.982	0.862	1.119
Ethnicity							

Ethnicity: Other (ref)	1.00			1.00		
Akan	1.075	0.791	1.461	0.675	0.280	1.631
Ga/Dangbe	0.607 *	0.435	0.848	0.173 *	0.070	0.428
Ewe	0.532 *	0.389	0.730	0.418 *	0.172	1.020
Guan	0.451 *	0.318	0.640	0.362 *	0.145	0.907
Mole-Dagbani	1.005	0.737	1.369	0.734	0.298	1.806
Grusi	1.176	0.822	1.683	0.906	0.347	2.365
Gurma	0.300 *	0.219	0.411	0.339 *	0.135	0.847
Mande	0.647 *	0.423	0.991	1.542	0.453	5.251
Individual Variables						
Household Size						
7+ members (ref)	1.00			1.00		
1-3 members	2.550 *	2.272	2.863	1.461 *	1.191	1.793
4-6 members	1.770 *	1.641	1.909	1.273 *	1.104	1.467
Age of Household Head						
15-24 years (ref)	1.00			1.00		
25-34 years	0.741 *	0.661	0.831	1.064	0.835	1.355
35-49 years	1.224	0.763	1.963	0.913	0.715	1.165
Having Pregnancy						
Yes (ref)	1.00			1.00		
No/Don't know	1.566 *	1.383	1.775	1.864 *	1.496	2.323
Sex of Household Head						
Female (ref)	1.00			1.00		
Male	0.547 *	0.502	0.598	0.782 *	0.668	0.916
Number of Women in Household						
1-2 women (ref)	1.00			1.00		
3-4 women	0.741 *	0.661	0.831	1.206	0.921	1.578
5+women	1.224	0.763	1.963	144	0.000	0.0
Breastfeeding						
No (ref)	1.00			1.00		
Yes	0.770 *	0.715	0.828	1.050	0.912	1.210
Household Means of Transport						
No (ref)	1.00					
Yes	0.937	0.874	1.006			
Access to Media						
No (ref)	1.00			1.00		
Yes	1.679 *	1.556	1.811	0.844 *	0.730	0.976
Marital Status						
Ever Married (ref)	1.00			1.00		
Never Married/Single	0.613 *	0.499	0.754	1.010	0.742	1.374
Married	0.497 *	0.400	0.616	0.672 *	0.493	0.916
Educational Status						
Uneducated (ref)	1.00			1.00		
Educated	2.150 *	1.936	2.386	1.212 *	1.069	1.373

Note: *Significance level is at 0.05; Ref: Reference category; C.I: Confidence Interval

4.3.1 Environmental factors and access to improved water sources

The geographical and seasonal distribution of rainy days and rainfall amounts are uneven across Ghana. The Northern, Upper East and Upper Regions, record the lowest annual rainfall, minimum rainfall and minimum number of rainy days compared to the other regions. Generally, water availability is higher in the south than in these regions. The findings show that a unit increase in average rainfall range was associated with access to improved water sources [OR 1.012; 95% CI (1.005 – 1.019)]. Conversely, a unit increase in average maximum rainy days in a month [OR 0.845; 95% CI (0.734 – 0.974)] and average minimum rainy days in a month [OR 0.665; 95% CI (0.596 – 0.742)] decreased access to improved water sources. Decreased access associated with increased number of rainy days in a month may seem counter intuitive. However, areas with increased precipitation frequency and intensity may have difficulty managing excess water. It can be lost to runoff or result in damage to water facilities and degradation of surface water sources. The Greater Accra Region in the coastal savannah zone, in particular, is prone to flooding (Atakorah et al. 2023; Dekongmen et al., 2021). In contrast, areas with lower average minimum rainy days annually, such as the northern regions, may experience longer periods between rainfall events, leading to poor groundwater recharge and reduced river flows (Adaawen, 2021; Fiasorgbor et al., 2018; Yiran & Stringer, 2016). According to the IPCC, by 2050, mean temperature in Ghana is expected to rise between 1.0°C and 3.0°C (IPCC, 2023), with the northern regions, which are drier, experiencing a faster rate of warming compared to coastal areas (Stanturf et al., 2011). This underlines the importance of proactive measures to address the impact of climate change on water resources when improving water access in Ghana.

These disparities in access are further compounded by ecological variations, with some regions enjoying better access to clean water due to broader environmental contexts. Households in the evergreen zone [OR 18.901; 95% CI (6.800 – 52.537)], coastal savannah zone [OR 5.263; 95% CI (2.974 – 9.314)], and deciduous forest zone [OR 2.982; 95% CI (1.711 – 5.198)] were identified to have higher odds of accessing improved water sources than those in the transitional zone, except households in the savannah zone, a semi-arid and less developed region [OR 0.248;

95% CI (0.136 – 0.449)]. For instance, the savannah zone has a mono-modal annual rainfall regime and high evaporation rates (Bessah et al., 2021a), which have significant implications for groundwater sources, the primary source of drinking water for most households in the region (Forkuor et al., 2013).

Findings also confirm the significant influence of the location of residence on access to improved water sources. Urban households [OR 1.469; 95% CI (1.233 – 1.750)] were found to have higher odds of accessing improved water sources than rural households. This is understandable because urban-biased development policies contribute to disparities in access to improved drinking water between urban and rural areas, such as the reported differences between Accra and Kumasi and other regions of Ghana (Dosu, 2021). The lack of political will and accountability, as well as poor rural infrastructure, contributes to the poor improved water access among rural inhabitants (Collaborative Africa Budget Initiative, 2019; Kokutse, 2009).

Interestingly, amidst these complexities, the study reveals a correlation between increased travel time to water sources and improved access among households [OR 1.00; 95% CI (1.000-1.001)]. While not yet confirmed in the literature, women may choose to travel further to obtain better quality water. While not the same context, women have been documented to travel further after flood events to obtain water from unaffected sources (Castañeda Carney et al., 2020; van Daalen et al., 2022).

4.3.2 Systemic and structural factors and access to improved water sources

The intersection between drivers and their interactions at different scales can impact improved drinking water access. Disparities in access are evident across ethnic groups, with some groups having better access than other. Findings of this study showed that households belonging to Ga/Dangbe [OR 0.173; 96% CI (0.070.-0.428)], Ewe [OR 0.418; 95% CI (0.172-

0.1.020)], Guan [OR 0.362; 95% CI (0.145-0.907)], and Gurma [OR 0.339; 95% CI (0.135-0.847)] ethnic groups had lower odds of accessing improved water source than other ethnic groups. Identifying as Akan, Mole-Dagbani, Grusis, and Mande was not statistically significant in the model. Socioeconomic status varies across these ethnic groups. Ethnic groups with lower access to education may be associated with lower socioeconomic status, as additional analyses indicate (Supplementary file 2, Appendix V). Whether because of ethnicity, region, or type of community, unequal distribution or allocation of access to resources, opportunities, and privileges shape access to basic social infrastructure, including drinking water access (Armah et al., 2018; Mulenga et al., 2017). Such disparities are magnified by endemic low education and high poverty levels among ethnic groups in different regions in Ghana as well as within districts (Ghana Statistical Service, 2015), exacerbating challenges related to water access and security.

Systemic factors influencing improved drinking water access extend to religion and its interplay with ethnicity. The study reveals that households that belonged to the traditional religion [OR 3.024; 95% CI (1.684-5.431)] were more likely to access improved water sources than households that did not belong to any religion. Christian and Islamic religions were not significantly associated with access to improved water sources. Religion can be associated with ethnicity, but religious practices historically align with health protection activities (Attum et al., 2018). Educational attainment among religious leaders can influence access to improved water sources (Mallonee et al., 2018). Educated religious leaders may possess greater awareness of the importance of clean water and sanitation, leading them to engage in awareness-raising campaigns, encouraging their members to use improved water for domestic purposes and religious activities, such as ablution (Huong et al., 2020; Mallonee et al., 2018). However, religion is not always significantly associated with access to improved water and sanitation, as demonstrated in a case study in Côte d'Ivoire (Angoua et al., 2018). In some rural communities in Ghana, chiefs determine access to water resources and water collection methods (Chew et al., 2019). They impose cultural norms concerning which water points water collectors can visit and on which days (Anokye, 2013).

In this study, occupational status was found to significantly influence improved water access. Individuals who engaged in informal work [OR 0.802; 95% CI (0.643 - 1.000)] had lower odds of accessing improved water sources compared to the unemployed. However, formal work was not significantly associated with access to improved water sources. Other studies similarly revealed that informal workers are less likely to have access to improved water supplies (Irianti et al., 2016; Oskam et al., 2021). Low wages and the time invested in seeking and undertaking this necessity-driven employment (Williams & Gashi, 2022) may reduce time available for water collection, especially when acquiring water involves significant time expenditures. Restricted choices and physical segmentation of the labour market, especially in low-income countries, may trap people in poverty. Data for this study show that almost 80% of those employed in the informal economy were poor (Supplementary file 2, Appendix V), demonstrating how this may affect access to improved water sources.

Similarly, household income status emerged as a critical determinant, with high-income households [OR 6.875; 95% CI (5.748 – 8.223)] having significantly higher odds of accessing improved water sources compared to their low-income counterparts. The odds of using improved water sources were six times higher among high-income bracket households than low-income bracket households, which was expected. There is ample evidence indicating that low-income households, including those in urban centres, are poorly served with public utilities and have access to poor quality and insufficient water (Enqvist & Ziervogel, 2019; Mitlin et al., 2019).

Thus, poverty, coupled with inadequate government support, increases the likelihood of using unimproved water sources such as rivers and dams for drinking, cooking, and personal hygiene. In South Africa, being unable to afford formal water supplies has been associated with "increasing household debt, widespread water service cuts, citizen unrest and cholera epidemics" (Francis, 2005; p.170).

4.3.3 Individual characteristics and access to improved water sources

Alongside environmental and systemic factors, individual-level variables play a significant role in determining access to improved water sources. Notably, the study highlights the importance of household size in shaping access to clean water. Households with 1 to 3 members [OR 1.461; 95% CI (1.191 - 1.793)] or 4 to 6 members [OR 1.273; 95% CI (1.104 - 1.467)] were more likely to have access to an improved water source than households with at least seven members. This finding has also been replicated in other studies elsewhere (Armah et al., 2018; Simelane et al., 2020). While evidence is increasing with respect to the association between larger household size and poor access to improved or clean water sources (Fotuè, 2013), other studies found no significant relationship between household size and water access (Adams et al., 2016; Rahut et al., 2015; Oskam et al., 2021). De Sherbiniin and colleagues (2009) report that increasing household size is associated with accessing improved or clean water sources. Large households may have more members to share water collection duties, including traveling long distances to access improved water sources (De Sherbiniin et al., 2009), or the increased number of people may create too high a water demand on the water fetchers in the family. However, large household sizes coupled with low socio-economic status may be unable to afford the absolute higher water volumes required over smaller households when provided through public utilities. Even when accessing water sources outside the home, larger numbers of people to account for in the home require larger volumes that will increase absolute time spent collecting water. In this study, 75% of households with at least seven members were poor compared to 34% of households with 1-3 members and 49% of households with 4-6 members (Supplementary file 2, Appendix V).

Similarly, households without pregnant women [OR 1.864; 95% CI (1.496 – 2.323)] had higher odds of accessing improved water sources than households with pregnant women, but breastfeeding status of mothers was not significant, suggesting that care of young children does not factor into whether the primary drinking water source is improved or unimproved. Pregnancy can create short-term difficulties accessing water, particularly in the latter stages of pregnancy (Jeil et al., 2020; Pommells et al., 2018; Wrisdale et al., 2017), which may be why this study found that at the time of survey, households with pregnant women were less likely to access improved drinking water sources. Given that only 7% of households reported a pregnant woman in the house, these findings need to be interpreted carefully given data skew.

Households headed by males [OR 0.782; 95% CI (0.668-0.916)] were less likely to access improved water sources compared to those headed by females, but age of household head did not affect level of access. In Ghana, approximately 72% of educated households fall into the highest income category, and 57% are employed in formal occupations (Supplementary file 2, Appendix V). Female-headed households are richer than male-headed households (60% versus 39%, respectively) (Supplementary file 2, Appendix V). This may explain why female-headed households are more likely to access improved drinking water sources than male-headed households, a finding that aligns with several studies (Armah et al., 2018; Morakinyo et al., 2015), but not with others (Bisung & Elliot, 2018; Simelane et al., 2020). Higher education levels in women have also been linked to improved health practices in households due to their traditional caregiving and domestic roles (Bellés-Obrero et al., 2023; Miller et al., 2017), which would likely include household water management (quantity and quality) when possible. Conversely, the absence of a wife or woman in a household has been shown to decrease the likelihood of accessing clean water (see Anguoa et al., 2018).

Furthermore, the educational status of households was a crucial factor in determining access to improved water sources. Unsurprisingly, educated households [OR 1.212; 95% CI (1.069-1.373)] had higher odds of accessing improved water sources than uneducated households. This is understandable because access to education typically translates into better paid jobs and higher incomes to enable people to pay for drinking water services (Antunes & Martins, 2020). Previous scholarship has emphasized the significant positive relationship between educational attainment and the probability of accessing improved water sources (Armah et al., 2018; Mahama et al., 2014; Morakinyo et al., 2015). The relationship between education and access to improved water sources may be influenced by religious beliefs or spirituality (Martin et al., 2021; Smith & Ali, 2006). In some cultural and religious communities, education is prioritized, which may lead to increased literacy rates and improved access to water sources (Huong et al., 2020; Mallonee et al., 2018). Conversely, religious beliefs and practices may restrict educational opportunities, particularly for women and girls, which can result in lower school enrollment and literacy rates (Iqbal et al., 2022; Udoh et al., 2020). While Christian institutions such as catholic schools in Ghana have played a crucial role in providing quality education (Brian, 2020), other religious groups may impose norms and practices that impede female educational participation and achievement (Frimpong, 2022; Nartey et a., 2023). This can exacerbate disparities in access to improved water sources.

Additionally, this study reveals an intriguing trend; households with access to media (listened to radio, watched television or read a newspaper or magazine) [OR 0.844; 95% CI (0.730-0.976)] were less likely to access improved water sources compared to those without media access. This finding is counterintuitive since it was anticipated that access to media would significantly contribute to improving access to improved water sources through education programs. It is crucial to note that media access, especially television, may be associated with higher wealth or socioeconomic status. While media access may appear to correlate with lower access to improved water sources, this relationship could be confounded by wealth-related factors. One possible explanation for the limited impact of media on water-related programming, such as discussions about improved water sources, is that households with media access may not be influenced by the content they receive. However, this does not negate the potential of media to educate individuals about safe water consumption and shape their preferences. Contrary to initial analysis (bivariate analysis), multivariable analysis showed an inverse relationship between media access and the use of improved water sources. This suggests that other variables may have influenced the relationship. Therefore, it is not surprising that this study's findings differ from others that suggest media access improves clean water access. Despite these findings, further research is needed to understand the role of news media in improving water access in Ghana and sub-Saharan Africa.

Also surprisingly, married people [OR 0.672; 95% CI (0.493-0.916)] had lower odds of accessing improved water sources than ever-married people although this relationship has been identified in another study (Oskam et al., 2021). Never married/single status was not significantly associated with water sources. This difference in access could be linked to households' socioeconomic status, as ever-married people (67%) were richer than married people

(47%) (Supplementary file 2, Appendix V). Another factor could be household size, as only 15% of married couples had 1-3 members, while 51% had 4-6 members and 24% had at least seven members. In contrast, 44% of ever-married people were in 1-3 member households and 43% in 4-6 member households versus 13% in households of seven or more (Supplementary file 2, Appendix V). Other studies (e., g, Irianti et al., 2016) contradict these findings, underscoring complexities, but also raising questions regarding how marital status is defined and cultural acceptance of different statuses.

Collectively, individual and structural factors can represent low adaptive capacity that, coupled with environmental variables, could adversely affect water availability, water access, and human livelihoods (Frumhoff et al., 2015). These local and zonal disparities in drivers that are related to poor water access highlight that: 1) all ecological zones and localities must be given equal attention regarding water access coverage and efforts to improve universal and equitable access to safely managed drinking water; 2) recognition and alleviation of resource constraints requires prioritization of the savannah and transitional zones; 3) rural and remote communities deserve more attention in efforts to improve equitable access to improved water sources; 4) pro-poor and poverty alleviation strategies need to be embedded in policies and in practice; 5) creating and increasing access to employment opportunities could help people become self-sustaining and significantly increase their access to improved drinking water; 6) dismantling socioeconomic inequalities and discriminatory socio-cultural structures and barriers; 7) religious leaders and institutions as well as community leaders need to be engaged in increasing awareness of the importance of accessing improved water for drinking and other domestic activities and how to improve drinking water supplies; 8) investing in and improving access to high-quality education is foundational; While prudent to improve equitable access to improved water sources for all, the most disadvantaged groups should be prioritised and targeted for interventions in situations where this is not possible.

4.4 Strengths and Limitations

Understanding of water inaccessibility has improved in recent decades. However, this is the first known study to apply a coupled systems framework to investigate drivers of drinking water access in Ghana. As such, the study augments and complements previous scholarship, providing a critical route to understanding better the drivers of drinking water access. It also contributes to policy formulation. Recognizing that drivers of drinking water access are diverse, complex and multi-faceted, operating at different frequencies and time scales, it will offer policymakers and stakeholders directions to design solutions to mitigate access challenges.

Despite the strengths of this study, some weaknesses are worth acknowledging. First, because of the study's cross-sectional nature, the results must be interpreted with caution; causality between the dependent and independent variables cannot be established. Second, desirability bias may have been encountered during the data collection phase, as participants may have misreported their background information such as age, income status, and educational levels. Similarly, there may have been the problem of recall bias, as participants were expected to provide information on some variables such as income and household size. All these can have a significant effect on the impact of the explanatory variables on the response variable.

Furthermore, the survey was designed in English and interpreted in the local dialects for some participants who could neither speak nor understand English. This could have affected the original meaning of issues and consequently affect the data produced. Finally, the use of the word “improved water” does not imply clean or safe water. In many rural and poor urban areas, where infrastructure and sanitation problems are pervasive and persistent, improved water sources are at risk for contamination from human and animal excreta and agricultural and industrial waste. Water quality test data from Ethiopia and Nigeria revealed that several "improved" water sources did not meet the safety standards (Gule et al., 2023; Harmon, 2012). Moreover, this study only explores association and not causality, even though the framework has inferred causality. Regardless of these limitations, this study has generated evidence-based results on drivers of drinking water access in Ghana that require the attention of Ghanaian scholars and policymakers.

4.5 Conclusions

Inequalities in accessing improved water sources among Ghanaian households are rooted in environmental, systemic, and individual factors. The goal of this study was to apply a new conceptual framework that connects multiple and mutually reinforcing factors contributing to these disparities, enriching our understanding of access inequities. In doing so, it contributes to increasing clarity regarding the drivers influencing drinking water access and their respective significance as well as relationships requiring additional research. Environmental conditions, exacerbated by climate change, play a crucial role in creating geographical disparities in access. Addressing climate change impacts is vital for safeguarding water resources and access. Systemic barriers connected to socioeconomic conditions and geographic inequality significantly contribute to water insecurity. Income distribution disparities affect access to improved water sources, emphasizing the need for equitable resource distribution and increased employment opportunities. Policymakers should prioritize evidence-based efforts in both rural and urban areas to reduce these disparities. Individual characteristics, particularly education, influence access to improved water sources, highlighting the need to improve educational attainment and address individual experiences to ensure universal access to improved water sources. Overall, addressing the gaps in improved water access requires multi-sectoral policy frameworks that acknowledge the complexity of the social-ecological system and the necessity for comprehensive solutions across all sectors and levels.

CHAPTER FIVE

Preamble

Chapter 5 examines the burdens rural women in a small community in northern Ghana face regarding water-collection, which demands scholarly and policy attention. This chapter presents the results and discusses the findings, which explain the various factors contributing to the inaccessibility of water among rural women and emphasizes the implications of these factors for their health and well-being. This investigation revealed that a combination of environmental factors (such as seasonality and distance to water sources), systemic factors (such as poverty), and individual factors (such as poor health) collectively impede water access and retrieval. These challenges expose rural women to various vulnerabilities and security threats, including physical and psychological injuries as well as economic hardships. In addition, this study revealed the intertwining of individual challenges related to water issues, resulting in sustained water insecurity and compounded retrieval difficulties. This aligns with existing research on the gendered consequences of women's water-collection responsibilities, providing empirical and theoretical support for established theories and hypotheses. This study further expands the literature by offering a fresh perspective on the intersecting consequences that women face. This narrative presents a novel finding that has yet to be replicated in previous studies, underscoring women's sustained water inaccessibility and heightened challenges when collecting water from distant sources. In this academic endeavour, Chapter 5 delves into the nuanced complexities of rural women's water-collection responsibilities, presenting a condensed yet comprehensive narrative that identifies challenges, while highlighting the resilience of these women. This academic endeavour calls for reconsidering policies and interventions to address this pressing issue effectively, in line with the Sustainable Development Agenda.

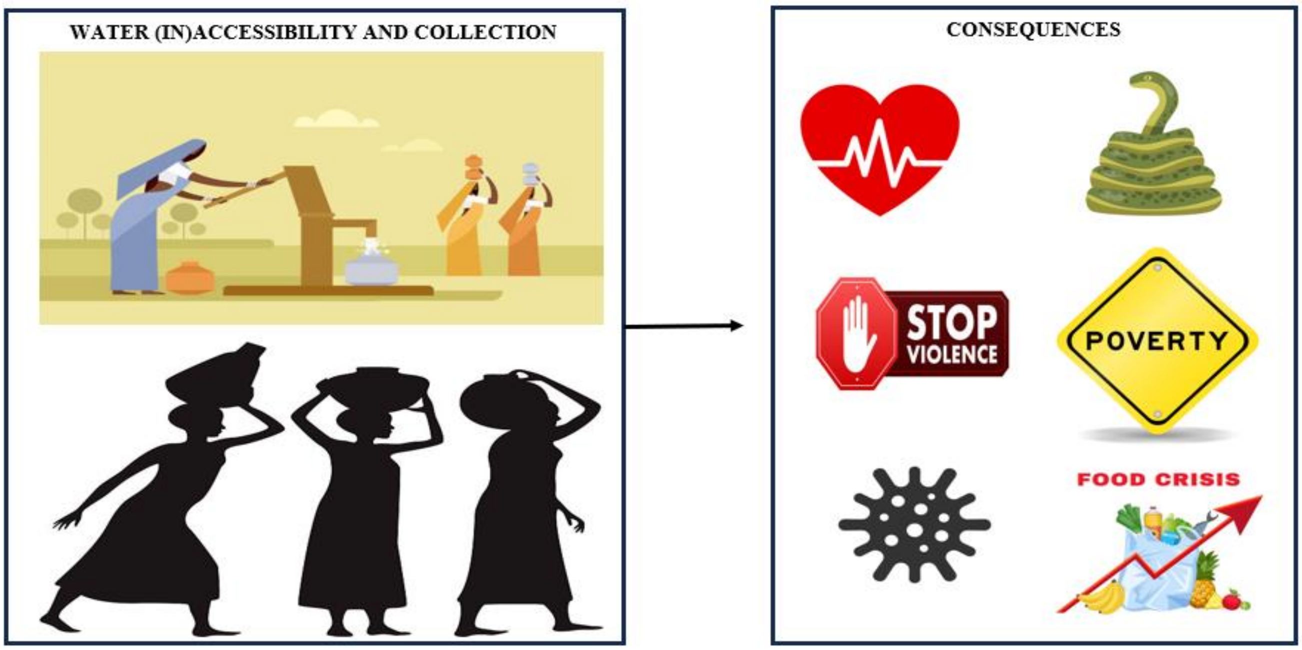
Manuscript #3: Exploring the experiences of the overburden of water collection responsibility of rural women in Ghana

Apatinga, G. A., Schuster-Wallace, C. J., & Dickson-Anderson, S. E. (2024). Exploring the experiences of the overburden water collection responsibility of rural women in Ghana (Accepted with minor revisions-Journal of Water and Health)

Abstract: Despite evidence emphasizing women's responsibility for collecting water in sub-Saharan Africa, more needs to be known about the gender-specific consequences of this obligation, especially in rural Ghana, where water inaccessibility is a persistent issue. Employing a community-based case study, this research aimed to explore the gendered consequences of women's water collection responsibility, using a coupled systems framework. Data were gathered from surveys and focus groups and analyzed statistically and thematically, respectively. Key findings highlighted intersecting influences in women's water access and collection difficulties, including distance to water sources, poverty, and health issues. Results revealed that over 50% of women experienced multiple consequences, including physical and psychological injuries (>80%), animal attacks (≤12%), spousal violence (>40%), nutritional challenges (>30%), hygiene problems (>40%), and socioeconomic issues (>50%). Over half faced three to seven intersecting water-related consequences, which intensified their difficulty in accessing and collecting water. Differences were observed across sub-communities. Interestingly, not all men had knowledge of these consequences, highlighting the crucial need to broaden their understanding as part of the solution to ease women's burdens. Addressing sociocultural norms and the various factors influencing access through effective and gendered water management and planning is imperative to alleviate women's burdens and improve equitable access.

Keywords: water access, water collection, gender, women, Ghana, Africa, SDG6: clean water and sanitation

Graphical Abstract



5.1 Introduction

Water inaccessibility characterized by inadequate access to affordable, reliable, and safe water (Jepson et al., 2017), impacts over 30% of sub-Saharan Africans, with rural inhabitants disproportionately affected by chronic underservice and a lack of sustainable water infrastructure (UNICEF & WHO, 2023). In 2020, only 41% of Ghanaian households had access to safely managed water, with significant disparities between rural and urban areas and across different regions (WHO & UNICEF, 2021). Evidence underscores that access to safely managed water is below 50% for rural dwellers (Dongzagla et al., 2022; UNICEF & WHO, 2023).

Studies have highlighted the consequences of water inaccessibility and the associated task of water collection beyond disease and mortality risks (Asoba et al., 2019; Cole et al., 2024; Geere et al., 2018; McDonald et al., 2019; Sorenson et al., 2011). Additional concerns include violence risks, animal attacks, nutritional deficiencies, psychological issues, musculoskeletal pain, and economic losses (Choudhary et al., 2020; Geere et al., 2018; McDonald et al., 2019; Miller et al., 2024; Venkataramanan et al., 2020). These findings emphasize the need for improved tools and programs to ensure equitable water resource distribution and achieve the Sustainable Development Goal 6 (Water and Sanitation) in support of other goals, such as Gender Equality (SDG 5).

Some studies have examined the gender consequences of water inaccessibility and long-distance water collection for (rural) women in Ghana (Ahiabli et al., 2023; Archer, 2005; Achore & Bisung, 2022; Jeil et al., 2020; Nordström & Widman, 2022). However, further empirical research is required to provide a comprehensive understanding and additional insights into the disproportionate domestic water-supply burden consigned to rural women. In Ghana, like most patriarchal African cultures and societies, gendered division of labour and power imbalances are perpetuated (Alaci et al., 2013; Jeil et al., 2020). Women have a disproportionate responsibility for water and must collect water to maintain social acceptance, while men hold wage earning responsibilities and (economic) power in households (Alaci et al., 2013; Jeil et al., 2020). These gendered divisions of labour and expectations drive women and men to engage in activities that align with their socially constructed identities and conform to prevailing gender norms (Cerrato & Cifre, 2018; Owoo & Lambon-Quayefio, 2021). As a result, women acquire and distribute water for household use, while men benefit from the advantages conferred by the patriarchal system (Graham et al., 2016; Jeil et al., 2020; Van Houweling, 2016).

Compounded by patriarchal systems and structures, rural women face significant challenges in accessing and collecting water due to the lack of piped water systems in their homes, inadequate water facilities, and the persistent failure of rural water projects (Alaci et al., 2013; Dongzagla et al., 2022; Jeil et al., 2020). Most of these women endure difficult journeys, traversing long distances through challenging terrains and venturing to water sources at night to avoid lengthy queues (Alaci et al., 2013; Jeil et al., 2020). This precarity may further be aggravated and long-lasting considering the already vulnerable status these women hold as the poorest of the poor (Aluko & Mbada, 2020; Jerumeh, 2024; Issahaku, 2018), which may hinder their ability to cope with and recover from water-related stress and shocks.

Addressing the need for improved water access and reducing vulnerabilities related to water inaccessibility, including gender-related threats, necessitates a comprehensive understanding of rural women's burden in water collection responsibilities, as captured in scholarly accounts (Choudhary et al., 2020; Geere et al., 2018; Miller et al., 2024; Venkataramanan et al., 2020). To this end, this research employed a community-based case study to explore factors influencing women’s difficulties in accessing and collecting water off-premises as well as the ensuing health and economic consequences. The aim is to make valuable contributions towards the development of an integrated and cross-sectional intervention models focused on ensuring sustainable water security in rural areas in Ghana, while advancing knowledge on the gender dimensions of water access and collection. Ultimately, this will aid in empowering women and planning gender-sensitive interventions needed to achieve SDG 6 – universal and sustainable access to safely managed drinking water.

5.2 Methods and Data

This study design is based on a coupled systems framework, designed to address water inaccessibility in rural sub-Saharan Africa, specifically focusing on gender and climate considerations (Apatinga et al., 2022). The framework highlights the interconnected nature of environmental, systemic, and individual elements that affect access to drinking water as well as the interplay between coping strategies in response to lack of access and the associated consequences. The study was conducted in Kologo in the arid Upper East Region in the savannah ecological zone of Ghana between August and October 2022. Kologo is an impoverished rural community in the Kassena-Nankana East Municipality, which is known for chronic water shortages. It is located approximately 25 minutes drive from the municipal capital - Navrongo. The Nankani-speaking people make up the majority of the community and has a diverse population of Christians, Muslims, and traditional worshippers. Kologo faces extreme water insecurity, with limited social amenities and infrastructure, including water facilities. Agriculture is the primary economic activity in the community, and literacy levels are generally low. Access to piped water is challenging due to poverty and high connection costs, leading households to rely on water sources such as boreholes, rainwater, and (un)protected dug wells. Water scarcity worsens during the long dry season.

The community consists of three sub-communities: Kolwingo, Nayiire, and Zuo (located in the savannah ecological zone). Kolwingo is the first area encountered when entering Kologo, known for its dispersed settlements and market square. Residents engage in subsistence and small-scale commercial farming. Kolwingo has one basic school and one dam, with social structures characterized by extended families and communal living. Water insecurity is a significant issue, with few boreholes and unprotected wells far from homes.

Nayiire, the second subdivision, is the residence of the chief, hence its name meaning "chief's area." It shares similarities with Kolwingo and Zuo in terms of agrarian economy, dispersed settlements, traditional practices, and communal living. Nayiire has a basic school, a health center serving all of Kologo, and a dam used for dry-season farming. However, this dam depletes during the dry season and is prone to breaches. Water facilities are limited, with a difficult-to-access community water tank and few boreholes.

Zuo is about a 20 to 25-minute walk from Nayiire, sharing characteristics with Kolwingo and Nayiire such as agricultural economy, extended families, scattered settlements, and communal living. Zuo has one basic school but no dam, relying on dams in Kolwingo and Nayiire for dry-season farming. It preserves the cultural heritage of Kologo through its practices and traditions, with few strategically placed boreholes for water access.

Water insecurity in Kologo is an issue of significant concern, making it a suitable location for documenting the consequences of water scarcity and distant water collection on women. A community meeting was conducted with the Chief and elders to explain the study's purpose, address questions, and seek permission. After gaining approval, the research team spent time establishing relationships within the community prior to conducting the research.

5.2.1 Research design and ethics

This study adopted a mixed-methods approach, blending quantitative and qualitative methods in a convergent parallel design. Ethics approval was secured from the University of Saskatchewan Behavioural Research Ethics Board (Beh-REB#2711), McMaster Research Ethics Board (MREB#5809), and the University of Ghana Ethics Committee for the Humanities (ECH355/21-22). Participants had to meet specific criteria; being adults aged 18 or above, residing in the community for at least one year, and providing consent. Consent was obtained via signature, thumbprint, or verbal agreement.

5.2.2 Survey data and analysis

The study involved community members from the three sub-communities in Kologo. Equal numbers of men and women across each sub-community were recruited through posters and announcements in local dialect (Nankani). Fifty individuals, including both men and women, were randomly selected from each community using cluster sampling (Kologo is divided into three sub-communities). This resulted in a sample size of three hundred. The sample size was determined based on the population of the Kologo community, which is slightly over 2,000, with the goal of achieving representativeness of the population under study, while also considering factors such as time and resources. Trained research assistants (one man and one woman) conducted the survey in the local dialect. The survey design was grounded in the conceptual framework and questions covered participants' backgrounds, water sources, gender roles, health implications, and household responses to water scarcity. The survey contained detailed information on demographic and socio-economic variables, health variables, and water access. Explanatory variables representing environmental, systematic, and individual level factors were categorized according to the conceptual framework, ensuring alignment with the research objective and relevance to the phenomenon under study (Table 5.1). Difficulty accessing and collecting water was used as the main outcome or dependent variable (difficult or very difficult as none of the respondents identified other categories on the five-point Likert scale).

The selected independent and dependent variables were analyzed using SPSS version 21. Initially, a multicollinearity test was conducted using tolerance and variance inflation factor (VIF) to assess potential correlations among the independent variables (Chatterjee & Simonoff, 2013). This step was crucial to confirm that the variables were independent of each other, which is essential for accurate regression analysis outcomes. According to the tolerance (tolerance value less than 10% indicates severe multicollinearity) and VIF (VIF > 10 indicates severe multicollinearity) standards (Chatterjee & Simonoff, 2013), all variables demonstrated sufficient independence (Table 5.1).

Regression analyses were then conducted to explore and highlight potential relationships between the predictors and categorical response variables. Binary logistic regression models, reporting odds ratios and 95% confidence intervals, were employed to identify significant predictors of women's relative difficulty in accessing and collecting water. This approach was chosen because of the binary nature of the dependent variable. Statistical significance was set at a 5% level. Using the enter method in binary logistic regression, two multivariable logistic regression models were created to understand: (1) women's water collection experiences; and (2) men’s perceptions regarding women's water-collection experiences. The enter method effectively includes all key independent variables in the model to evaluate their joint influence on the dependent variable. It examines each predictor beyond what other variables in the model have already predicted, reducing biases by incorporating all variables, irrespective of their statistical significance. This method is particularly useful in logistic regression when researchers seek a straightforward and comprehensive method for examining the relationship between multiple predictor variables and a binary outcome. (Halinski & Feldt, 1970; Stevens, 2002; Gary, 2018; Thompson, 1989, 1995). The modeling process followed a hierarchical strategy, starting with environmental factors, then systemic variables, and finally addressing individual variables. This method allows for a comprehensive examination of various levels of influence on the dependent variable. By aligning with the adapted conceptual framework, this structured approach enhances interpretability and robustness, offering a well-defined path for the analysis of variables (Gary, 2018).

Additive scale analysis (De Mutsert et al., 2011) provided insights into cumulative water-related issues among women. To calculate the composite score in SPSS for identifying cumulative water-related challenges, the variables representing health challenges (e.g., physical injuries, psychological health issues), safety issues (e.g., animal attacks, spousal violence, quarrels at water sources), and nutritional and hygiene challenges (e.g., not cooking enough food, uncompleted household tasks) were summed together using a binary scale (yes and no). These variables were assigned values of 0 for "no" and 1 for "yes." For example, health challenges were calculated as the sum of physical health challenges and psychological health challenges related to water collection from alternative sources. Similar calculations were performed for the other categories. Descriptive statistics, including frequencies, were then computed to provide summary statistics. Additionally, cross-tabulations were conducted to understand how socioeconomic backgrounds influence water-related challenges.

Table 5.1: Description of dependent and independent variables

Variables		Collinearity Statistics (Independent Variables)	
Dependent variable	**Variable Description**	**Tolerance**	**VIF**

Difficulty accessing and collecting water	The extent of challenge women face when accessing and collecting water. It is categorized as: (i) difficulty and (ii) very difficult. (While respondents were given a 5-choice Likert scale, only these two were chosen)	N/A	N/A
Independent variables			
Environmental factors			
Community	Different sub-communities within the Kologo region. It is categorized as: (i) Kolwingo, (ii) Nayiire, and (iii) Zuo	73%	1.367
Time spent collecting water daily in a week in the wet season (minutes)	Self-reported amount of time women dedicate daily to water collection, measured weekly during the wet season (considered as a continuous variable).	23%	4.278
Time spent collecting water daily in a week in the dry season (minutes)	Self-reported amount of time women dedicate daily to water collection, measured weekly during the dry season (considered as a continuous variable).	23%	4.302
Systemic factors			
Occupation	The livelihood pursuits of participants during the data collection period. It is categorized as: (i) Farming, (ii) Trading/Business, and (iii) Formal or Skilled Work.	88%	1.136
Income rank	This variable characterizes the income range of participants, classified as: (i) Below Average, (ii) Average, and (iii) Above Average.	46%	2.142
Weekly income	The weekly monetary earnings of participants (considered as a continuous variable).	50%	1.973
Paying for water	Whether participants pay for water services. It is categorized as: (i) Yes and (ii) No	84%	1.180
Individual Factors			
Educational status	The educational attainment of participants during the data collection period. It is categorized as: (i) No Education, (ii) Primary Education, (iii) Secondary Education, and (iv) Beyond Secondary Education	69%	1.436
Age	Participants' age during the data collection period. It is categorized as: (i) 18-30, (ii) 31-50, and (iii) 50+	57%	1.755

Family size	Participants' family size during the data collection period (considered as a continuous variable)	77%	1.291
Health status	The health status of participants during the data collection period. It is categorized as: (i) healthy and (ii) unhealthy.	74%	1.347

Note: **VIF**: Variance Inflation Factor set at 10: N > 10 indicates multicollinearity
Tolerance: A value lower than 10% indicates significant multicollinearity

5.2.3 Focus group discussions and analysis

Participants were recruited using similar techniques as for the surveys. FGDs were held in each of the three sub-communities for young men or women (≤30), adult men or women (31-50), and older men or women (≥51). Led by a research assistant of the same gender, discussions focused on water access challenges and strategies, and were audio-recorded after securing participants' consent.

Thematic analysis was employed to analyze the transcribed FGDs, using NVivo 12. The coding process involved deductive coding based on the adopted conceptual framework and interview questions and inductive coding to capture additional emerging themes. Codes were organized into categories and sub-categories aligned with the study's objective. Themes were derived by synthesizing related categories and sub-categories, capturing patterns in the data. The themes underwent thorough review and refinement to ensure accuracy, coherence, and relevance to the study's objective. Findings were presented using these refined themes, supported by de-identified verbatim quotes from participants.

5.3 Findings & Discussion

5.3.1 Gender disparities in demographic distribution, socioeconomic status, and health

Women (50 from Kolwingo, 50 from Nayiire, and 50 from Zuo) and men (50 from Kolwingo, 50 from Nayiire, and 50 from Zuo) were equally represented in the sampled population across communities (Table 5.2). Family sizes were generally consistent across communities, with an average of at least five members per household. Educational attainment beyond the secondary level was higher among men than women and among men in Kolwingo (10%) than in Nayiire and Zuo (4%). Zuo had the highest percentage of individuals, both men (34%) and women (40%), without formal education.

At least half of respondents reported that their income was average compared to others in their sub-communities, with Nayiire women (72%) most likely to report average income, followed by Kolwingo (64%) and Zuo (60%). More men reported average income than women (Nayiire men-86%, Zuo men-78%, Kolwingo men-69%). Farming was the predominant occupation among respondents indicating its dominance as the primary livelihood source in Kologo. For example, the majority of Zuo men (96%), and women (70%) engaged with farming. Across genders, responses indicated that men reported better health than women. Further, across sub-communities, a larger percentage of Kolwingo women (86%) and men (90%) reported being healthy as compared to those in Nayiire (women 68%, men 88%) and Zuo (women 66%, men 84%). The socioeconomic disparities between genders in Kologo underscore the patriarchal structure of the community, favoring men while marginalizing women.

Table 5.2: Background information of participants

Variables	Kolwingo		Nayiire		Zuo	
	Women	Men	Women	Men	Women	Men
	Frequency (%) or Mean ± SD					
Community	50 (33.3)	50 (33.3)	50 (33.3)	50 (33.3)	50 (33.3)	50 (33.3)
Age						
18-30	22 (44)	12 (24)	19 (38)	11 (22)	17 (34)	3 (6)
31-50	20 (40)	27 (54)	20 (40)	30 (60)	16 (32)	25 (50)
50+	8 (16)	11 (22)	11 (22)	9 (18)	17 (34)	22 (44)
Educational Status						

No education	14 (28)	15 (30)	17 (34)	9 (18)	20 (40)	17 (34)
Primary education	28 (56)	18 (36)	21 (42)	28 (56)	26 (52)	28 (56)
Secondary education	8 (16)	12 (24)	11 (22)	11 (22)	4 (8)	3 (6)
Beyond secondary education	0 (0)	5 (10)	1 (2)	2 (4)	0 (0)	2 (4)
Family Size	5.94 ±2.477	6.12±2.51	6.26±2.686	6.50±2.33	6.74±2.126	5.26±1.67
Weekly Income	75.0±43.38	73.5±57.34	82.70±41.406	52.12±44.9	95.88±10.99	57.36±38.79
Income Rank						
Below average	14 (28)	5 (10.2)	9 (18)	5 (10)	7 (14)	5 (10.9)
Average	32 (64)	34 (69.4)	36 (72)	43 (86)	30 (60)	36 (78.3)
Above Average	4 (8)	10 (20.4)	5 (10)	2 (4)	13 (26)	5 (10.9)
Occupation						
Farming	28 (56)	33 (66)	30 (60)	40 (80)	35 (70)	48 (96)
Trading/Business	17 (34)	6 (12)	15 (30)	4 (8)	11 (22)	1 (2)
Formal/Skilled work	5 (10)	11 (22)	5 (10)	6 (12)	4 (8)	1 (2)
Health Status						
Healthy	43 (86)	45 (90)	34 (68)	44 (88)	33 (66)	42 (84)
Unhealthy	7 (14)	5 (10)	16 (32)	6 (12)	17 (34)	8 (16)
Water sources and use patterns						
Pay for water						
Yes	5 (10)	4 (8)	9 (18)	1 (2)	1 (2)	0 (0)
No	45 (90)	46 (92)	41 (82)	49 (98)	49 (98)	50 (100)
Improved water sources						
Pipe/Tape	4 (8)	4 (8)	9 (18)	0 (0)	1 (2)	0 (0)
Boreholes	30 (60)	41 (82)	33 (66)	43 (86)	50 (100)	42 (84)
Protected dug wells	2 (4)	7 (14)	1 (2)	3 (6)	0 (0)	3 (6)
Protected spring	0 (0)	1 (2)	0 (0)	6 (12)	0 (0)	2 (4)
Rainwater	21 (42)	41 (82)	37 (74)	18 (36)	32 (54)	6 (12)
Unimproved water sources						

Unprotected dug wells	30 (60)	6 (12)	15 (30)	11 (22)	22 (44)	16 (32)
Unprotected spring	1 (2)	4 (8)	0 (0)	4 (8)	0 (0)	0 (0)
Surface water	4(8)	0 (0)	4 (8)	0 (0)	0 (0)	0 (0)
Time collecting water daily in a week in the wet season (minutes)	111.90±63.53	----	130.70±56.78	----	139.80±51.52	**----**
Time collecting water daily in a week in the dry season (minutes)	171.30±84.71	----	172.50±60.47	----	169.0±52.77	**----**
Gendered roles in water collection: Perceptions, Challenges, and Shared Responsibilities						
Gender division of labour						
Yes	44 (88)	46 (92)	43 (86)	47 (94)	48 (96)	48 (96)
No	6 (12)	4 (8)	7 (14)	1 (2)	2 (4)	0 (0)
Don't know	0 (0)	0 (0)	0 (0)	2 (4)	0 (0)	2 (4)
Household decision-making						
Yes	19 (38)	30 (60)	6 (12)	12 (24)	2 (4)	6 (12)
No	31 (62)	20 (40)	44 (88)	38 (76)	47 (94)	42 (84)
Don't know	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	2 (4)
Equal participation in household decision-making						
Yes	39 (78)	44 (88)	40 (80)	40 (80)	35 (70)	41 (82)
No	11 (22)	6 (12)	10 (20)	3 (6)	15 (30)	5 (10)
Don't know	0 (0)	0 (0)	0 (0)	14 (7)	0 (0)	4 (8)
Water collection responsibility						
Man	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Woman	50 (100)	50 (100)	50 (100)	50 (100)	50 (100)	50 (100)
Who else collects water						
Other woman	10 (20)	----	8 (16)	----	3 (6)	----
Girl	16 (32)	----	20 (40)	----	26 (52)	----
Man	2 (4)	----	2 (4)	----	0 (0)	----
Boy	2 (4)	----	1 (2)	----	0 (0)	----

Difficulty accessing and collecting water*						
Difficult	19 (38)	21 (42)	16 (32)	29 (58)	16 (32)	28 (56)
Very difficult	31 (62)	29 (58)	34 (68)	21 (42)	34 (68)	22 (44)
Water collection in wet season						
<=30 minutes	6 (12)	----	2 (4)	----	0 (0)	----
>30 minutes	44 (88)	----	48 (96)	----	50 (100)	----
Water collection in dry season						
<=30 minutes	0(0)	----	0 (0)	----	0 (0)	----
>30 minutes	50 (100)	----	50 (100)	----	50 (100)	----

* no-one chose the lower three options on a 5-point Likert Scale

5.3.2 Water sources and use patterns

Data reveal the prevalent use of government-provided, free-of-charge communal borehole water facilities throughout the year, reported by 66% of Zuo women, 60% of Nayiire, and 60% of Kolwingo (Table 5.2). Men perceived borehole usage to be higher: 86% in Nayiire, 86% in Zuo, and 82% in Kolwingo. Notably, 98% of women in Zuo, 90% in Kolwingo, and 82% in Nayiire reported obtaining water without payment. FGDs supported survey findings, emphasizing the significance of boreholes, as expressed by respondents from all three sub-communities: *"We fetch from a borehole"* (Young Women, FGD, Kolwingo). This aligns with previous studies highlighting the prevalent use of boreholes or handpumps in rural areas (Fisher et al., 2015; Foster et al., 2018). However, women and men also reported scarcity of boreholes: *"We do not have boreholes"* (Adult Women, FGD, Kolwingo); "*One borehole serves about two or three sub-communities"* (Yong Men, FGD, Kolwingo); and *"The number of boreholes is limited"* (Adult Men, FGD, Nayiire).

Rainwater harvesting was also widely used according to survey responses, with 42% in Kolwingo, 74% in Nayiire, and 54% in Zuo reporting its use in the wet season. Nayiire women mentioned: *"Women harvest rainwater for use in the rainy season"* (Adult Women FGD, Nayiire), resonated by Nayiire men: *"Women also harvest rainwater for use"* (Young Men, FGD, Nayiire). The semi-arid climate prevalent in the area, characterized by unpredictable rainfall patterns and a scarcity of government-provided water infrastructure, emphasizes the importance of rainwater harvesting as a sustainable method of water supply. However, other improved sources such as piped/tap water, protected dug wells, and springs were not commonly identified as water sources. For example, only 9% of Nayiire, 8% of Kolwingo, and 2% of Zuo women reported piped or tap water use, with only men in Kolwingo (8%) recognizing that their households depend on piped or tap water. Chronic poverty within the communities worsens the restricted use of piped water, as it is only accessible to a small minority who can afford it.

As a result of chronic poverty and poor access to improved water facilities within the communities, respondents indicated the use of unimproved sources, particularly dug wells (Table 5.2). In Kolwingo, 60% of women reported using unprotected wells, followed by Zuo (44%) and Nayiire (30%). Men's responses corresponded with these patterns, but underreported usage, notably in Kolwingo (12%). Discussions within focus groups confirmed this reliance on unprotected wells across men and women and all sub-communities: *"We go to the wells sometimes"* (Young Women, FGD, Zuo) and *"In my household, we get water from a well"* (Adult Men, FGD, Zuo). Limited use of other unimproved sources like unprotected springs and surface water was also reported (Kolwingo and Nayiire-8%). The dispersed settlements underscore the challenges in accessing distant water facilities, exacerbating reliance on unimproved water sources. Other research highlights the simultaneous use of improved and unimproved water sources in rural areas due to inadequate infrastructure and frequent breakdowns (Chew et al., 2019; Foster, 2013; Foster et al.,2018).

5.3.3 Gendered roles in water collection

There is extensive evidence showcasing the unequal gender roles in domestic and community activities in patriarchal African cultures (Jeil et al., 2020; Owoo & Lambon-Quayefio, 2021), extending to water rights, use and control (Jeil et al., 2020; Van Houweling, 2016). Nearly all men (>90%) across all three sub-communities acknowledged gender disparities in household chores, corroborated by over 80% of women, reflecting societal recognition of these dynamics (Table 5.2). Decision-making aligns with this division, with men predominantly influencing financial matters while women reporting more control in household chores and childcare decisions. Although over 70% both men and women advocate for gender equality in decision-making, women's primary responsibility for water collection persists due to entrenched gender roles, as expressed in all men’s focus groups: *"Traditionally, a woman is born to fetch water"* (Young Men, FGD, Kolwingo).

Despite socioeconomic shifts challenging traditional roles, the prevailing societal norms still unevenly allocate domestic tasks. Water collection primarily falls on women, often involving girls collectively or on a rotating basis (Table 5.2). Zuo women predominantly (56%) receive support from girls in water collection, reiterated in FGDs: *"My daughter... helps me fetch water"* (Adult Women, FGD, Zuo). Men mainly collect water circumstantially, reinforced by statements like: *"When the woman is sick, the man has to go and fetch water"* (Adult Men, FGD, Kolwingo). Such sporadic men’s involvement, often stigmatized culturally, aims to maintain social approval, reinforcing men’s dominance within household dynamics (Asaba, 2013; Van Houweling, 2016).

The traditional duty of water collection, combined with decentralized water systems, burdens women, consuming significant time—often over 30 minutes daily (>80%) (Table 2), aligning with global rural water access challenges (WHO & UNICEF, 2021). This difficulty is echoed in women's and men's discussions in all sub-communities, highlighting the strenuous efforts to access clean water: *"It is not easy to fetch water because you have to suffer before you get water to fetch"* (Young Women, FGD, Nayiire); *"Women fetch water as their duty, so they have to endure a lot of pain"* (Adult Men, FGD, Zuo). Consistent with prior research (Apatinga et al., 2022; Van Houweling, 2016; Yillia et al., 2008), these findings underline the gender-based inequalities and burdens placed on women in water collection and access.

5.3.4 Factors influencing women's difficulty in accessing and collecting water

Multivariable analysis identified certain factors as statistically significant in explaining women's experiences with poor water access (Table 5.3). However, none of these variables were statistically significant when exploring men's perceptions of women's water access experiences. This demonstrates the disconnect between men as primary decision-makers and women as water purveyors in these communities.

Table 5.3: Multivariable regression analysis of factors influencing women's difficulty in accessing and collecting water

	Model 1: Women's Experiences		**Model 2: Men's Perceptions**
Explanatory Variables	**AOR with 95% CI**		**AOR with 95% CI**
Environmental Factors			
Community			
Kolwingo (ref)	1.0		1.0
Nayiire	1.32 (0.45, 3.84)		0.51 (0.21, 1.27)
Zuo	0.37 (0.11, 1.21)		0.43 (0.16, 1.12)
Time collecting water daily in a week in the wet season (minutes)	1.01 (0.99, 1.03)		----

Time collecting water daily in a week in the dry season (minutes)	0.99 (0.98, 1.00)		----
Systemic Factors			
Weekly Income	1.00 (0.99, 1.01)		0.99 (0.98, 1.00)
Income Rank			
Below average (ref)	1.0		1.0
Average	1.75 (0.48, 6.29)		1.23 (0.37, 4.04)
Above Average	4.48 (0.60, 33.32)		1.30 (0.25, 6.72)
Occupation			
Farming (ref)	1.0		1.0
Trading/Business	0.19 (0.07, 0.57) *		0.29 (0.04, 2.12)
Formal/Skilled work	0.53 (0.14, 2.04)		1.77 (0.43, 7.35)
Paying for Water			
No (ref)	1.0		1.0
Yes	0.07 (0.02, 0.34) *		3.78 (0.18, 80.68)
Individual Factors			
Age			
50+ (ref)	1.0		1.0
18-30	1.59 (0.33, 7.58)		1.21 (0.29, 5.06)
31-50	5.09 (1.18, 21.94) *		1.04 (0.41, 2.65)
Educational Status			
No education (ref)	1.0		1.0
Primary education	0.38 (0.12, 1.20)		0.42 (0.16, 1.09)
Secondary education	0.17 (0.04, 0.82) *		0.81 (0.23, 2.88)
Beyond secondary education	0.00 (0.00, 0.00)		0.18 (0.02, 1.33)
Family Size	0.86 (0.71, 1.04)		0.89 (0.75, 1.05)
Health Status (self-reported)			
Unhealthy (ref)	1.0		1.0
Healthy	0.25 (0.06, 0.97) *		2.55 (0.69, 9.46)
Note: * statistically significant at $p < 0.05$, Hosmer and Lemeshow test for women's model is 0.954; Hosmer and Lemeshow test for men's model is 0.707, AOR: Adjusted odds ratio, CI: Confidence interval; Ref or 1.0 is reference category			

5.3.4.1 Environmental factors

Evidence underlines the significance of environmental factors in water availability and access (Abu et al., 2021; Apatinga et al., forthcoming; Foster, 2013; Yillia et al., 2008). However, variables like community and time collecting water daily in a week in the wet and dry seasons lacked statistical significance in women's experiences (model 1) and men's perceptions (model 2). Despite this, earlier research highlights how these factors affect women's water access. Seasonal changes influence water availability and travel patterns (Kelly et al., 2018; Yillia et al., 2008). Rainfall can help, but also creates challenging muddy paths, as expressed in women's and men's focus groups in all sub-communities: "*In the wet season, paths are muddy and make carrying water difficult"* (Young Women, FGD, Kolwingo); *"A woman can slip and fall carrying water in the wet season"* (Young Men, FGD, Zuo). Conversely, dry seasons exacerbate scarcity: *"We get water from the wells in the rainy season, but they dry up in the dry season"* (Older Men, FGD, Kolwingo). The depletion of these wells is expected due to Kologo's climate, which features only a single, brief rainy season, coupled with limited groundwater recharge rate. These challenges align with earlier findings in Africa (Wilbur & Danquah, 2015; Wrisdale et al., 2017).

In addition, responses indicated that women often spend significant time in water retrieval (Table 2). Over 50% of women across communities spend more than thirty minutes collecting water in wet (Kolwingo-111.90±63.53, Nayiire-130.70±56.78, Zuo-139.80±51.52) and dry (Kolwingo-171.30±84.71, Nayiire- 172.50±60.47, Zuo-169.0±52.77) seasons, a sentiment echoed in women's and men's discussions: "*Time spent fetching water could help with work and money"* (Adult Women, FGD, Kolwingo); "*Women spend a lot of time fetching water"* (Adult Men, FGD, Kolwingo); and *"You can queue at the borehole for hours"* (Adult Women, FGD, Nayiire). As emphasized in both genders and across communities, this enduring commitment is often reflected in the distance to water sources, a widely voiced concern that significantly affects access and fetching: "*We walk to far places to fetch water"* (Young Women, FGD, Kolwingo); *"Distance to water points is very far for women"* (Older Men, FGD, Nayiire). These findings corroborate studies addressing rural water access (Graham et al., 2016; Prokurat, 2015), demonstrating the impact on per capita consumption (see Prokurat, 2015).

These challenges impact different vulnerable groups uniquely. In Zuo, a visually impaired woman highlighted her struggle that: *"I am blind and can't help myself, so if I could get support with closer water point"* (Adult Women, FGD, Zuo), aligning with Geere and Cortobius' (2017) conclusion regarding the obstacles disabilities pose to accessing water. Women's and men's discussions revealed a reliance on unprotected sources due to distance: "*We fetch from the dam because some boreholes are far"* (Adult Women, FGD, Nayiire); Men: "*Some fetch water from wells and the dam because of distance to boreholes"* (Adult Men, FGD, Zuo). The dispersed nature of settlements in the Kologo community, combined with decentralized water systems and women's limited access to transportation, compels them to spend time and energy traveling long distances to collect water. The distance deters the use of improved sources (Chew et al., 2019), leading to a preference for accessible but unsafe water sources.

5.3.4.2 Systemic factors

Scholars emphasize addressing poverty and enhancing water infrastructure to alleviate disparities (Apatinga et al., 2022; Schuster-Wallace et al., 2019; UNICEF & WHO, 2023). This study supports these with occupation and water payment statistically significantly associated with difficulty collecting water for women (model 1). From an occupational perspective, women who were traders/business owners experienced less difficulty accessing water [OR 0.196; 95% CI (0.067, 0.569)] than those who were farmers. Also, women paying for water experienced less difficulties [OR 0.071; 95% (0.015, 0.340)] than those who did not. These findings underscore that higher-income occupations and the ability to pay improve water access (Debela et al., 2020; Hailu et al., 2021; Wrisdale et al., 2017).

From a qualitative perspective, women and men consistently highlighted financial constraints hindering water access in FGDs across communities: *"Poverty makes it difficult to access water because we can't get pipes into our homes"* (Older Women, FGD, Zuo); *"Poverty is the reason; we cannot afford to connect government tap water system in the community"* (Young Men, FGD, Nayiire). Consequently, FGDs reveal that some women resort to unsafe water sources: *"We fetch from the dams because of no money"* (Adult Women, FGD, Nayiire). Poverty and low literacy levels are widespread in the communities of Kologo, posing challenges for women in accessing piped water into their homes, despite the presence of a centralized water tank in Nayiire serving the entire community. Poverty may encourage reliance on unsafe sources (Chew et al., 2019; Kulinkina et al., 2016) and intertwine with insufficient water infrastructure, creating a critical link between economic limitations and inadequate water systems in rural areas (Kelly et al., 2018). Inadequate facilities compound water access challenges (Kelly et al., 2018), emphasizing that addressing water infrastructure gaps is crucial for equitable water access (Schuster-Wallace et al., 2019).

5.3.4.3 Individual factors

Research highlights the significance of individual factors like education, health, age, and family size in determining water access (Apatinga et al., 2022; Geere & Cortobius, 2017; Wrisdale et al., 2017). This study confirmed the significance of all of these factors in women's water access challenges with the exception of family size. Women with secondary education had lower odds [OR 0.173; 95% CI (0.037, 0.819)] of facing difficulty compared to those with no education, likely due to better opportunities for employment and improved resources (Armah et al., 2018; Simelane et al., 2020). Age was influential, with women aged 31-50 having higher odds [OR 5.097; 95% CI (1.184, 21.938)] of encountering difficulty compared to older women. This is counterintuitive, as it was expected that older women will experience more difficulty in collecting water than adult women, as evidenced in prior research (Geere & Cortobius, 2017). Possibly because of the cultural significance of respecting elders in the Kologo community, older women are often revered, as is customary in many African cultures, making them receive more familial assistance, particularly in physically demanding tasks like water collection, compared to adult women. Research by Geere & Cortobius (2017) indicates that roughly 60% of children help retrieve water. This support network could ease older women's challenges in collecting water. Although family size did not show statistical significance, larger families typically face more challenges accessing water due to financial constraints, as more members increase water demand and expenses (Apatinga et al., forthcoming; Armah et al., 2018; Simelane et al., 2020). Good health correlated with less difficult in water collection [OR 0.246; 95% CI (0.062, 0.973)] compared to health-challenged women, with women's and men's FGDs across communities confirming this link: "*Distance to water sources becomes difficult because I am sick"* (Adult Women, FGD, Nayiire); *"Women who are not well may find it difficult to carry water"* (Young Men, FGD, Zuo). Given the challenging circumstances of dispersed settlements in Kologo and decentralized water systems, physically strong women might manage better when collecting water from decentralized systems over long distances compared to those who are in poor health, heightening the vulnerability of the latter to water insecurity (Geere & Cortobius, 2017; Wrisdale et al., 2017).

5.3.5 Impact of inadequate water access and water collection on women

5.3.5.1 Health issues

Most women and men acknowledge the physical health issues associated with water collection (Table 5.4). In Kolwingo, 86% of women and 96% of men acknowledged women's challenges during water collection, echoing similar patterns in Nayiire and Zuo. This highlights men's awareness of the physical challenges despite not directly participating in collecting water. Surprisingly, some men across communities underreported women experiences (Kolwingo - 2%; Nayiire - 4%; Zuo - 6%), suggesting that they do not understand the health toll that water collection has on their spouses. Pain and injury were the most commonly reported issues by women in Kolwingo (88%) and Nayiire (70%). Men's perspectives again corroborated these trends in higher numbers than the women themselves, notably in Zuo (95%). Fatigue was less frequently reported by women (44 of 150), with the majority from Nayiire (51%), followed by Zuo (30%) and Kolwingo (11%).

Table 5.4: Health problems associated with water collection and shortages

Kologo sub-communities	**Physical health problems going to collect water**				
	Women		**Men**		
	Frequency (%)		**Frequency (%)**		
	Yes	**No**	**Yes**	**No**	**Don't know**
Kolwingo	43 (86)	7 (14)	48 (96)	1 (2)	1 (2)
Nayiire	47 (94)	3 (6)	46 (92)	2 (4)	2 (4)
Zuo	50 (100)	0 (0)	47 (94)	0 (0)	3 (6)
	Self-reported physical health problems associated with water collection				
		Pain & Injury	**Tiredness/Fatigue**	**Animal attacks**	
		Frequency (%)			
Kolwingo	**Women**	38 (88.4)	5 (11.6)	0 (0)	
	Men	34 (70.8)	0 (0)	14 (29.2)	
Nayiire	**Women**	22(46.8)	24 (51.1)	1 (2.1)	
	Men	34 (72.3)	0 (0)	13 (27.7)	
Zuo	**Women**	35 (70)	15 (30)	0 (0)	
	Men	46 (95.8)	0 (0)	2 (4.2)	
	Worry, or anxiety, or concern about water shortages, or collection				
	Women		**Men**		

		Frequency (%)				Frequency (%)			
		Yes		No		Yes		No	
Kolwingo		45 (90)		5 (10)		49 (98)		1 (2)	
Nayiire		48 (96)		2 (4)		46 (92)		4 (8)	
Zuo		47 (94)		3 (6)		50 (100)		0 (0)	
		Issues women and men worry because of water shortages and collection							
		Distance to water sources	Pain and Injuries	Time spent collecting water	Crowds at water sources	Water carriage	Road accidents	Animal Attacks	Tiredness /Fatigue
		Frequency (%)							
Kolwingo	Women	9 (18)	12 (24)	11 (22)	2 (4)	2 (4)	1 (2)	1 (2)	7 (14)
	Men	18 (36)	13 (26)	7 (14)	1 (2)	0 (0)	0 (0)	7 (14)	3 (6)
Nayiire	Women	4 (8)	16 (32)	8 (16)	2 (4)	6 (12)	7 (14)	0 (0)	5 (10)
	Men	20 (40)	13 (26)	6 (12)	0 (0)	1 (2)	0 (0)	3 (6)	3 (6)
Zuo	Women	8 (16)	9 (18)	9 (18)	3 (6)	9 (18)	4 (8)	0 (0)	5 (10)
	Men	13 (26)	19 (38)	3 (6)	0 (0)	4 (8)	0(0)	1 (2)	10 (20)

FGDs among women and men across communities echoed these challenges, sharing a spectrum of physical strains women experience with water collection: *"We experience rib, chest, neck, and back pains after water fetching"* (Adult Women, FGD, Kolwingo); *"I have chest, waist, and leg pain after fetching; sometimes, I can't walk properly"* (Adult Women, FGD, Zuo); and *"Carrying water is tiring and gives women neck, chest, and body pains"* (Adult Men, FGD, Nayiire). Dispersed settlements and limited water facilities within the communities of Kologo mean women must travel longer distances to collect water, increasing physical strain and injury risks. Additionally, Kologo's socio-economic context, marked by poverty and limited infrastructure, adds to the burden on women. The lack of medical facilities and support systems further compounds physical health issues, with only one health center serving the entire community. These findings add to the scant research linking musculoskeletal pain and injuries to distant water collection and heavy containers used for water carriage (Geere et al., 2018; Geere & Hunter, 2020; Sorenson et al., 2011; Venkataramanan et al., 2020).

In addition, over 90% of women across communities expressed worry about water collection and shortages and similar numbers of men also perceived this stress in women (Table 5.4). Long distances leading to pain and injuries (≥20%), fatigue (≤20%), and time loss (6-22%) were commonly reported reasons across genders and communities, highlighting the psychological burden stemming from water-related challenges. As a result, women shared deep frustrations across communities in FGDs: *"We [women] suffer a lot because of water issues; my slippers got broken and all that disturbs us; sometimes, we contemplate suicide because of the anger"* (Young Women, FGD, Zuo). Men concurred, linking women's mental well-being with water challenges, noting that: *"Women age very rapidly due to carrying water*" (Young Men, FGDs, Kolwingo). The community dynamics of Kologo, marked by communal living and extended family setups in all subdivisions impose additional responsibilities on women to fulfill the water requirements of large households, thus amplifying their psychological strain. Additionally, Kologo's economic backdrop, characterized by poverty and insufficient infrastructure, further compounds this psychological burden. The need to meet gendered obligations and social expectations combined with long walks and queueing at water sources are physically and emotionally demanding, leading to worry, frustration, and anxiety (Achore & Bisung, 2022; Collins et al., 2019; Geere et al., 2018).

5.3.5.2 Safety risks

In Kolwingo and Zuo, approximately 20% of both women and men acknowledged incidents that compromise women's personal safety during water collection, with slightly lower percentages in Nayiire (women-16%, men 12%) (Table 5.5). While relatively low frequency, more Nayiire women reported animal attacks (12%) compared to Kolwingo (8%) and Zuo (6%). In focus groups, women and men expressed concerns about women encountering snakes and insects during water retrieval: *"Fetching water exposes us to dangers like snake bites"* (Young Women, FGD, Kolwingo); *"Fetching water in the morning or evening can lead to snake bites"* (Young Men, FGD, Zuo) also documented in previous research (Berrian et al., 2016; Pommells et al., 2018). In Kologo, dense vegetation and trees, particularly during the rainy season, create habitats for snakes and insects, posing significant threats during water collection, especially in low visibility times like early mornings or late evenings. Cultural practices exacerbate these risks as women, primarily responsible for water collection, are frequently exposed to hazards. The prevalence of extended family structures means women collect water not only for immediate families but also for extended households, increasing their exposure. During the dry season, water scarcity forces women to travel farther, heightening the risk of encounters with dangerous animals. Kolwingo and Zuo experience slightly fewer safety issues, possibly due to closer water sources, reducing travel distances compared to Nayiire.

Table 5.5: Safety risks associated with water collection off premises

<table>
<tr><th colspan="2" rowspan="4">Kologo sub-communities</th><th colspan="5">Attacks collecting water</th></tr>
<tr><th colspan="3">Women</th><th colspan="2">Men</th></tr>
<tr><th colspan="3">Frequency (%)</th><th colspan="2">Frequency (%)</th></tr>
<tr><th colspan="2">Yes</th><th>No</th><th>Yes</th><th>No</th></tr>
<tr><td colspan="2">Kolwingo</td><td colspan="2">10 (20)</td><td>40 (80)</td><td>10 (20)</td><td>40 (80)</td></tr>
<tr><td colspan="2">Nayiire</td><td colspan="2">8 (16)</td><td>42 (84)</td><td>6 (12)</td><td>44 (88)</td></tr>
<tr><td colspan="2">Zuo</td><td colspan="2">9 (18)</td><td>41 (82)</td><td>4 (8)</td><td>46 (92)</td></tr>
<tr><td colspan="2" rowspan="3"></td><th colspan="5">Possible Attacks</th></tr>
<tr><th>Animal/Insect attacks</th><th>Conflicts at water sources</th><th colspan="2">Health attack collecting water</th><th>Road attacks</th></tr>
<tr><th colspan="5">Frequency (%)</th></tr>
<tr><td rowspan="2">Kolwingo</td><td>Women</td><td>4 (8)</td><td>4 (8)</td><td colspan="2">1 (2)</td><td>1 (2)</td></tr>
<tr><td>Men</td><td>10 (20)</td><td>0 (0)</td><td colspan="2">0 (0)</td><td>0 (0)</td></tr>
<tr><td rowspan="2">Nayiire</td><td>Women</td><td>6 (12)</td><td>1 (2)</td><td colspan="2">0 (0)</td><td>1 (2)</td></tr>
<tr><td>Men</td><td>6 (12)</td><td>0 (0)</td><td colspan="2">0 (0)</td><td>0 (0)</td></tr>
<tr><td rowspan="2">Zuo</td><td>Women</td><td>3 (6)</td><td>2 (4)</td><td colspan="2">2 (4)</td><td>2 (4)</td></tr>
<tr><td>Men</td><td>4 (8)</td><td>0 (0)</td><td colspan="2">0 (0)</td><td>0 (0)</td></tr>
<tr><td colspan="2" rowspan="2"></td><th colspan="5">Spousal violence because of water shortages and collection</th></tr>
<tr><th colspan="3">Women</th><th colspan="2">Men</th></tr>
</table>

		Yes		No	Yes	No	
		Frequency (%)			Frequency (%)		
Kolwingo		24 (48)		26 (52)	0 (0)	50 (100)	
Nayiire		21 (42)		29(58)	0 (0)	50 (100)	
Zuo		22 (44)		28 (56)	0 (0)	50 (100)	
		Reasons for spousal violence against women because of water shortages and collection					
		Unwashed clothes	**Unwashed dishes**	**Less or lack of water for bathing**	**Less or lack of drinking water**	**Less/ no/late cooking**	**Poor house keeping**
		Frequency (%)					
Kolwingo	**Women**	4 (8)	2 (4)	5 (10)	3 (6)	10 (20)	0 (0)
Nayiire	**Women**	2 (4)	1 (2)	3 (6)	6 (12)	7 (14)	2 (4)
Zuo	**Women**	4 (8)	0 (0)	13 (26)	1 (2)	3 (6)	1 (2)
		Quarrels among women at water sources					
		Women					
		Yes		**No**			
		Frequency (%)					
Kolwingo		13 (26)		37 (74)			
Nayiire		10 (20)		40 (80)			
Zuo		15 (30)		35 (70)			
		Reasons for quarrels at water sources					
		Crowds/Queues		**Misunderstanding**		**Water shortages**	
		Frequency (%)					
Kolwingo	**Women**	3 (6)		9 (18)		1 (2)	
Nayiire	**Women**	4 (8)		3 (6)		3 (6)	
Zuo	**Women**	5(10)		5 (10)		5 (10)	

Interpersonal conflicts tend to arise at water sources due to overcrowding and misunderstandings resulting from insufficient facilities (Table 5.5). Notably, more women in Zuo (30%), followed by Kolwingo (26%) and Nayiire (20%) reported these conflicts. Women also described these scenarios during focus groups: *"Fetching water often leads to fights at crowded boreholes"* (Young Women, FGD, Kolwingo). In these communities, the combination of limited water facilities and communal lifestyles transforms water sources into social hubs where tensions can quickly flare up. The scarcity of boreholes and wells, spread sparsely across the area, forces women to congregate at these few sources, increasing the likelihood of conflicts over water.

Competition for water often leads to misunderstandings and disputes among women. Despite the presence of a community water tank, many residents still face accessibility issues, resulting in overcrowding at other sources and escalating conflicts. Furthermore, the reliance on agriculture and traditional practices means water collection may coincide with peak farming periods, further exacerbating overcrowding and tension at water points.

FGDs also identified sexual violence risks, particularly for pre-pubescent girls: *"Young girls are at risk of assault while fetching water, especially during the rainy season"* (Adult Men, FGD, Nayiire). The risk of sexual violence, particularly affecting young girls, is intensified by the need to travel long distances to fetch water, often traversing isolated and hazardous areas. Cultural norms and the extended family structure in Kologo commonly designate water-collection tasks to young girls, heightening their susceptibility to assaults, especially during the rainy season when paths become more perilous and visibility decreases. This underscores the risk of gender-based violence linked to water inaccessibility authors have been calling for greater research and policy attention (Fleifel et al., 2019; Pommells et al., 2018). Such assaults not only cause physical harm but also expose women to enduring health risks like HIV (Fleifel et al., 2019; Krumdieck et al., 2016).

The gender-based violence risk extends to the domestic arena (Cole et al., 2024; Collins et al., 2019; Pommells et al., 2018; Tallman et al., 2023), as evidenced by the number of women reporting spousal violence across communities (48% of Kolwingo women, 42% of Nayiire women, and 44% of Zuo women), often triggered by delays in water-related tasks like cooking (≤20) and bathing (6-26%) due to water scarcity and collection (Table 5.5). FGDs provided additional context of conflicts arising from these shortages, as a woman from Nayiire articulated: *"We fight when there is no water to cook after coming back late from the farm"* (Older Women, FGD, Nayiire). A Zuo man concurred, stating that: *"Sometimes, we get [into] conflicts with our wives due to water shortages; in fact, fetching water is a serious challenge"* (Adult Men, FGD, Zuo). The long journeys to water sources and dependence on communal water points lead to delays and extended waiting times, causing tensions to rise within households. With communal living arrangements, any delay in water-related tasks affects the entire extended family, placing added pressure on women and frequently sparking domestic conflicts. Balancing agricultural work with household duties due to the agrarian economy further fuels conflicts when water tasks are postponed. The cultural significance in these communities amplifies social expectations, where any deviation from these norms, such as delays in cooking or bathing, can result in spousal abuse. Entrenched gender roles often unfairly attribute these delays to women, despite underlying structural issues. This blend of physical and emotional strain, coupled with high expectations placed on women, heightens stress levels and the likelihood of domestic violence.

5.3.5.3 Socio-economic risk

Remote water retrieval hinders paid and unpaid activities (Cooper-Vince et al., 2017; Geere & Cortobius, 2017; Komarulzaman et al., 2019). Respondents reported several negative impacts of water retrieval on women's economic engagements (Table 5.6).

Table 5.6: Water collection and shortages affecting paid and non-paid activities

Kologo sub-communities	Women		Men			
	Frequency (%)		Frequency (%)			
	Yes	No	Yes	No	Don't know	
Kolwingo	31 (62)	19 (38)	50 (100)	0 (0)	0 (0)	
Nayiire	29 (58)	21 (42)	38 (76)	12 (24)	0 (0)	
Zuo	27 (54)	23 (46)	23 (46)	15 (30)	12 (24)	
	Paid and non-paid activities affected by water collection and shortages					
	Domestic work	Farming	Trading/ business	School attendance	Less time for work	Miss or late to work
	Frequency (%)					

Kolwingo	**Women**	15(30)	6 (12)	10(20)	0 (0)	0 (0)	0 (0)
	Men	1(2)	4 (8)	8 (16)	1 (2)	30(60)	6(12)
Nayiire	**Women**	6 (12)	9(18)	13(26)	1(2)	0 (0)	0(0)
	Men	0 (0)	1(2)	5 (10)	4 (8)	16 (32)	12 (24)
Zuo	**Women**	2 (4)	17 (34)	6(12)	2 (4)	0(0)	0 (0)
	Men	0 (0)	0(0)	2 (4)	1(2)	10(20)	10(20)
		Occupational category most affected by water collection and shortages					
		Women			**Men**		
		Yes	**No**	**Don't know**	**Yes**	**No**	**Don't know**
		Frequency (%)			**Frequency (%)**		
Farmers		51 (60)	42 (65.6)	0 (0)	68 (80)	52 (81.3)	1 (100)
Traders or business owners		25 (29.4)	17 (26.6)	1 (100)	6 (7.1)	5 (7.8)	0 (0)
Formal or skilled workers		9 (10.6)	5 (7.8)	0 (0)	11 (12.9)	7 (10.9)	0 (0)

At least half of the women surveyed across sub-communities reported that water collection off premises impacts work- and non-work-related activities. However, men's perceptions differed significantly between communities; while men from Zuo reported similar levels of impact, this fell to less than 50% of men in Nayiire. Women reported significant impacts of water collection on trading/business (Nayiire-26%, Kolwingo-20%, and Zuo-12%) and farming (Zuo-34%, Nayiire-18%, and Kolwingo-12%) across communities. Men also recognized these impacts, citing reduced work time (Kolwingo-60%, Nayiire-32%, and Zuo-20%) and lateness or absenteeism at work (Nayiire-24%, Zuo-20%, Kolwingo-12%). Reported impacts were higher among women farmers (60%) than those who were traders (29%) or, formal, or skilled workers (10%). These differences could be attributed to the physically demanding nature of farming activities, amplifying women's challenges associated with water collection. In focus groups, women and men across sub-communities described the substantial time and opportunity losses: *"Fetching water takes the time meant for working and earning money; it is like spending the entire day on just that task"* (Adult Women, FGD, Kolwingo); *"The time spent fetching water could have been utilized more productively"* (Adult Men, FGD, Nayiire). The distant location of improved water facilities in these communities leads to longer travel times for water access, reducing available time for economic pursuits. In Kolwingo, where the market square acts as a central business hub, any time spent on water collection can significantly impact the incomes of women traders, especially those not residing locally. Reliance on communal water sources worsens the situation, with women often enduring long queues, further cutting into their productive hours. Balancing domestic duties with agricultural work, the time-consuming process of water collection affects both farming and trading activities. High societal expectations place pressure on women to efficiently manage multiple roles, resulting in decreased productivity and economic losses, as observed by men noting reduced work time and increased tardiness or absenteeism. Women in Zuo particularly highlight the substantial impact on farming activities, illustrating the heavy burden of water collection they bear. In addition, FGDs across communities revealed out-of-pocket payments related to maintaining water facilities: *"As for our borehole, we contributed and drilled it by ourselves, and we do same with the maintenance. A woman pays 10 cedis [$1.5], and a man 20 cedis [$2.5]"* (Young Women, FGD, Nayiire); *"When a borehole breaks down, every household contributes for repairs"* (Older Men, FGD, Zuo). The collective use of water facilities implies that any malfunction necessitates joint efforts and financial contributions from all households. The expenses linked with borehole repairs compound economic pressures, especially in communities reliant on agriculture as the main economic activity, where income and literacy levels are generally low, thus restricting income-generating prospects. Additionally, women raised concerns about health expenses resulting from adverse health effects of water collection*: "The distance to water sources makes our health bad, which you will need to buy medicines to be treated but there is no money"* (Young Women, FGD, Kolwingo). Relying on distant water sources exacerbates women's health challenges. Travelling long distances for water exposes them to physical strain and environmental hazards, increasing the risk of injuries and illnesses. Limited healthcare facilities within these communities worsen their health issues, leading residents to incur additional costs for treatment. In economically impoverished communities, the added expense of purchasing medications further strains household finances. Women are tasked with supporting water infrastructure while also covering healthcare expenses, highlighting the intertwining economic and health obstacles in the community. In addition to the usual health concerns, the scarcity of water and water collection from remote sources result in a multitude of unforeseen complications that extend to socioeconomic consequences (Ablo & Yekple, 2018; Collins et al., 2019).

5.3.5.4 Nutrition and hygiene issues

Poor water access and distant water collection disrupt essential household activities like washing, cooking, and bathing (Brewis et al., 2019), reducing the consumption of quality items and decreasing dietary diversity (Choudhary et al., 2020; Miller et al., 2024; Workman & Ureksoy, 2017). Women reported that sometimes they are unable to cook desired meals and enough food because of water shortages and the time-consuming nature of water collection (Table 5.7).

Table 5.7: Nutritional and hygiene issues associated with water collection and shortages

Kologo sub-communities	**Not cooked desirable food due to water shortages and collection?**				
	Women		**Men**		
	Frequency (%)		**Frequency (%)**		
	Yes	**No**	**Yes**	**No**	**Don't know**
Kolwingo	22(44)	28(56)	0 (0)	31 (62)	19(38)
Nayiire	17(34)	33(66)	0 (0)	48 (96)	2(4)
Zuo	27(54)	23(46)	0 (0)	25 (50)	25(50)
	Not cooked enough food because of water scarcity, or water collection?				
	Women		**Men**		
	Frequency (%)		**Frequency (%)**		
	Yes	**No**	**Yes**	**No**	**Don't know**
Kolwingo	18 (36)	32 (64)	0 (0)	47 (94)	3(6)

Nayiire	13 (26)	37 (74)	0 (0)	50 (100)	0(0)
Zuo	18 (36)	32 (64)	0 (0)	25 (50)	25(50)
	Incompletion of household tasks because of water shortages and collection?				
	Women		**Men**		
	Yes	**No**	**Yes**		**No**
	Frequency (%)		**Frequency (%)**		
Kolwingo	28 (56)	22 (44)	0 (0)		50 (100)
Nayiire	23 (46)	27 (54)	0 (0)		50 (100)
Zuo	24 (48)	26 (52)	0 (0)		50 (100)
	Unperformed, or uncompleted household tasks because of water shortages and collection				
	Women				
	Bathing	**Cooking**	**House keeping**	**Washing**	**Water collection**
	Frequency (%)				
Kolwingo	2 (4)	15 (30)	0 (0)	8 (16)	3 (6)
Nayiire	1 (2)	12 (24)	3 (6)	6 (12)	1 (2)
Zuo	2 (4)	17 (34)	1 (2)	2 (4)	2 (4)

More women in Zuo (54%) reported the inability to cook desired meals than Kolwingo (44%) and Nayiire (34%). Also, more women in Kolwingo (36%) and Zuo (36%) reported not being able to cook enough food than Nayiire (26%). Women and men expressed their frustrations in FGDs: *"When we come back late from the farm, you are not able to cook for your family*, *and everyone has to sleep on an empty stomach"* (Adult Women, FGD, Nayiire); *"We sometimes have to eat less than three times a day because of water problems"* (Adult Men, FGD, Nayiire). These findings highlight the significant impact of water-related challenges on household food security and nutrition, influenced by the unique characteristics of each sub-community. Dependence on communal water sources exacerbates issues faced during meal preparation. Limited water availability affects cooking options, resulting in compromises in both the quality and quantity of meals. These difficulties are magnified by the seasonal nature of farming activities in these communities, which can exacerbate food insecurity during periods of reduced agricultural output. Inadequate nutrition compounded by a lack of quality diet can result in malnutrition and undernourishment (UNICEF et al. Bank, 2015), particularly impacting women who often prioritize the needs of men and children over their well-being.

Hygiene concerns were also reported, with 56% of Kolwingo women, 48% of Zuo women, and 46% of Nayiire women unable to complete household tasks due to water scarcity (Table 5. 7). The inability to wash was reported most often by women from Kolwingo (16%) followed by Nayiire (12%) and Zuo (4%) and supported through focus groups discussions: *"If no water, I won't cook, talk less of anyone bathing, and when all this happens, I am always unhappy"* (Older Women, FGD, Kolwingo); *"When there is not enough water, we use little to cook and bathe till the next day"* (Adult Women, FGD, Zuo). The persistent poverty and reliance on distant water sources in these communities exacerbate the challenges of maintaining hygiene standards. Water scarcity hinders the completion of essential household tasks like cooking and bathing, leading to increased frustration and dissatisfaction among residents. Women are forced to ration water, allocating minimal amounts for cooking and bathing, which may compromise personal hygiene and sanitation norms.

5.3.5.5 Compounding impacts

While analysis to this point has focused on the prevalence of impacts, none of these exist in isolation. Indeed, women experience compounded adverse effects across different areas, such as health, safety, and socioeconomics, due to water insecurity (Table 5.8). This interconnectedness is evident in how specific health issues, both physical and psychological, coincide among women. Notably, 87% of women in Kologo reported both sets of health issues together; more Nayiire (35%) and Zuo (35%) women reported both sets of issues together than Kolwingo (29%). These health issues are closely intertwined with safety concerns arising from water insecurity. Over half of Kologo women (58%) faced various safety problems due to water insecurity. This overlap is higher among Kolwingo women (71%), followed by Nayiire (28%), and none of the Zuo women reported experiencing all three safety issues together. These safety worries contribute significantly to mental and emotional stress (Workman & Ureksoy, 2017; Wutich et al., 2020). Moreover, 20% of Kologo women simultaneously grappled with two or three nutritional and hygiene problems alongside these challenges. In contrast to Zuo (36%) and Nayiire (23%), more Kolwingo women (40%) confronted these compounded issues.

The convergence of these challenges amplifies their impact on women's health, reinforcing their vulnerability to overlapping problems. For example, fewer Kologo women faced only one problem (2.9%) or nine problems (1.6%), while 16% faced four issues concurrently, closely followed by 14% dealing with five problems, demonstrating the multifaceted impact of water-related problems on their lives, encompassing health, safety, socioeconomic, and nutritional/hygiene aspects. Socioeconomic backgrounds play a pivotal role; for instance, farmers (66%) faced disproportionate effects compared to those in trading (22%) or formal/skilled work (1%). Even over 50% of women who identified as healthy experienced all consequences, highlighting the severity and impact of water insecurity in these communities. These persistent issues perpetuate a cycle of water insecurity, exacerbating the challenges of collecting water for these women (Table 5.8). With 71% of women dealing with three to seven interconnected water-related consequences, their struggle to access and collect water intensifies, underscoring the complexity and distress of their experiences. The variations in the compounded adverse effects on women across the three sub-communities result from several contextual factors. The presence of dispersed settlements and limited water access magnifies challenges for women. Insufficient water infrastructure and safety measures increase their vulnerability to health and safety risks, contributing to the observed compounded adverse effects. Socioeconomic factors, such as reliance on traditional livelihoods and inadequate access to essential services, intersect with these adverse effects. Additionally, cultural norms and gender roles influence women's vulnerability to these challenges, further exacerbating the compounded adverse impacts.

Table 5.8: Combination of water-related issues

Kologo		**Number of health Issues: Physical health injuries and psychological health problems**			
		Frequency		**Percentage**	
0		1		0.7	
1		18		12	
2		131		87.3	
Total		150		100	
Kologo sub-communities		**Number of health issues Physical health injuries and psychological health problems**			
		0	**1**	**2**	**Total**
		Frequency (%)			
Kolwingo	**Women**	0 (0)	12 (66.7)	38 (29)	50 (33.3)
Nayiire	**Women**	1 (100)	3 (16.7)	46 (35.1)	50 (33.3)
Zuo	**Women**	0 (0)	3 (16.7)	47 (35.9)	50 (33.3)
Number of safety issues		**Number of safety issues Attacks collecting water, spousal violence, and conflicts at water sources**			
		Women			
		Frequency		**Percentage**	
0		51		36.4	
1		58		41.4	
2		24		17.1	
3		7		5	
Total		140		100	
Kologo sub-communities		**Number of safety issues: Attacks collecting water, spousal violence, and conflicts at water sources**			
		0	**1**	**2**	**3**
		Frequency (%)			

Kolwingo	**Women**	16 (31.4)	16 (27.6)	6 (25)	5 (71.4)
Nayiire	**Women**	20 (39.2)	19 (32.8)	10 (41.7)	0 (0)
Zuo	**Women**	15 (29.4)	23 (39.7)	8 (33.3)	2 (28.6)

Number of issues	**Number of nutritional and hygiene issues: Not cooked desirable food, not cooked enough food, and uncompleted/ unperformed domestic activities**	
	Women	
	Frequency	**Percentage**
0	52	34.7
1	37	24.7
2	31	20.7
3	30	20
Total	150	100

Kologo sub-communities		**Number of nutritional and hygiene issues women experience: Not cooked desirable food, not cooked enough food, and uncompleted/ unperformed domestic activities**			
		Women			
		0	**1**	**2**	**3**
		Frequency (%)			
Kolwingo	**Women**	17 (32.7)	11 (29.7)	10 (32.3)	12 (40)
Nayiire	**Women**	20 (38.5)	14 (37.8)	9 (29)	7 (23.3)
Zuo	**Women**	15 (28.8)	12 (32.4)	12 (38.7)	11 (36.7)
Total		52 (100)	37 (100)	31 (100)	30 (100)

Number of issues	**Number of all water-related consequences examined women experience: Health, Safety, Socioeconomic, and Nutritional and Hygiene Issues**	
	Women	
	Frequency	**Percentage**
1	4	2.9
2	21	15.3
3	21	15.3
4	22	16.1
5	20	14.6
6	17	12.4

7	21	15.3
8	9	6.6
9	2	1.6
Total	137	100

Kologo sub-communities		**Number of all water-related consequences examined women experience: Health, Safety, Socioeconomic, Nutritional, and Hygiene Issues**								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		Frequency (%)								
Kolwingo	**Women**	3 (75)	7 (33.3)	5 (23.8)	5 (22.7)	5 (25)	6 (35.3)	5 (23.8)	4 (44.4)	2 (100)
Nayiire	**Women**	1 (25)	8 (38.1)	11 (52.4)	7 (31.8)	9 (45)	4 (23.5)	6 (28.6)	3 (33.3)	0 (0)
Zuo	**Women**	0 (0)	6 (28.6)	5 (23.8)	10 (45.5)	6 (30)	7 (41.2)	10 (47.6)	2 (22.2)	0 (0)
Total		4 (100)	21 (100)	21 (100)	22 (100)	20 (100)	17 (100)	21 (100)	9 (100)	2 (100)

Demographic and socioeconomic variables	**Number of all water-related consequences examined women experience**								
	Women								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	Frequency (%)								
Education									
No education	2 (50)	6 (28.6)	7 (33.3)	12 (54.5)	9 (45)	5 (29.4)	5 (23.8)	1 (11.1)	0 (00
Primary education	2 (50)	9 (42.9)	10 (47.6)	9 (47.6)	9 (45)	9 (52.9)	11 (52.4)	7 (77.8)	2 (100)
Secondary education	0 (0)	6 (28.6)	3 (13.3)	1 (4.5)	2 (10)	3 (17.6)	5 (23.8)	1 (11.1)	0 (0)
Beyond secondary education	0 (0)	0 (0)	1 (4.8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Occupation									
Farmers	1 (25)	15 (71.4)	14 (66.7)	15 (68.2)	10 (50)	9 (52.9)	12 (57.1)	6 (66.7)	2 (100)
Trader/business owners	3 (75)	5 (23.8)	7 (33.3)	5 (22.7)	7 (35)	6 (35.3)	6 (28.6)	2 (22.2)	0 (0)
Formal or skilled workers	0 (0)	1 (4.8)	0 (0)	2 (9.1)	3 (15)	2 (11.8)	3 (14.3)	1 (11.1)	0 (0)
Health Status									

Healthy	3 (75)	16 (76.2)	13 (61.9)	13 (59.1)	15 (75)	15 (88.2)	18 (85.7)	7 (77.8)	2 (100)
Unhealthy	1 (25)	5 (23.8)	8 (38.1)	9 (40.9)	5 (25)	2 (11.8)	3 (14.3)	2 (22.2)	0 (0)
Age									
18-30	1 (25)	6 (28.6)	9 (42.9)	9 (40.9)	8 (40)	6 (35.3)	7 (33.3)	5 (55.6)	1 (50)
31-50	2 (50)	11 (52.4)	6 (28.6)	6 (27.3)	4 (20)	8 (47.1)	12 (57.1)	3 (33.3)	1 (50)
50+	1 (25)	4 (19)	6 (28.6)	7 (31.8)	8 (40)	3 (17.6)	2 (9.5)	1 (11.1)	0 (0)
Income Rank									
Below average	1 (25)	7 (33.3)	5 (23.8)	4 (18.2)	6 (30)	2 (11.8)	2 (9.5)	0 (0)	1 (50)
Average	2 (50)	12 (57.1)	13 (61.9)	15 (68.2)	12 (60)	13 (76.5)	14 (66.7)	6 (66.7)	1 (50)
Above average	2 (25)	2 (9.5)	3 (14.3)	3 (13.6)	2 (10)	2 (11.8)	5 (23.8)	3 (33.3)	0 (0)
Family size									
<=4	3 (75)	6 (28.6)	6 (28.6)	4 (18.2)	5 (25)	3 (17.6)	2 (9.5)	0 (0)	1 (50)
>4	1 (25)	15 (71.4)	15 (71.4)	18 (81.8)	15 (75)	14 (82.4)	19 (90.5)	9 (100)	1 (50)

Women's experiences of all water-related consequences examined	**Accessing and collecting water**	
	Women	
	Difficult	**Very Difficult**
	Frequency (%)	
1	3 (75)	1 (25)
2	9 (42.9)	12 (57.1)
3	6 (28.6)	15 (71.4)
4	6 (27.3)	16 (72.7)
5	7 (35)	13 (65)
6	6 (35.3)	11 (64.7)
7	6 (28.6)	15 (71.4)
8	4 (44.4)	5 (55.6)
9	1 (50)	1 (50)
Total	48 (35)	89 (65)

5.4 Strengths & Limitations

This cross-sectional study employs a multi-faceted approach to the challenges women face in accessing and collecting water. It acknowledges the intricate health and socio-economic difficulties involved. By utilizing Apatinga et al.'s integrated framework, this research underscores the interplay between environmental, systemic, and individual factors at the community level. The comprehensive approach integrating surveys, FGDs, and coupled systems frameworks provides an in-depth understanding of these women's challenges while collecting water. This study not only identified individual challenges caused by water-related issues but also revealed how these challenges compound, leading to sustained water insecurity and exacerbating difficulties in water retrieval—a novel finding not previously evidenced in scholarship.

While this study holds significant research and policy implications, it is important to note that the findings might only apply to some rural women in Ghana. Sociocultural contexts, socio-economic disparities, and geopolitical boundaries may influence how rural women experience water access and collection differently. However, while experiences may vary among specific groups, the ideas and responses hold transferable value. Additionally, it is crucial to consider the potential impact of social desirability bias on the study's outcomes, as participants may have underreported or overreported issues related to water access and collection. Nonetheless, taking into account Kologo's extended family arrangements, cultural norms, and communal living, delving into the unique yet interlinked experiences of its sub-communities offered valuable insights into the socioeconomic consequences and daily struggles arising from water insecurity. By linking women’s water collection experiences and the drivers offers a plausible route to create more holistic and scalable interventions. Understanding multiple influences is crucial in designing integrated, cross-sectional approaches that can be applied to diverse settings (rural or urban) to improve access to water resources on a larger scale.

5.5 Conclusion

This study employed a community-based case study to explore factors influencing women's difficulties in accessing and collecting water off-premises as well as the ensuing health and economic consequences. The study moves beyond the identification of drivers and impacts of lack of water access to underscore the interplay between the significant challenges women face in obtaining and collecting water, stemming from multifaceted environmental, systemic, and individual factors. Women can find themselves trapped in a relentless cycle where water insecurity exacerbates existing health and socio-economic challenges, creating a self-perpetuating process. Gender-based divisions of labour, power dynamics, and societal expectations disproportionately burden women regarding water access and insecurity. The intertwining influence of gender constructs, sociocultural identities, and persistent water insecurity significantly influences the diverse lived experiences of these women. In doing so, this study emphasizes the critical need for an intersectional, gender-focused approach to address remote water collection and water scarcity issues. It is imperative for governments and policymakers to acknowledge these complexities in integrated water resource management strategies.

Ensuring equitable access to water is a critical step to closing access gaps among different social groups. In all of these, geographical proximity to water sources is the underlying factor influencing the health, economic challenges, and security threats rural women face during water retrieval. If women do not undertake lengthy journeys to access water sources, they can avoid navigating uneven terrains and have more time for productive activities, thereby reducing risks and security threats. Minimizing the distance to water sources becomes imperative in reducing these challenges and underlines the necessity of in-house piped water systems or nearby water sources in rural communities. Overall, addressing gender norms, power structures, and socio-environmental and individual issues influencing women's water access challenges is crucial for paving a sustainable future aligned with the sustainable development agenda.

CHAPTER SIX

Preamble

Chapter 6 analyzes the coping strategies rural women employ when faced with insufficient water access and the hardships of water collection from a distance. The objective is to comprehensively examine how rural women in Northern Ghana navigate the complexities of inadequate water access and remote water collection. By utilizing surveys and focus group discussion instruments integrated with the coupled systems framework proposed by Apatinga et al., this chapter aims to contribute valuable insights to the ongoing scholarly discourse on women's coping strategies in water access challenges. As discussed in Chapter 5, the intricate interplay of factors makes water access and collection challenging for women, exposing them to vulnerabilities and security threats. Understanding how rural women cope with water inaccessibility while fulfilling their gender-specific responsibilities is crucial in this challenging context. This chapter argues that rural women employ exit, loyalty, and voice strategies concurrently or interchangeably to cope with the unreliability of the domestic water supply and the difficulties of distant water collection. By analyzing women's narratives and the existing literature, this chapter reveals that specific coping strategies may be maladaptive, potentially subjecting women to negative long-term consequences. The goal is to contribute to the growing yet limited body of scholarship that critically assesses coping in the face of water insecurity and vulnerability in Ghana and broader contexts. Building on previous research, this chapter aims to stimulate progress in enhancing equitable access to safely managed water in rural and marginalized areas, echoing the global pursuit of sustainable and inclusive water resource management.

Manuscript #4: Exploring women's coping strategies to combat suboptimal water access in rural Ghana

Apatinga, G. A., Dickson-Anderson, S. E., & Schuster-Wallace, C. J. (2024). Exploring women's coping strategies to combat suboptimal water access in rural Ghana (Under review in the Journal of Climate and Development)

Abstract: Scholarly accounts on the importance and types of adaptive practices for suboptimal water access in Ghana's rural areas, where water inaccessibility persists, are lacking. Conducted in a small community in northern Ghana, known for its severe water insecurity, this study aimed to understand how women manage and adapt to poor water access. Surveys and FGDs were analyzed statistically and thematically. Findings reveal that these women employ exit (alternative water sources, purchasing water, collaborative sharing), loyalty (storage, conservation, treatment), and voice (community-driven actions, complaints to authorities) strategies to address water challenges simultaneously or interchangeably. However, specific coping mechanisms can be ineffective and even detrimental long-term, highlighting the double burden of enduring persistent water inaccessibility. The study underscores that women's coping strategies alone cannot comprehensively tackle the systemic issues causing access challenges. Collaborative efforts, policy interventions, and gender-sensitive approaches are required to improve equitable water access and alleviate the persistent challenges faced by these women and communities.

Keywords: coping strategies, Ghana, women, water access, SDG 6: clean water and sanitation

6.1 Introduction

There is sparse but nascent literature emphasizing the importance and types of strategies applied in navigating the challenges of suboptimal water access, particularly with respect to rural women (Majuru et al., 2018; Venkataramanan et al., 2019). To achieve the Sustainable Development Goals on water and gender equality, it is critical to understand the practices that women adopt in response to lack of access and assess whether these practices are effective and sustainable or create harm. Like many other countries, water inaccessibility is prevalent in many rural communities in Ghana (Dongzagla et al., 2022; Nordström & Widman, 2022), compounded by traditional gender norms and roles (Alaci, Jiya, & Omata, 2013; Jeil et al., 2020). In addition to disrupting daily gendered responsibilities, poor water access and scarcity impose physical and psychological burdens on rural women, impacting their overall well-being and productivity (Apatinga et al. forthcoming; Nordström & Widman, 2022; Ambuehl et al., 2021).

Following on from an assessment of the drivers and impacts of water inaccessibility in Kologo, northern Ghana (Apatinga et al. forthcoming), the purpose of this study was to investigate the coping strategies employed by rural women to manage and mitigate poor water access. Understanding the coping strategies related to water inaccessibility will help in developing context-specific interventions to support households in positively adapting to water scarcity and insecurity and alleviating the burdens women experience in these water-insecure contexts. The aim is to contribute to a comprehensive assessment of coping strategies in water insecure environments, facilitating the development of sustainable and gender-responsive approaches to address domestic water supply challenges and enhance the well-being and resilience of rural women and their families in Ghana. The overarching goal is to encourage continued progress in achieving universal and equitable access to safely managed drinking water for all.

6.2 Methods and Data

The research was conducted in Kologo, a rural community in the arid Upper East Region of Ghana, from August to October 2022. Located within the Kassena-Nankana East Municipality, Kologo faces persistent water scarcity and severe water insecurity. The community is primarily inhabited by the Nankani-speaking people, with a mixture of Christians, Muslims, and practitioners of traditional beliefs. The community confronts substantial obstacles, such as poor social infrastructure and inadequate water facilities. Agriculture serves as the primary economic activity, with low literacy levels prevalent. Piped water access is hindered by poverty and high connection fees, causing households to rely on alternative water sources, including boreholes, rainwater, and unprotected wells. During the protracted dry season, water scarcity intensifies. A full description of research site, community engagement process, participant recruitment, and informed consent can be found in Apatinga et al. (Forthcoming), which is focused on drivers and impacts of water collection for rural women.

6.2.1 Research design and ethics

This study employed on a mixed-methods approach, which combined both quantitative and qualitative methods within a convergent parallel framework. Ethical considerations were obtained from multiple boards, including the University of Saskatchewan Behavioral Research Ethics Board (Beh-REB#2711), the McMaster Research Ethics Board (MREB#5809), and the University of Ghana Ethics Committee for the Humanities (ECH355/21-22).

6.2.2 Data and analysis

As described in Apatinga et al. (Forthcoming), this study engaged residents from three distinct sub-communities in Kologo– Kolwingo, Nayiire, and Zuo. From each sub-community, fifty individuals (both men and women) were randomly selected using cluster sampling, resulting in a total sample size of three hundred participants. The survey was conducted by trained research assistants, one man and one woman, who communicated with participants in Nankani (local dialect). The survey design was based on a conceptual framework (Apatinga et al., 2022) and included questions about participants' backgrounds, water sources, gender roles, health impacts, and household strategies for coping with water scarcity. Men and women respondents were asked specific questions regarding their actions during water shortages. In addition, six focus group discussions (FGDs) were held in each sub-community, consisting of one each for young women or men (≤30), adult women or men (31-50), and older women or men (≥51) (see Apatinga et al., forthcoming for detailed description of analyses).

Data on coping strategies from the surveys were analyzed using the Statistical Package for the Social Sciences (SPSS) software version 21. Actions were classified according to the coping strategy represented (exit, loyalty, voice) (Majuru et al. 2016). The exit strategy seeks water access through methods like well drilling and purchasing water. Loyalty strategy involves various practices such as delaying tasks and reducing water use. The voice strategy includes complaints, protests, forming groups, and supporting water projects (Majuru et al. 2016). Variables representing these strategies were selected based on the adopted conceptual framework and insights from previous literature.

Descriptive analyses were conducted to calculate means and standard deviations for continuous variables, while frequencies were determined for categorical variables. Cross-tabulations were performed to identify significant differences or associations between dependent and independent variables. An additive scale analysis was also conducted (De Mutsert et al., 2011), where values or scores from different variables or factors were combined to form a composite or summary score to identify the combination of women's coping strategies. This was to provide a nuanced understanding of how women navigate challenges related to water access. To calculate the composite score in SPSS for identifying the combination of women's coping strategies, the variables representing exit (e.g., water collection from alternative sources, water purchase), loyalty (e.g., water use reduction/prioritization, postponement of domestic activities due to water shortages), and voice strategies (e.g., attendance at community meetings, participation in water-related discussions) were added together using the same scale (yes and no). These variables were assigned values of 0 for "no" and 1 for "yes." For instance, exit strategies were calculated as the sum of: water collection from alternative sources + water purchase + borrowing water + collecting water. Similar calculations were made for loyalty and voice strategies. Descriptive statistics, including frequencies, were then calculated to provide summary statistics. Additionally, cross-tabulations were conducted to examine differences in coping strategy utilization among women across communities and to understand how their socioeconomic backgrounds influence the adoption of these strategies.

6.3 Findings and Discussion

While the majority of respondents reported achieving primary education (approximately 50%), a significant proportion reported no formal education (approximately 40%) (Apatinga et al. forthcoming). In all sub-communities, farming emerged as the predominant occupation for both men and women, although they also engaged in other livelihood activities such as trading and skilled work. Most individuals in these communities access improved water sources through a government-provided decentralized system, primarily communal boreholes, which translates to minimal water-related expenses. As anticipated, women assume the primary responsibility for collecting water for domestic purposes due to prevailing gender norms and roles. Interestingly, nearly all participants highlighted the existence of significant challenges for women when accessing and collecting water. Responses to these challenges represented all three coping strategy categories.

6.3.1 Exit Strategies

Survey data indicate that women employ various exit strategies to deal with limited water access, including alternative water sources, buying water and collaborative water-sharing initiatives (Table 6.1). These findings replicate other studies (Amit & Sasidharan, 2019; Abubakar & Doan, 2017; Majuru et al., 2016). For instance, in Mozambique, Van Houweling (2016) discovered that in the extended dry season, local wells and streams frequently run dry, compelling individuals collecting water to travel longer distances in search of alternative water sources.

Table 6.1: Exit strategies against suboptimal water access

Kologo sub-communities	Women		
	Collecting water from alternative sources		
	Frequency (%)		
	Yes		No
Kolwingo	44 (88)		6 (12)
Nayiire	30 (60)		20 (40)
Zuo	33 (66)		17 (34)
	Alternative water sources women access		
	Dam	**Rainwater**	**Unprotected wells**
	Frequency (%)		
Kolwingo	5 (10)	6 (12)	33 (66)
Nayiire	3 (6)	10 (20)	17 (34)
Zuo	0 (0)	9 (18)	24 (48)

	Buying water			
	Women		Men	
	Yes	No	Yes	No
	Frequency (%)		Frequency (%)	
Kolwingo	5 (10)	45 (90)	4 (8)	46 (92)
Nayiire	9 (18)	41 (82)	1 (2)	49 (98)
Zuo	1 (2)	49 (98)	0 (0)	50 (100)

	Weekly estimate of purchasing water			
		GHC<=5	GHC>5	Non-buying of water
		Frequency (%)		
Kolwingo	**Women**	1 (2)	4 (8)	45 (90)
	Men	1 (2)	3 (6)	46 (92)
Nayiire	**Women**	1 (2)	8 (16)	41 (82)
	Men	0 (0)	1 (2)	49 (98)
Zuo	**Women**	0 (0)	1 (2)	49 (98)
	Men	0(0)	0 (0)	50 (100)

	Borrowed water from household members		Collected water from neighbours	
	Women		Women	
	Yes	No	Yes	No
	Frequency (%)		Frequency (%)	
Kolwingo	5 (10)	45 (90)	5 (10)	45 (90)
Nayiire	7 (14)	43 (86)	7 (14)	43 (86)
Zuo	8 (16)	42 (84)	6 (12)	44 (88)

		Reasons some women borrowed water from household members		Reasons some women collected water from neighbours	
		Cook	Drink	Cook	Drink
		Frequency (%)		Frequency (%)	
Kolwingo	**Women**	2 (4)	3 (6)	4 (8)	1 (2)
Nayiire	**Women**	3 (6)	4 (8)	1 (2)	6 (12)
Zuo	**Women**	3 (6)	5 (10)	2 (4)	4 (8)

6.3.1.1 Alternative methods of obtaining water

Women commonly collect water from alternative sources, although the extent varies among sub-communities (Table 6.1). Kolwingo has the highest percentage (88%) of women using alternative sources, followed by Zuo (66%) and Nayiire (60%). These alternative sources primarily include unprotected wells, dams, and rainwater. However, collecting water from these sources may mean limited quantities unless transportation options are available to facilitate collection of larger volumes and reduce time spent on such activities (Cook et al., 2016). Unprotected wells are used among women in all three communities, with respondents from Kolwingo reporting highest use (66%), followed by Zuo (48%), and Nayiire (34%). Rainwater is also collected in the wet season but to a lesser extent, with women in Nayiire (20%) and Zuo (18%) relying more on this source, followed by Kolwingo (12%). The use of dam water is comparatively lower across the communities, with no use reported by women in Zuo and, only 10% in Kolwingo and 6% in Nayiire. FGDs highlighted additional sources such as digging wells: *"For the past years, no support to provide water for this community. So, we dig our own wells to help us get water enough for our use"* (Older Women, FGD, Zuo). Men help with this: *"We as a community have come together to dig wells to support the few boreholes we have"* (Adult Men, FGD, Zuo). These alternate water sources are more susceptible to contamination (Bansal & Asthana, 2019), a fact that participants are aware of: *"We cope by digging our own wells, so that we can at least get water to drink but the water is not good"* (Older Women, FGD, Kolwingo).

Further analyses demonstrate that use of alternate water sources varies significantly according to demographic and socioeconomic backgrounds (Table 6.2). Notably, the largest group accessing alternative water sources consists of women with primary (56%) or no (31%) education. Conversely, women with secondary or higher education exhibit a lower reliance on alternative water sources (12%). This implies that educated women might not necessarily require access to these alternatives; they might have the means to purchase water instead. From an occupation perspective, 67% of farmers rely heavily on alternative water sources. Furthermore, women belonging to larger families (78%), demonstrate a higher percentage, as they require more water and lack alternative options, necessitating the collection of water from alternative sources in contrast to those with smaller family sizes at 21%. The scattered settlements and scarce water facilities in Kologo and its sub-communities impact water accessibility and availability, necessitating reliance on alternative sources for daily needs. Women resort to these alternatives due to distant and limited water sources. Additionally, the communities' socioeconomic status, marked by poverty and low literacy, exacerbates water insecurity. High connection costs for piped water further restrict access, compelling women to rely on alternative, often unreliable, sources. Economic constraints also hinder maintenance of water facilities, resulting in frequent breakdowns and insufficient infrastructure, evidenced by the necessity for collective contributions for borehole drilling and upkeep.

6.3.1.2 Buying water

In addition to resorting to alternative water sources, the data highlight that a limited number of women also purchase water to augment water supplies (Table 6.1). This was highest in Nayiire (18% of women), followed by Kolwingo (10%). Very few women in Zuo reported purchasing water (2%). While respondents from Zuo reported lower levels of education, the majority reported average incomes, suggesting that an inability to afford to purchase water was not a factor in the differences observed (Apatinga et al., forthcoming). Notably, the number of men respondents reporting purchasing water was lower than the number of women across all sub-communities (Nayiire 2%; Kolwingo 8%; Zuo 0%). Survey data indicate that individuals who purchase water typically spend a minimum of five Ghana cedis ($US 0.5) per week to secure their water supply. When asked to provide an estimate of weekly water expenditures, only 16% of Nayiire women and 8% of Kolwingo women reported allocating this amount. Even fewer men reported this level of spending, suggesting that men may not recognise or understand the cost of water during periods of scarcity. As over 50% of women respondents indicated that households' decisions are made by the man (Apatinga et al. forthcoming), this may remove water purchasing as a coping strategy from the reach of some women. In FGDs, one woman indicated: *"We pay fee or money to a different community to fetch water"* (Adult Women, FGD, Zuo). Buying water can offer relief from water insecurity, but it can pose a financial burden, particularly for low-income rural households. This challenge is particularly acute within Kologo communities, where poverty is widespread, disproportionately impacting women. This expenditure might impact the well-being of women and their families, diverting funds that could otherwise enhance household welfare toward daily water purchases, leaving fewer resources for essential goods and improvements. Furthermore, the pricing of water plays a crucial role in determining the amount women can afford to purchase to meet their daily needs. Within Kologo communities, where water insecurity is dire, water vendors might capitalize on this situation to charge higher prices, exacerbating the financial strain on already vulnerable households. Higher prices limit access for women with limited financial resources, impacting their ability to acquire sufficient quantities and ultimately affecting their per capita consumption (Katko & Hukka 2015; Wrisdale et al., 2017).

6.3.1.3 Water sharing practices

While not common, a number of women (10% in Zuo; 8% in Nayiire; 6% in Kolwingo) (Table 6.1) reported borrowing water from family members and neighbours: *"I go to my* *neighbour to collect water from her, so I can prepare my child for school early before I will go and fetch"* (Young Women, FGD, Kolwingo). Essential domestic tasks, primarily drinking (Nayiire and Zuo) and cooking (Kolwingo), were found to be the primary motivations prompting women to borrow water. Participating in water-sharing practices enables women to more effectively manage their time and resources, guaranteeing that vital responsibilities like preparing children for school remain unaffected by increased demands of water collection during water scarcity (Abubakar, 2018). Kologo's cultural values emphasize communal support and mutual aid, including practices like sharing water during shortages. These communal living arrangements foster strong interpersonal ties, enabling women to depend on social networks for essential resources like water, ensuring they can manage household tasks even in times of scarcity. Women with low (50%) or no (35%) education represented the greatest proportion of women borrowing water, while women educated beyond secondary levels did not borrow water (Table 6.2). In Kologo, where literacy rates tend to be low, educational achievement plays a crucial role in determining access to resources and adaptive measures. Women with higher education levels might have better access to resources and potentially better financial means, allowing them to implement measures to secure their water needs without resorting to borrowing from others (Mason, 2014). Women from larger families reported borrowing water (95%) more than those from smaller families (5%). Larger families consume more water due to increased household needs, which may lead to a higher likelihood of running out of water and needing to borrow from neighbours (Mason, 2014). In Kologo, extended families are common, leading to higher water demands and potential shortages. Women in these large households often face the pressure of securing enough water, prompting them to seek help from neighbors to meet their family's needs.

Table 6.2: Demographic and socioeconomic variables and the adoption of exit strategies

Variables	Water sharing practices					
	Borrowed water from household members			Collected water from neighbours		
	Women			Women		
	Yes	No	Don't Know	Yes	No	Don't Know
	Frequency (%)			Frequency (%)		
Education						
No education	7 (35)	44 (34.1)	0 (0)	3 (16.7)	48 (36.6)	0 (0)
Primary education	10 (50)	65 (50.4)	0 (0)	11 61.1)	64 (48.9)	0 (0)
Secondary education	3 (15)	19 (14.7)	1 (100)	4 (22.2)	18 (13.7)	1 (100)
Beyond secondary education	0 (0)	1 (0.8)	0 (0)	0 (0)	1 (0.8)	0 (0)
Occupation						
Farmers	12 (60)	81 (62.8)	0 (0)	12(66.6)	81 (61.8)	0 (0)
Trader/business owners	6 (30)	37 (28.7)	0 (0)	3 (16.7)	40 (30.5)	0 (0)
Formal or skilled workers	2 (10)	11 (8.5)	1 (100)	3 (16.7)	10 (7.7)	1 (100)
Health Status						
Healthy	14 (70)	95 (73.6)	1 (100)	16(88.9)	93 (71)	1 (100)
Unhealthy	6 (30)	34 (26.4)	0 (0)	2 (11.1)	38 (29)	0 (0)
Age						
18-30	5 (25)	53 (41.1)	0 (0)	7 (38.9)	51 (38.9)	0 (0)
31-50	9 (45)	46 (35.7)	1 (100)	9 (50)	46 (35.1)	1 (100)
50+	6 (30)	30 (23.3)	0 (0)	2 (11.1)	34 (26)	0 (0)
Income Rank						
Below average	2 (10)	28 (21.7)	0 (0)	2 (11.1)	28 (21.4)	0 (0)
Average	15 (75)	82 (63.6)	1 (100)	12(66.7)	85 (64.9)	1 (100)
Above average	3 (15)	19 (14.7)	0 (0)	4 (22.2)	18 (13.7)	0 (0)
Family size						
<=4	1 (5)	29 (22.5)	1 (100)	2 (11.1)	28 (21.4)	1 (100)
>4	19 (95)	100 (77.5)	0 (0)	16 88.9)	103(78.6)	0 (0)

Variables	Buying water			
	Women		Men	
	Yes	No	Yes	No
	Frequency (%)		Frequency (%)	
Education				
No education	7 (46.7)	44 (32.6)	1 (20)	40 (27.6)
Primary education	5 (33.3)	70 (51.9)	2 (40)	72 (49.7)
Secondary education	3 (20)	20 (14.8)	1 (20)	25 (17.2)
Beyond secondary education	0 (0)	1 (0.7)	1 (20)	8 (5.5)
Occupation				
Farmers	8 (53.3)	85 (63)	2 (40)	119 (82.1)

Trader/business owners	5 (33.3)	38 (28.1)	1 (20)	10 (6.9)
Formal or skilled workers	2 (13.3)	12 (8.9)	2 (40)	16 (11)
Health Status				
Healthy	10 (66.7)	100 (74.1)	5 (100)	126 (86.9)
Unhealthy	5 (33.3)	35 (25.9)	0 (0)	19 (13.1)
Age				
18-30	4 (26.7)	54 (40)	1 (20)	25 (17.2)
31-50	6 (40)	50 (37)	3 (60)	79 (54.5)
50+	5 (33.3)	31 (23)	1 (20)	41 (28.3)
Income Rank				
Below average	6 (40)	24 (17.8)	0 (0)	15 (10.7)
Average	7 (46.7)	91 (67.4)	4 (80)	109 (77.9)
Above average	2 (13.3)	20 (14.8)	1 (20)	16 (11.4)
Family size				
<=4	6 (40)	25 (18.5)	3 (60)	38 (26.2)
>4	9 (60)	110 (81.5)	2 (40)	107 (73.8)

Variables	**Collecting water from alternative sources**		
	Women		
	Yes	**No**	**Don't know**
	Frequency (%)		
Education			
No education	32 (31.1)	18 (39.1)	1 (100)
Primary education	58 (56.3)	17 (37)	0 (0)
Secondary education	13 (12.6)	10 (21.7)	0 (0)
Beyond secondary education	0 (0)	1 (2.2)	0 (0)
Occupation			
Farmers	69 (67)	23 (50)	1 (100)
Trader/business owners	25 (24.3)	18 (39.1)	0 (0)
Formal or skilled workers	9 (8.7)	5 (10.9)	0 (0)
Health Status			
Healthy	76 (73.8)	34 (73.9)	0 (0)
Unhealthy	27 (26.2)	12 (26.1)	1 (100)
Age			
18-30	45 (43.7)	13 (28.3)	0 (0)
31-50	37 (35.9)	19 (41.3)	0 (0)
50+	21 (20.4)	14 (30.4)	1 (100)

Income Rank				
Below average	21 (20.4)	9 (19.6)	0 (0)	
Average	64 (62.1)	33 (71.7)	1 (100)	
Above average	18 (17.5)	4 (8.7)	0 (0)	
Family size				
<=4	22 (21.4)	9 (19.6)	0 (0)	
>4	81 (78.6)	37 (80.4)	1 (100)	

6.3.2 Loyalty strategy

During water shortages, women prioritize essential uses like cooking and drinking, draw strength from their faith and rely on God for support, and engage in water treatment and storage techniques, all of which are loyalty strategies (Table 6.3).

Table 6.3: Loyalty strategies against suboptimal water access

Kologo sub-communities	**Reduced/prioritize water use due to water shortages and collection**						
	Women			**Men**			
	Frequency (%)			**Frequency (%)**			
	Yes	**No**		**Yes**	**No**		
Kolwingo	37 (74)	13 (26)		28 (56)	22 (44)		
Nayiire	40 (80)	10 (20)		11 (22)	39 (78)		
Zuo	49 (98)	1 (2)		0 (0)	50 (100)		
	Postponed activities due to water shortages and collection						
	Frequency (%)			**Frequency (%)**			
	Yes	**No**	**Don’t know**	**Yes**	**No**	**Don’t know**	
Kolwingo	37(74)	13(26)	0 (0)	32 (64)	18 (36)	0 (0)	
Nayiire	37(74)	13(26)	0 (0)	26 (52)	24 (48)	0 (0)	
Zuo	47(94)	3(6)	0 (0)	22 (44)	23 (46)	5 (10)	
	Water storage			**Water treatment**			
	Women			**Women**			
	Frequency (%)			**Frequency (%)**			
	Yes	**No**		**Yes**	**No**		
Kolwingo	50(100)	0 (0)		4(8)	46(92)		

Nayiire	50(100)	0 (0)			3(6)	47(94)		
Zuo	50(100)	0 (0)			0(0)	50(100)		
		Domestic activities that women reduced or prioritized water use						
		Bathing		**Bathing and washing**	**Cooking**	**Washing**	**All domestic activities**	
		Frequency (%)						
Kolwingo	**Women**	5 (10)		2 (4)	7 (14)	23 (46)	0 (0)	
	Men	0 (0)		0 (0)	0 (0)	0 (0)	28 (56)	
Nayiire	**Women**	10 (20)		4 (8)	2 (4)	24 (48)	0 (0)	
	Men	0 (0)		0 (0)	0 (0)	0 (0)	6 (12)	
Zuo	**Women**	15 (30)		6 (12)	5(10)	23 (46)	0 (0)	
	Men	0 (0)		0 (0)	0 (0)	0 (0)	0(0)	
		Postponed activities, or tasks due to water shortages and collection						
		Bathing	**Washing**	**Cooking**	**House cleaning**	**Washing and cooking**	**Farming activities**	**Business activities**
		Frequency (%)						
Kolwingo	**Women**	3 (6)	13 (26)	13 (26)	3 (6)	5 (10)	0 (0)	0 (0)
	Men	0 (0)	0 (0)	14 (28)	0 (0)	3 (6)	7 (14)	8 (16)
Nayiire	**Women**	2 (4)	20 (40)	9 (18)	5 (10)	1 (2)	0 (0)	0 (0)
	Men	0 (0)	0 (0)	13 (26)	0 (0)	4 (8)	2 (4)	7(14)
Zuo	**Women**	5 (10)	22(44)	11 (22)	5 (10)	4 (8)	0 (0)	0 (0)
	Men	0 (0)	0 (0)	11 (22)	0 (0)	9 (18)	0 (0)	2 (4)
		Water storage containers				**Water treatment method**		
		Jerrycans		**Water clay pots**	**Other(e.g., Tank)**	**Filtration**		
		Frequency (%)				**Frequency (%)**		
Kolwingo	**Women**	19 (38)		15 (30)	16 (32)	4 (8)		
Nayiire	**Women**	28 (56)		16 (32)	6 (12)	3 (6)		
Zuo	**Women**	21 (42)		28 (56)	1 (2)	0 (0)		

6.3.2.1 Reducing or prioritizing water use

In both Kolwingo and Nayiire, 74% of women (corroborated by 56% of men) reported reducing or prioritizing water use due to the demands of collecting water or scarcity (Table 6.3).

In Zuo, almost 100% of women indicate that they used these strategies, despite none of the men recognising that women engage in these practices. While varying across sub-communities, changes primarily focused on washing (over 40%), bathing (≥30%), and cooking (≥14%). However, this practice carries potential risks and vulnerabilities for women and their families, such as nutritional and hygiene issues (Apatinga et al., forthcoming). As with borrowing water, highest priority is placed on drinking and cooking: *"We prioritize cooking and drinking when there is water shortage but when critical, we use for drinking only till the next day"* (Young Women, FGD, Nayiire); *"When there's not enough water, we use little to cook and bath till the next day"* (Older Women, FGD, Zuo). There is also evidence of the intersection between exit and loyalty strategies: *"Because we buy the water, we manage it by using little to bath and also cook"* (Older Women, FGD, Kolwingo). These prioritizations appear to be supported by men, even in Zuo, which was not apparent in survey data: *"In case of water shortages, cooking and drinking are given the highest priority"* (Young Men, FGD, Kolwingo); *"Drinking is the most prioritized when we don't have enough water"* (Young Men, FGD, Nayiire); *"When there is water shortage, drinking and cooking are the highest priority. This is because, if you don't drink water, you can die likewise eating. Therefore, we give much priority to drinking and cooking"* (Adult Men, FGD, Zuo). In Kologo, persistent water shortages lead to adaptive measures like reducing or prioritizing water use. Women, responsible for household tasks due to traditional gender roles, ensure vital needs like drinking and cooking are met, playing a crucial role in deciding how water is used. Women with primary education were more inclined to reduce or prioritize water use (52%), followed by those without education (33%) (Table 6.4). In contrast, women with secondary education (13%) and beyond secondary education (0.8%) exhibit lower engagement in reducing or prioritizing water use. Perhaps because they might have better access to financial and water resources that alleviate the immediate need for stringent water conservation measures, as demonstrated in the use of loyalty strategies and Mason (2014). Women engaged in farming activities are notably more prone to reduce or prioritize water use (62%) compared to their counterparts working as traders (27%) and formal or skilled workers (10%). A majority of participants with larger family sizes (more than 60%) were more likely to reduce or prioritize water use than those with smaller families, again likely due to overall household demand being higher, exacerbating impacts of water shortages.

6.3.2.2 Postponing or deferring (domestic) activities

Over 70% of women from all sub-communities mentioned postponing activities due to the need to collect water. The activity most delayed was washing (reported by 40 % of women in Nayiire, 44% of women in Zuo, and 26% of women in Kolwingo) (Table 6.3). Cooking was also identified, particularly among women and men in Kolwingo (26% and 28%, respectively) and Zuo (26% and 22%, respectively). In addition, men's narratives shed light on how water shortages and the time spent collecting water led to the postponement of agricultural and non-agricultural activities, with this issue being more pronounced in Kolwingo (16%) and Nayiire (14%). In FGDs, women also discussed curtailing essential activities like bathing and laundry: *"If there is not much water, I cook and reserve some for drinking and forgo the washing"* (Adult Women, FGD, Kolwingo*); "When there is water shortage, we use the little to cook because if you use the water to bath without cooking, the children will cry till daybreak. We postpone bathing"* (Young Women, FGD, Nayiire); *"Due to the distance, we are, sometimes, not able to get enough for bathing, so we just cook and leave bathing out"* (Older Women, FGD, Zuo). Kologo's arid setting complicates water access, influencing women's decision-making. The distance to water sources and the lack of infrastructure force women to prioritize water collection over other tasks, often delaying activities like farming. Limited amenities and financial resources exacerbate these challenges, leading women to adjust their schedules and prioritize essential uses such as cooking and drinking, while delaying washing and bathing. Traditional gender roles place the burden of water collection and household chores on women, highlighting the significant impact of water scarcity on their daily lives and responsibilities. However, postponing activities due to water shortages and the need to collect water varies among women (Table 6.4). Similar to the use of other coping strategies, women with primary (53%) or no education (37%) are more inclined to delay activities (Table 6.4). Women with higher levels of education likely have access to better resources and opportunities, such as the ability to pay for water services, which may prevent them from postponing activities compared to those with lower levels of education. Farmers also exhibit the highest percentage (60%) of postponed activities due to water shortages compared to individuals in other occupations do women with larger families (78%). Abubakar (2018) found that suspending domestic activities and recycling water were common practices among households facing water insecurity in Nigeria. These findings also align with a study conducted in Tanzania by Nganyanyuka et al. (2014). Although not explored in this study, loyalty strategies such as reducing water use and postponing activities may pose health risks for women and their families (Abubakar, 2018; Majuru et al., 2016). For instance, refraining from bathing and minimizing water use due to water insecurity can have significant health implications (Hutton & Chase, 2016).

6.3.2.3 Water storage

Women across communities universally store water in their households (Azage et al., 2021; Oloruntoba et al., 2019) (Table 6.3). Various water storage vessels, including jerrycans, clay pots, and tanks were reported. Jerrycans were the predominant choice for storage containers in Nayiire

(56%) and were used to a lesser degree in Kolwingo (38%), while clay pots were preferred in Zuo (56%). However, if women lack resources to maintain storage containers (Daniel, 2021; Tafesse et al., 2021) or if stored for long periods (Ablo & Yekple, 2018; Wright et al., 2018), water contamination can become an issue, threatening the health of the household. This is particularly challenging when there is a lack of access to water quality testing. Within Kologo's communities, the availability and reliability of water sources directly affect the need for home water storage. Due to persistent water scarcity and limited access to centralized water systems, households store water in containers to manage the impact of fluctuating supply and to ensure they have water during times of scarcity.

6.3.2.4 Water treatment

While less common, some women take measures to enhance the safety of their water (Table 6.3). Eight percent of women in Kolwingo and 6% in Nayiire report treating water. In these communities, frequent challenges in accessing clean and safe water arise from insufficient infrastructure and environmental factors. As a result, women often resort to water treatment techniques to manage water collected from unimproved sources. Filtration was the primary form of treatment and was associated with water from unprotected wells and surface water sources: *"We fetch from the wells when there is no money to buy from the tap and we boil it before we drink, or we sieve it"* (Older Women, FGD, Kolwingo); *"We tie nets at the mouths of our pots to sieve particles when pouring the water inside"* (Older Women, FGD, Nayiire); *"I fetch and wait for the dirt to settle then I sieve into another clean basin before pouring the dirt away"* (Young Women, FGD, Zuo). If treating water, rural households often resort to basic methods like boiling and filtration to render water safe for drinking (Merga et al., 2022; Tsegaye et al., 2021). Because of the impoverished nature of communities in Kologo, women often have limited financial capacity to invest in advanced water treatment technologies. Many face financial constraints that make it difficult to afford costly treatment systems or commercially treated water. As a result, women rely on affordable and simple methods like boiling and filtration, which are more economically feasible. Despite convenience, relatively low cost, and ability to eliminate some particles, these traditional techniques may not completely eliminate pathogens (Chaurasia & Tiwari, 2016).

6.3.2.5 Psychological response

FGDs identified emotional and psychological strategies in response to water shortages. For example, women shared their dependence on faith and spirituality as mechanisms to navigate the difficulties arising from water scarcity. They openly discussed the profound distress they endure due to insufficient support: *"It is not easy to fetch or access water but because we have no choice, we take it like that"* (Adult Women, FGD, Kolwingo), and conveyed a feeling of acceptance as they rely on divine intervention for relief: *"Our suffering is too much; we don't have any support, so we give everything to God knowing it is impossible"* (Adult Women, FGD, Zuo). Men also emphasized a spirit of persistence and dependence on faith when confronting water-related obstacles. *"All our hope is on God; we rely on God for our upliftment"* (Older Men, FGD, Nayiire). In Kologo and its communities, which are comprised of a mix of Christians, Muslims, and traditional worshippers, cultural and spiritual traditions significantly influence how women and residents cope with water scarcity. Faith and spirituality, rooted in their diverse beliefs and values, serve as key coping mechanisms in addressing such challenges. These narratives underscore the intricate interplay between external challenges and inner emotional reactions, showcasing women's ability to navigate challenging situations while drawing strength and support from their cultural values and personal beliefs. Similar findings have been observed in previous studies (Grasham et al., 2019; Smiley, 2016). However, one could contend that loyalty-focused strategies are relatively less effective and adaptive among the various coping strategies. When certain fundamental activities are prioritized over others or delayed due to water scarcity, it has adverse consequences for every family member. This situation disproportionately affects women, as they are often required to prioritize the needs of men first, followed by those of children, before considering their own (Pommells et al., 2018).

Table 6.4: Demographics and socioeconomic variables and adoption of loyalty strategies

Variables	Reduced, or prioritized water use due to water shortages and collection				
	Women		Men		
	Yes	No	Yes	No	
	Frequency (%)		Frequency (%)		
Education					
No education	42 (33.6)	9 (36)	8 (20.5)	33 (29.7)	
Primary education	65 (52)	10 (40)	17 (43.6)	57 (51.4)	
Secondary education	17 (13.6)	6 (24)	11 (28.2)	15 (13.5)	
Beyond secondary education	1 (0.8)	0 (0)	3 (7.7)	6 (5.4)	
Occupation					
Farmers	78 (62.4)	15 (60)	25 (64.1)	96 (86.5)	
Trader/business owners	34 (27.2)	9 (36)	7 (17.9)	4 (3.6)	
Formal or skilled workers	13 (10.4)	1 (4)	7 (17.9)	11 (9.9)	
Health Status					
Healthy	91 (72.8)	19 (76)	36 (92.3)	95 (85.6)	
Unhealthy	34 (27.2)	6 (24)	3 (7.7)	16 (14.4)	
Age					
18-30	51 (40.8)	7 (28)	13 (33.3)	13 (11.7)	
31-50	43 (34.4)	13 (52)	21 (53.8)	61 (55)	
50+	31 (24.8)	5 (20)	5 (12.8)	37 (33.3)	
Income Rank					
Below average	21 (16.8)	9 (36)	2 (5.3)	13 (12.1)	

Average	83 (66.4)	15 (60)	28 (73.7)	85 (79.4)
Above average	21 (16.8)	1 (4)	8 (21.1)	9 (8.4)
Family size				
<=4	22 (17.6)	9 (36)	12 (30.8)	29 (26.1)
>4	103 (82.4)	16 (64)	27 (69.2)	82 (73.9)

	Postponed activities due to water shortages and collection				
	Women		**Men**		
	Yes	**No**	**Yes**	**No**	**Don't Know**
	Frequency (%)		**Frequency (%)**		
Education					
No education	37 (30.8)	14 (46.7)	27 (33.8)	12 (18.5)	2 (40)
Primary education	64 (53.3)	11 (36.7)	34 (42.5)	38 (58.5)	2 (40)
Secondary education	18 (15)	5 (16.7)	14 (17.5)	11 (16.9)	1 (20)
Beyond secondary education	1 (0.8)	0 (0)	5 (6.3)	4 (6.2)	0 (0)
Occupation					
Farmers	73 (60.8)	20 (66.7)	63 (78.8)	54 (83.1)	4 (80)
Trader/business owners	35 (29.2)	8 (26.7)	6 (7.5)	5 (7.7)	0 (0)
Formal or skilled workers	12 (10)	2 (6.7)	11 (13.8)	6 (9.2)	1 (20)
Health Status					
Healthy	89 (74.2)	21 (70)	69 (86.3)	57 (87.7)	5 (100)
Unhealthy	31 (25.8)	9 (30)	11 (13.8)	8 (12.3)	0 (0)
Age					
18-30	49 (40.8)	9 (30)	14 (17.5)	11 (16.9)	1 (20)
31-50	44 (36.7)	12 (40)	43 (53.8)	36 (55.4)	3 (60)
50+	27 (22.5)	9 (30)	23 (28.7)	18 (27.7)	1 (20)
Income Rank					
Below average	23 (19.2)	7 (23.3)	7 (8.9)	8 (13.1)	0(0)
Average	79 (65.8)	19 (63.3)	59 (74.7)	49 (80.3)	5 (100)
Above average	18 (15)	4 (13.3)	13 (16.5)	4 (6.6)	0 (0)
Family size					
<=4	26 (21.7)	5 (16.7)	23 (28.7)	17 (26.2)	1 (20)
>4	94 (78.3)	25 (83.3)	57 (71.3)	48 (73.8)	4 (80)

Variables	**Water treatment**	
	Women	
	Yes	**No**
	Frequency (%)	
Education		
No education	3 (42.9)	48 (33.6)
Primary education	4 (57.1)	71 (49.7)
Secondary education	0 (0)	23 (16.1)
Beyond secondary education	0 (0)	1 (0.7)
Occupation		
Farmers	4 (57.1)	89 (62.2)
Trader/business owners	3 (42.9)	40 (28)

Formal or skilled workers	0 (0)	14 (9.8)	
Health Status			
Healthy	5 (71.4)	105 (73.4)	
Unhealthy	2 (28.6)	38 (26.6)	
Age			
18-30	1 (14.3)	57 (39.9)	
31-50	3 (42.9)	53 (37.1)	
50+	3 (42.9)	33 (23.1)	
Income Rank			
Below average	2 (28.6)	28 (19.6)	
Average	4 (57.1)	94 (65.7)	
Above average	1 (14.3)	21 (14.7)	
Family size			
<=4	2 (28.6)	29 (20.3)	
>4	5 (71.4)	114 (79.7)	

6.3.3 Voice strategy or collective action

Both women and men participants reported engaging in collective action to address water access challenges and mitigate the burden of water insecurity on women at the community level (Table 6.5).

Table 6.5: Voice strategies against suboptimal water access

Kologo sub-communities	**Discuss water related issues at the individual level**					
	Women			**Men**		
	Frequency (%)			**Frequency (%)**		
	Yes		**No**	**Yes**	**No**	
Kolwingo	44 (88)		6 (12)	39 (78)	11 (22)	
Nayiire	43 (86)		7 (14)	18 (36)	32 (64)	
Zuo	44 (88)		6 (12)	9 (18)	41(82)	
	Discuss water-related issues at community meetings					
	Women			**Men**		
	Frequency (%)			**Frequency (%)**		
	Yes	**No**	**Don't know**	**Yes**	**No**	**Don't know**
Kolwingo	27 (54)	10 (20)	13 (26)	40 (80)	5 (10)	5 (10)
Nayiire	27 (54)	15 (30)	8 (16)	37 (74)	2 (4)	11(22)

Zuo	19 (38)	19 (38)	12 (24)	28(56)	2(4)	20 (40)
	Attending community meetings to discuss water-related issues					
	Women			**Men**		
	Frequency (%)			**Frequency (%)**		
	Yes	**No**		**Yes**	**No**	
Kolwingo	23 (46)	27 (54)		39 (78)	11 (22)	
Nayiire	19 (38)	31 (62)		34 (68)	16(32)	
Zuo	18 (36)	32 (64)		30 (60)	20 (40)	
	Women's participation in water decision-making in Kologo					
	Women			**Men**		
	Frequency (%)			**Frequency (%)**		
	Yes	**No**	**Don't know**	**Yes**	**No**	**Don't know**
Kolwingo	27(54)	7 (14)	16 (32)	39 (88)	0 (0)	11(22)
Nayiire	21 (42)	16 (32)	13 (26)	35 (70)	0 (0)	15 (30)
Zuo	17 (34)	20 (40)	13 (26)	30 (60)	0 (0)	20(40)
	Is the government doing well in providing sufficient water for your community?					
	Women			**Men**		
	Frequency (%)			**Frequency (%)**		
	Yes	**No**		**Yes**	**No**	
Kolwingo	12 (24)	38 (76)		28 (56)	22 (44)	
Nayiire	10 (20)	40 (80)		30 (60)	20 (40)	
Zuo	9 (18)	41 (82)		41 (82)	9 (18)	

Discussions centred on water access and its associated challenges are prevalent topics of conversation within the Kologo community (Table 6.5). At the individual level, more than 80% of women in all sub-communities engage in dialogues related to water issues. Notably, 88% of women in Kolwingo and Zuo indicated increased participation rates in dialogues, with Zuo women following closely at 86%. While men also discuss water issues among themselves, their reported involvement lags behind that of women, particularly in Nayiire (36% of men) and Zuo (18% of men). This gap can be explained by the cultural norms of Kologo, where men typically avoid direct participation in household water-related duties, leading to their reduced involvement in these discussions. This pattern reflects the broader context of Kologo, where water scarcity and its management are closely intertwined with daily activities and community interactions. The cultural contexts of Kologo dictate that women and girls are uniquely responsible for water collection: *"Traditionally, a woman is born to fetch water. Again, women do use water more than man"* (Young Men, FGD, Kolwingo); *"It is nature that gave women the responsibility to fetch water"* (Young Men, FGD, Nayiire). Conversely, men predominantly influence household decision-making regarding financial matters (Apatinga et al. forthcoming). This naturally leads to women sharing their experiences, especially during gatherings or when collaborating on these tasks. However, when attending community meetings to address water access and related issues, 20-30% more men reported participating than women across all three sub-communities (Table 6.5). For example, in Kolwingo, 78% of men versus 46% of women attend these meetings. This gender gap in meeting attendance is not unexpected, especially in the Kologo communities where deeply ingrained traditional gender norms assign leadership roles to men and encourage their greater involvement in public forums like community meetings. Additionally, there might be a lack of awareness among women or primary responsibilities such as household chores and caregiving that limit their availability for these gatherings.

However, it is crucial to note that women who attend these meetings significantly contribute to decision-making regarding water at the community level. This is evident, especially in Kolwingo, where 54% of women participate in these decisions and 60% of men acknowledged the valuable contributions of women to water decision-making processes (Table 6.5). While traditional gender roles in these communities often designate women as responsible for domestic tasks, including water collection, there is recognition of the valuable insights and contributions women bring to water management. This underscores women's crucial role in managing water resources and advocating for their communities' needs. The active involvement of women in these conversations indicates that their voices are considered when addressing water-related challenges. This inclusive approach defies cultural and traditional norms and promotes women's empowerment, drawing upon their experiences and perspectives to enhance water security within their communities.

FGDs shed light on how women and men proactively participate in collective efforts, including social action and voicing concerns, to tackle water access challenges in their communities. They take the initiative to introduce local solutions and engage in communal measures to resolve water-related challenges, such as digging wells: "*We* as a *people have tried a lot in providing water. Digging of wells and making sure boreholes are maintained is part of our duties in providing water for us"* (Adult Men, FGD, Zuo).

In addition to collective efforts to diversify water sources, women from Kolwingo and Zuo reported attempts to voice grievances and seek assistance from external entities, primarily the government, in addressing their water predicament. However, they expressed frustration at the lack of tangible results, perceiving these efforts to be met with empty promises. *"We have spoken about this [water problem] countless time and they come and deceive us without any help to improve our situation"* (Older Women, FGD, Kolwingo); *"The government should get us water to drink. I have been saying this, but nothing happens, we are pleading for help"* (Young Women, FGD, Zuo). These expressions of discontent reveal their dissatisfaction and disappointment regarding the absence of external aid and cooperation in tackling their water-related problems. In particular, their discontent is directed towards the national government, with many individuals complaining about how it has failed to ensure an adequate water supply for their communities (Table 6.5). Essentially, Kologo epitomizes an underdeveloped community characterized by a lack of crucial social amenities and restricted water resources. This absence of infrastructure and aid highlights a broader issue; the pervasive neglect and inadequate support faced by rural areas like Kolwingo and Zuo. The issues voiced by women underscore a significant gap in fulfilling the basic needs of these communities. Notably, women across sub-communities consistently expressed significantly higher levels of dissatisfaction, exceeding 70%, in contrast to men, whose dissatisfaction tends to be below 50%. This divergence in perception is likely due to prevailing gender norms and roles, with men less directly involved in domestic water management. Dissatisfaction tends to decrease as educational attainment rises (Table 6.6). Men (48%) and women (52%) with primary education tended to express higher dissatisfaction levels with government water provision, followed by those with no education, secondary education, and education beyond the secondary level. Furthermore, the highest dissatisfaction rates are reported among women (45%) and men (66%) engaged in farming. In addition, larger family sizes tend to correspond with higher dissatisfaction rates, affecting both women (94%) and men (36%). Like the Kologo community, similar strategies have been identified in studies conducted in other regions (Etongo et al., 2018; Jamal & Rahman, 2012). For instance, Bisung et al. (2014) reported the formation of a water and sanitation committee in Usoma, Kenya, where community members mobilized resources to support international organizations' efforts to provide water supply. However, the occurrence of collective action may depend on various factors (Manzungu et al., 2012). Social cohesion, trust, coordination, leadership, and financial capacity are vital in promoting collective action (Chaminuka & Nyatsanza, 2013; Nganyanyuka et al., 2014), suggesting that in the absence of such elements poor water access will be a persistent reality. Limited social capital, as found by Levison et al. (2011) in Usoma, Kenya, can impact the effectiveness of collective action. Some participants in this study also highlighted financial challenges, with difficulties in making payments or prolonged delays in collective contributions towards water facility maintenance due to poverty. While local communities must embark on self-initiated projects to enhance their water access, it is essential to recognize that these efforts alone may not guarantee adequacy, reliability, and affordability. Such initiatives can become a substantial burden without external assistance, particularly for communities with limited resources.

Table 6.6: Demographic and socioeconomic variables and dissatisfaction with government

Variable	Dissatisfaction with government provisioning of water			
	Women		Men	
	Yes	No	Yes	No
	Frequency (%)			
Education				
No education	11(35.5)	40 (33.6)	26 (26.5)	15 (28.8)
Primary education	13 (41.9)	62 (52.1)	49 (50)	25 (48.1)
Secondary education	6 (19.4)	17 (14.3)	15 (15.3)	11 (21.2)
Beyond secondary education	1 (3.2)	0 (0)	8 (8.2)	1 (1.9)
Occupation				
Farmers	14 (45.2)	79 (66.4)	82 (83.7)	39 (75)
Trader/business owners	15 (48.4)	28 (23.5)	5 (5.1)	6 (11.5)
Formal or skilled workers	2 (6.5)	12 (10.1)	11 (11.2)	7 (13.5)
Health Status				
Healthy	25 (80.6)	85 (71.4)	85 (86.7)	46 (88.5)
Unhealthy	6 (19.4)	34 (28.6)	13 (13.3)	6 (11.5)
Age				
18-30	8 (25.8)	50 (42)	12 (12.2)	14 (26.9)
31-50	15 (48.4)	41 (34.5)	57 (58.2)	25 (48.1)
50+	8 (25.8)	28 (23.5)	29 (29.6)	13 (25)
Income Rank				
Below average	5 (16.1)	25 (21)	10 (10.8)	5 (9.6)
Average	23 (74.2)	75 (63)	73 (78.5)	40 (76.9)
Above average	3 (9.7)	19 (16)	10 (10.8)	7 (13.5)

Family size				
<=4	6 (19.4)	25 (21)	25 (25.5)	16 (30.8)
>4	25 (80.6)	94 (79)	73 (74.5)	36 (69.2)

6.3.4 Combination of strategies to cope with suboptimal water access

From the foregoing, it is clear that various coping mechanisms are employed to tackle the issue of limited water access. While there is great variation, these strategies may be deployed simultaneously or interchangeably within and across strategy types to address water access challenges (Tables 6.7 & 6.8).

Table 6.7: Combination of strategies Kologo women employ against suboptimal water access

Coping strategies	Women	
Number of Exit Strategies	**Frequency**	**Percentage**
0	35	23.3
1	86	57.3
2	18	12
3	10	6.7
4	1	0.7
Total	150	100
Number of Loyalty Strategies		
0	14	9.3
1	26	17.3
2	104	69.3
3	6	4.0
Total	150	100
Number of Voice Strategies		
0	9	7.7
1	34	29.1
2	21	17.9
3	53	45.3

Total	117	100

Table 6.8: Combination of strategies against suboptimal water access women employ in Kologo sub-communities

<table>
<tr><th rowspan="3">Kologo Sub-communities</th><th colspan="8">Number of Exit Strategies</th></tr>
<tr><th colspan="2">0</th><th>1</th><th colspan="2">2</th><th>3</th><th colspan="2">4</th></tr>
<tr><th colspan="8">Frequency (%)</th></tr>
<tr><td>Kolwingo</td><td colspan="2">7 (14)</td><td>33 (66)</td><td colspan="2">6 (12)</td><td>4 (8)</td><td colspan="2">0 (0)</td></tr>
<tr><td>Nayiire</td><td colspan="2">14 (28)</td><td>25 (50)</td><td colspan="2">8 (16)</td><td>2 (4)</td><td colspan="2">1 (2)</td></tr>
<tr><td>Zuo</td><td colspan="2">14 (28)</td><td>28 (56)</td><td colspan="2">4 (8)</td><td>4 (8)</td><td colspan="2">0 (0)</td></tr>
<tr><th rowspan="3"></th><th colspan="6">Number of Loyalty Strategies</th><th colspan="2"></th></tr>
<tr><th colspan="2">0</th><th>1</th><th colspan="2">2</th><th>3</th><th colspan="2">Total</th></tr>
<tr><th colspan="8">Frequency (%)</th></tr>
<tr><td>Kolwingo</td><td colspan="2">9 (64.3)</td><td>8 (30.8)</td><td colspan="2">29 (27.9)</td><td>4 (66.7)</td><td colspan="2">50 (33.3)</td></tr>
<tr><td>Nayiire</td><td colspan="2">5 (35.7)</td><td>13 (50)</td><td colspan="2">30 (28.8)</td><td>2 (33.3)</td><td colspan="2">50 (33.3)</td></tr>
<tr><td>Zuo</td><td colspan="2">0 (0)</td><td>5 (19.2)</td><td colspan="2">45 (43.3)</td><td>0 (0)</td><td colspan="2">50 (33.3)</td></tr>
<tr><th rowspan="3"></th><th colspan="8">Number of Voice Strategies</th></tr>
<tr><th colspan="2">0</th><th>1</th><th colspan="2">2</th><th>3</th><th colspan="2">Total</th></tr>
<tr><th colspan="8">Frequency (%)</th></tr>
<tr><td>Kolwingo</td><td colspan="2">1 (11.1)</td><td>10 (29.4)</td><td colspan="2">6 (28.6)</td><td>20 (37.7)</td><td colspan="2">37 (31.6)</td></tr>
<tr><td>Nayiire</td><td colspan="2">2 (22.2)</td><td>13 (38.2)</td><td colspan="2">10 (47.6)</td><td>17 (32.1)</td><td colspan="2">42 (35.9)</td></tr>
<tr><td>Zuo</td><td colspan="2">6 (66.7)</td><td>11 (32.4)</td><td colspan="2">5 (23.8)</td><td>16 (30.2)</td><td colspan="2">38 (32.5)</td></tr>
<tr><th rowspan="3"></th><th colspan="8">Deploying tactics across the three distinct strategies</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th></tr>
<tr><th colspan="8">Frequency (%)</th></tr>
<tr><td>Kolwingo</td><td>1 (2.7)</td><td>1 (2.7)</td><td>3 (8.1)</td><td>10 (27)</td><td>7 (18.9)</td><td>10 (27)</td><td>3 (8.1)</td><td>2 (5.4)</td></tr>
<tr><td>Nayiire</td><td>0 (0)</td><td>2 (4.8)</td><td>11 (26.2)</td><td>8 (19)</td><td>9 (21.4)</td><td>5 (11.9)</td><td>5 (11.9)</td><td>2 (4.8)</td></tr>
<tr><td>Zuo</td><td>0 (0)</td><td>3 (7.9)</td><td>4 (10.5)</td><td>9 (23.7)</td><td>9 (23.7)</td><td>10 (26.3)</td><td>2 (5.3)</td><td>1 (2.6)</td></tr>
</table>

Almost one in four women surveyed (35 out of 150) did not utilize an exit strategy (primarily in Nayiire and Zuo), while almost one in three employed a single exit strategy (e.g., accessing alternative water sources). Only 12% adopted two strategies and 6% used three different approaches (accessing alternative water sources, buying water and water sharing)

(Table 6.7). However, in Nayiire, 50% of women reported using two exit strategies (Table 6.8). The utilization of two or more exit strategies suggests that women need to diversify their approaches to address constraints related to water access. It is important to recognize that the combination of these strategies is influenced by various demographic and socioeconomic factors among women (Table 6.9). The diverse strategies likely stem from a mix of demographic and socioeconomic factors observed in Kologo, such as education levels, household composition, and financial access. Additionally, contextual factors like the availability of communal water infrastructure and reliability of alternative water sources also influence women's decisions regarding exit strategies.

Likewise, women employ a mix of loyalty strategies (Table 6.7). A relatively small proportion of women (9%) did not employ any loyalty strategies, while about 17% utilized one loyalty strategy. Most women (69%) employed two loyalty strategies (e.g., reducing water usage and postponing activities), and 4% utilized all three (reducing water usage, postponing activities and water treatment). The number of women not engaging in loyalty strategies was higher than exit strategies, with 64% of women in Kolwingo and 35% in Nayiire (Table 6.8). These differences in strategy adoption can be attributed to several factors, including access to resources, personal preferences, community norms, and cultural values. For instance, women with greater access to resources, such as time, finances, and support networks, may be better positioned to employ multiple strategies than those with limited resources. Additionally, local community norms and practices can strongly influence strategy adoption. If a particular loyalty coping strategy is commonly employed within a community, women may be more inclined to adopt it, regardless of their characteristics. The different rates of loyalty strategy adoption among sub-communities highlight the need to grasp the unique socio-cultural contexts and community dynamics within Kologo. The scattered settlements in Kologo greatly affect the availability and accessibility of water sources. Households farther from these sources may often encounter more significant obstacles in obtaining water, potentially leading them to employ different loyalty strategies compared to those closer to accessible sources.

Regarding voice strategies (Table 6.7), a minimal percentage (7.7%) of women did not partake in any voice strategies. Almost 29% adopted a single voice strategy, 17% employed two strategies, and the most substantial share (45%) utilized three voice strategies (engaging in individual water discussions, engaging in community water discussions, and attending community meetings). This proactive engagement originates directly from the lack of water facilities in these communities. It prompts individuals to participate actively in meetings and discussions, advocating for improvements to address the persistent water challenges. This significant engagement in voice strategies demonstrates a strong commitment to collaborative efforts and advocacy to address water access issues at the community and individual levels. However, the degree of collective action varies across communities (Table 6.8). A higher percentage of women from Kolwingo (37%) employed three voice strategies compared to Nayiire women (32%) and Zuo women (30%). The more severe water insecurity situation in Kolwingo, relative to the other two communities, particularly Nayiire where the chief of Kologo resides, underscores the need for more active engagement and advocacy in Kolwingo. Despite these differences, the data underscore women's substantial endeavours to address water access challenges through community initiatives and advocacy. This contradicts evidence suggesting women are frequently marginalized or overlooked in water resource management and planning. What is required is discovering methods to foster and enhance women's involvement in these meetings to leverage their experiences and perspectives to inform water resource management and planning (Eaton et al., 2021; Mandara et al., 2017).

Significant differences become apparent when considering the demographic and socioeconomic variables of women participating in voice strategies (Table 6.9). Women with no education (52%) demonstrate a higher tendency to employ three strategies compared to those with primary education (35%), secondary education (11%), and beyond secondary education (0%). This discrepancy may be due to more severe access challenges faced by uneducated women, compelling them to engage in collective action strategies to address their water challenges. Furthermore, farmers (64%) and traders/business owners (34%) exhibit a higher tendency to use three strategies than formal or skilled workers (1.9%). In a farming community like Kologo, forming unions is common among farmers, fostering stronger ties and networks. This increased community cohesion may contribute to the greater inclination of women in this occupational type to participate in collective voice strategies. These discrepancies highlight the socioeconomic context of the Kologo community, marked by elevated poverty levels and limited literacy rates. They emphasize the intricate interplay among education, employment, and communal dynamics in shaping women's responses to water insecurity in Kologo. Women who self-identified as healthy (62%) were more inclined to use three strategies than those who describe themselves as unhealthy (37%). This is not surprising as healthy women's physical and mental well-being may enable them to actively engage in collective voice strategies more effectively. Women with larger family sizes (83%) also tend to use three strategies more than those with smaller families (17%). Larger families have more significant water requirements, which makes it reasonable for them to adopt a combination of voice strategies to address access challenges. It is clear that a complex interplay of factors influences women's adoption of voice strategies. While various backgrounds play a role, utilizing three strategies suggests that these women are more actively involved in collective efforts and are more committed to addressing water access challenges within their communities than those who rely on one or two strategies. Although there is a collective responsibility to address water access challenges, the degree of involvement varies among women with different backgrounds.

In some cases, women employ a combination of exit (seeking alternative water sources or relocating), loyalty (adapting and conserving water), and voice (expressing grievances and advocating for change) strategies to tackle access challenges (Table 6.8). For example, women employed six tactics within these strategies (e.g., utilizing alternative water sources, sharing water, reducing water consumption, delaying tasks, engaging in community water discussions, and attending community meetings), with varying proportions across communities (Kolwingo-27%; Zuo-26%; Nayiire-11%). This variation is understandable given the widespread water insecurity in Kologo, exacerbated by enduring poverty and low literacy rates. These factors limit access to the opportunities and resources needed to ensure water availability. This proactive engagement in diverse methods highlights an intensified effort to confront water access challenges. However, capital-intensive strategies like purchasing water and drilling wells can impose financial burdens (Lee et al., 2019; Majuru, 2015). Laborious or time-intensive coping strategies, such as collecting water from distant sources and treating water, can result in time loss for productive activities, increased risk of violence, and nutritional depletion (Majuru, 2015). Balancing the benefits of these coping mechanisms while minimizing potential risks, particularly associated with exit and loyalty strategies, is crucial.

Surprisingly, this study has discovered a phenomenon worth further study where some women across communities abstained from employing coping strategies when confronted with water insecurity within the same communities as their peers (Tables 6.7 & 6.8). Among those who did not employ exit strategies, a considerable proportion had no formal (40%) or primary education (40%) (Table 6.9). Also, many women with an average income (71%) did not employ exit strategies. Zero-loyalty strategies were more common among women with lower education levels, specifically those with no education (35%) and primary education (42%) (Table 6.9). Regarding those who did employ voice strategies, a substantial proportion consisted of women with no education (44%) and primary education (44%), primarily farmers (44%) and traders/business owners (33%). Additionally, women with below-average incomes (22%) and larger family sizes (88%) were significantly represented in this category. This situation illustrates how contextual and compositional factors in Kologo greatly impact women's adoption of coping mechanisms to address insufficient water access. Factors like widespread poverty, low literacy rates, and inadequate water infrastructure affect women in diverse ways within these communities, hindering some from employing coping strategies due to these formidable challenges. Questions that arise are: How do these women, who share the same water-scarce environments as their counterparts, manage to exist without resorting to any coping mechanisms? What factors might inhibit these women from embracing strategies to enhance their water access in the face of the ongoing water insecurity in their communities?

Table 6.9: Demographic and socioeconomic variables and combination of strategies women employ against suboptimal water access

Variables	Number of Exit Strategies					
	0	1	2	3	4	Total
	Frequency (%)					
Education						
No education	14 (40)	27 (31.4)	8 (44.4)	2 (20)	0 (0)	51 (34)
Primary education	14 (40)	46 (53.5)	8 (44.4)	6 (60)	1 (100)	75 (50)
Secondary education	6 (17.1)	13 (15.1)	2 (11.1)	2 (20)	0 (0)	23 (15.3)
Beyond secondary education	1 (2.9)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.7)

Occupation						
Farmers	20 (57.1)	52 (60.5)	14 (77.8)	7 (70)	0 (0)	93 (62)
Trader/business owners	12 (34.3)	25 (29.1)	4 (22.2)	2 (20)	0 (0)	43 (28.7)
Formal or skilled workers	3 (8.6)	9 (10.5)	0 (0)	1 (10)	1 (100)	14 (9.3)
Health Status						
Healthy	27 (77.1)	61 (70.9)	12 (66.7)	9 (90)	1 (100)	110 (73.3)
Unhealthy	8 (22.9)	25 (29.1)	6 (33.3)	1 (10)	0 (0)	40 (26.7)
Age						
18-30	12 (34.3)	34 (39.5)	9 (50)	3 (30)	0 (0)	58 (38.7)
31-50	14 (40)	31 (36)	4 (22.2)	6 (60)	1 (100)	56 (37.3)
50+	9 (25.7)	21 (24.4)	5 (27.8)	1 (10)	0 (0)	36 (24)
Income Rank						
Below average	6 (17.1)	18 (20.9)	5 (27.8)	1 (10)	0 (0)	30 (20)
Average	25 (71.4)	57 (66.3)	8 (44.4)	7 (70)	1 (100)	98 (65.3)
Above average	4 (11.4)	11 (12.8)	5 (27.8)	2 (20)	0 (0)	22 (14.7)
Family size						
<=4	5 (14.3)	22 (25.6)	3 (16.7)	1 (10)	0 (0)	31 (20.7)
>4	30 (85.7)	64 (74.4)	15 (83.3)	9 (90)	1 (100)	119 (79.3)

	Number of Loyalty Strategies				
	0	**1**	**2**	**3**	**Total**
	Frequency (%)				
Education					
No education	5 (35.7)	12 (46.2)	32 (30.8)	2 (33.3)	51 (34)
Primary education	6 (42.9)	9 (34.6)	56 (53.8)	4 (66.7)	75 (50)
Secondary education	3 (21.4)	5 (19.2)	15 (14.4)	0 (0)	23 (15.3)
Beyond secondary education	0 (0)	0 (0)	1 (1)	0 (0)	1 (0.7)
Occupation					
Farmers	8 (57.1)	19 (73.1)	62 (59.6)	4 (66.7)	93 (62)
Trader/business owners	5 (35.7)	6 (23.1)	30 (28.8)	2 (33.3)	43 (28.7)
Formal or skilled workers	1 (7.1)	1 (7.1)	12 (11.5)	0 (0)	14 (9.3)
Health Status					
Healthy	10 (71.4)	19 (73.1)	77 (74)	4 (66.7)	110 (73.3)
Unhealthy	4 (28.6)	7 (26.9)	27 (26)	2 (33.3)	40 (26.7)
Age					
18-30	3 (21.4)	10 (38.5)	44 (42.3)	1 (16.7)	58 (38.7)
31-50	8 (57.1)	9 (34.6)	36 (34.6)	3 (50)	56 (37.3)
50+	3 (21.4)	7 (26.9)	24 (23.1)	2 (33.3)	36 (24)
Income Rank					

Below average	6 (42.9)	4 (15.4)	18 (17.3)	2 (33.3)	30 (20)	
Average	8 (57.1)	18 (69.2)	68 (65.4)	4 (66.7)	98 (65.3)	
Above average	0 (0)	4 (15.4)	18 (17.3)	0 (0)	22 (14.7)	
Family size						
<=4	4 (28.6)	6 (23.1)	19 (18.3)	2 (33.3)	31 (20.7)	
>4	10 (71.4)	20 (76.9)	85 (81.7)	4 (66.7)	119 (79.3)	
	Number of Voice Strategies					
	0	**1**	**2**	**3**	**Total**	
	Frequency (%)					
Education						
No education	4 (44.4)	8 (23.5)	2 (9.5)	28 (52.8)	42 (35.9)	
Primary education	4 (44.4)	21 (61.8)	15 (71.4)	19 (35.8)	59 (50.4)	
Secondary education	1 (11.1)	5 (14.7)	4 (19)	6 (11.3)	16 (13.7)	
Beyond secondary education	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
Occupation						
Farmers	4 (44.4)	20 (58.8)	12 (57.1)	34 (64.2)	70 (59.8)	
Trader/business owners	3 (33.3)	11 (32.4)	5 (23.8)	18 (34)	37 (31.6)	
Formal or skilled workers	2 (22.2)	3 (8.8)	4 (19)	1 (1.9)	10 (8.5)	
Health Status						
Healthy	6 (66.7)	27 (79.4)	20 (95.2)	33 (62.3)	86 (73.5)	
Unhealthy	3 (33.3)	7 (20.6)	1 (4.8)	20 (37.7)	31 (26.5)	
Age						
18-30	4 (44.4)	11 (32.4)	13 (61.9)	14 (26.4)	42 (35.9)	
31-50	2 (22.2)	15 (44.1)	8 (38.1)	19 (35.8)	44 (37.6)	
50+	3 (33.3)	8 (23.5)	0 (0)	20 (37.7)	31 (26.5)	
Income Rank						
Below average	2 (22.2)	9 (26.5)	0 (0)	11 (20.8)	22 (18.8)	
Average	3 (33.3)	20 (58.8)	18 (85.7)	36 (67.9)	77 (65.8)	
Above average	4 (44.4)	5 (14.7)	3 (14.3)	6 (11.3)	18 (15.4)	
Family size						
<=4	1 (11.1)	9 (26.5)	1 (4.8)	9 (17)	20 (17.1)	
>4	8 (88.9)	25 (73.5)	20 (95.2)	44 (83)	97 (82.9)	

6.4 Strengths and limitations of the study

Giving voice to participants in the Kologo community of Ghana sheds light on their coping strategies, which have been largely overlooked in previous research. While coping strategies may differ across regions, there is potential for sharing general ideas, approaches, and actions that are crucial for advancing gender equity in terms of water access and knowing which strategies are available to whom and when. It brings attention to the dynamics in coping with water access challenges to help inform targeted interventions and support programs aimed at improving water access resilience among diverse groups of women.

Considering the constraints inherent in different research methods and designs, integrating quantitative and qualitative approaches within a single study is instrumental in mitigating individual limitations. This synthesis yields a more nuanced understanding of how rural women contend with suboptimal access, a notable departure from prior research that relied solely on quantitative or qualitative methods.

While the study's findings provide important insights, it is essential to acknowledge the contextual limitations. Water-related experiences can vary across different geographical contexts, and caution should be exercised in generalizing the findings to other rural women and communities. Furthermore, the potential influence of social desirability bias must be considered, as participants may have over- or under-reported their experiences. Nonetheless, exploring this topic in Kologo, characterized by its extensive family networks, communal living setups, and the unique yet interconnected experiences of its sub-communities, yielded a holistic understanding of how women manage insufficient water access and remote water collection. This study points out the adaptive practices of rural women and communities in Ghana in coping with water inaccessibility, laying the foundation for future studies and initiatives to improve equitable water access and address the multifaceted impacts of water insecurity.

6.5 Conclusion

The aim of this study was to explore the coping strategies rural women employ to manage suboptimal water access in the rural community of Kologo in Ghana. Using statistical and thematic analyses to summarize the data, the findings reveal that rural women respond to suboptimal water access by employing various coping strategies simultaneously or interchangeably, which are categorized herein as exit, loyalty, and voice strategies based on the framework developed in this dissertation. Exit strategies include accessing alternative water sources, purchasing water, and collaborative water sharing within social networks. Loyalty strategies involve water treatment and storage, prioritizing or reducing water use, postponing non-essential activities, relying on faith and resilience, and seeking assistance from relatives. The voice strategy encompasses social action, such as financial contributions for maintenance and expressing complaints to address the lack of external support.

In situations where water insecurity persists, women must continue to rely on these (less effective) strategies. Meeting gender-specific responsibilities, conforming to societal norms, and avoiding potential spousal violence may drive them to utilize these coping mechanisms when confronted with water-related difficulties amidst the ongoing water insecurity. Furthermore, the ability to employ these coping mechanisms varies based on women's socioeconomic backgrounds. For instance, those in higher income brackets may not struggle to afford alternative clean water sources like piped or tap water, while those in lower income brackets may resort to unsafe sources due to financial constraints, emphasizing the critical role of socioeconomic status in coping strategies against suboptimal water access. While these coping strategies reflect the resilience and determination of rural women and dwellers to manage the impacts of poor water access, it is essential to recognize that they cannot fully address the systemic issues contributing to water access challenges. Examining women's narratives critically and drawing from existing literature sheds light on the limitations of these coping strategies. Although these strategies may aid in meeting immediate gender-specific obligations, they will likely fail to offer sustainable support. They perpetuate the issue, prompting women to utilize multiple strategies concurrently or interchangeably to tackle access challenges, consequently heightening potential risks.

Consider the scenario where rural women, reliant on distant alternative water sources, face the risk of violence and physical harm during their journeys to water sources. Similarly, loyalty strategies such as reducing water use and postponing activities are inadequate in effectively addressing the root of water access issues. Combining multiple ineffective strategies further compounds the risks, jeopardizing women's health and well-being. Thus, the challenge lies in how these women can leverage the advantages of these coping strategies while mitigating associated risks. Collectively, this underscores the notion that promoting and perpetuating the concept of coping with suboptimal water access is not an option. Coping only helps to adapt to and build resilience against the situation but does not completely resolve it. Allowing the use of (maladaptive) coping strategies for inadequate water access will only potentially hamper or undo progress towards women's empowerment and the goal of gender equality within the sustainable development framework in the long term. In addition, this research adds to and enhances the existing but limited body of literature that critically examines the coping strategies that rural women employ in the face of water insecurity and vulnerability in Ghana and other contexts. It highlights a crucial topic and aids progress in ensuring equitable access to safely managed water in impoverished and remote areas, in alignment with the global goal of sustainable and inclusive water resource management.

CHAPTER SEVEN

Conclusion

7.0 Introduction

In sub-Saharan Africa, households traditionally task women and adolescent girls to provide water for domestic use, a practice rooted in socially constructed gender norms and roles. In rural areas of sub-Saharan Africa, accessing water is a significant challenge largely due to the deficiencies in water infrastructure and the decentralized nature of water systems. While the responsibility of water collection by women has been well-documented, their perspectives and experiences concerning water scarcity and the remote retrieval of water remain underrepresented in research, especially in Ghana. This study aimed to address research gaps and advance knowledge on the gender dynamics of water access and collection, focusing on the factors driving water inaccessibility, its consequences, and the coping mechanisms employed by women. To achieve this goal, a multi-prong approach was employed, encompassing surveys, FGDs, and a coupled systems framework, to address the following research objectives:

a) Identify factors contributing to rural women's difficulties in accessing and collecting water for domestic use in Northern Ghana
b) Examine the impact of inadequate water access and distant water collection on rural in Northern Ghana
c) Explore the coping strategies rural women employ to manage and address suboptimal water access and distant water collection in Northern Ghana

This chapter provides an overview of the key findings. It also outlines the primary contributions of this research and acknowledges its limitations. The chapter concludes by discussing the implications of these findings for policy, research, and practical applications while also suggesting avenues for future research.

7.1 Summary of key findings

This study investigated the difficulties women in rural Kologo of Ghana faced due to water inaccessibility and collecting water from remote locations. It emphasized the significant threats to livelihoods and health that arise from limited access to water and the need to collect water from sources beyond the household. This thesis consists of four substantive papers (Chapters 3, 4, 5, and 6). Chapter 3 serves as the foundation, developing a conceptual framework by systematically reviewing the literature on water access. This review, with a particular focus on gender and climate considerations, aims to address the issue of water inaccessibility in rural sub-Saharan Africa. The key takeaways from this chapter include:

1. Water inaccessibility among rural women results from various complex factors, including political, ecological, and social conditions. These factors interact and reinforce each other, making it challenging for these women to access clean and reliable water.
2. When rural women struggle to obtain sufficient and reliable water supplies, they resort to coping mechanisms to meet their water needs.
3. These coping strategies are influenced by intricate relationships between social, economic, political, and ecological factors, and some of these strategies may need to be more effective and sustainable.
4. Poor access to clean water and inadequate coping strategies lead to adverse consequences for rural women's livelihoods, health, and overall well-being.
5. The health and livelihood challenges experienced by these women, in turn, affect their ability to access quality water and determine the coping strategies they employ.

Chapter 3 sheds light on the experiences of rural women, whose opportunities and choices are greatly influenced by interconnected systems and power structures. It underscores the underlying factors exacerbating water inaccessibility among rural women and advocates for a holistic approach to understanding this issue. To address these challenges, it calls for synthesizing diverse perspectives and identifying research gaps. Furthermore, the review emphasizes that investigating causal links necessitates a re-evaluation of research scope and methods. Different contexts may require culturally and practically appropriate research methods and designs. For instance, the increasing impacts of climate change need improved methods and frameworks to examine the connections between climate change, water inaccessibility, and gender. Addressing these research gaps and employing appropriate and innovative data collection and analysis methods are crucial for enhancing our understanding of water inaccessibility trends. This understanding can inform policy, planning, and practice, including vulnerability considerations, impacts, grassroots solutions, and co-benefits. In a broader context, this review provides valuable insights by elucidating the drivers of water inaccessibility and how local water challenges translate into adverse health, social, and economic outcomes for women in rural sub-Saharan Africa. It underscores the need for a comprehensive approach to tackle this pressing issue.

Chapter 4 of this thesis applied the coupled systems framework (Chapter 3) to investigate the factors influencing access to improved water sources among households in Ghana. The research combined Ghana's 2014 Demographic and Health Survey data with meteorological records from 1991 to 2021. Relationships among these variables were explored through binary logistic regression analysis. The findings from the multivariable analysis revealed significant geographical disparities in improved water access, stemming from a complex interplay of environmental, systemic, and individual factors. Regarding critical environmental factors, it was observed that an increase in the average range of rainfall contributed to improved access to safe water sources. However, an increase in the average monthly maximum and minimum number of rainy days had the opposite effect, reducing access. Additionally, households in the evergreen, deciduous forest, and coastal savannah zones were more likely to have access to improved water sources than those in the transitional zone, except for residents in the savannah zone. Regarding systemic factors, affluent households and traditional worshippers had higher odds of accessing improved water sources than poorer households and non-religious ones. Furthermore, critical individual factors revealed that households with fewer members, female-headed households, households without pregnant women, and educated households were more likely to access or use improved water sources. These findings not only validate existing literature by confirming the significance of individual factors but also emphasize that the accessibility or inaccessibility of water results from a complex interplay of factors that are interconnected and mutually reinforcing across various levels of the biophysical and social environment. Thus, achieving equitable and universal access to safely managed drinking water necessitates the development of comprehensive and multi-sectoral policy frameworks, recognizing the multifaceted nature of the challenges posed by water access disparities.

Chapter 5 employed surveys, FGDs, and a coupled systems framework to investigate the significant burden of water collection placed on women in rural Northern Ghana, with a specific focus on the Kologo community in the Upper East Region. This chapter delved into the causes, gendered experiences, and consequences of water inaccessibility and the arduous task of collecting water for these women. The findings revealed a series of challenges women face in accessing and collecting water to meet their household needs and fulfill gender-specific obligations. A complex interplay of environmental factors, systemic barriers, and individual characteristics influenced these challenges.

First, the research identified several environmental factors that profoundly impacted women's access to and collection of water. Seasonality, the distance to water sources, and the significant time required to access water emerged as the most prevalent issues affecting water acquisition. Seasonal variations in water availability created additional hardships for women.

Second, economic challenges and inadequate infrastructure were identified as systemic barriers undermining women's access to water. Economic constraints within their communities limited access to essential water facilities such as boreholes and tap water systems. Poverty made it challenging for women and their households to afford connection fees and the installation of pipes in their homes. The scarcity of improved water sources exacerbated the burden on women, leading to longer journeys to access water and, in some cases, reliance on unsafe water sources.

Lastly, the study highlighted individual factors influencing women's difficulties in accessing and collecting water, including education, health status, age, and family size. Women with secondary education experienced significantly less difficulties than those without education. Women aged 31 to 50 faced higher odds of encountering challenges than those aged 50 and above. Good health correlated with lower odds of difficulties in water access. These findings underscore the disproportionate responsibility placed on women for water collection across all communities, illustrating the interconnectedness of environmental and systemic issues with individual experiences contributing to access challenges. These challenges exposed women to complex risks and security threats, including physical injuries, psychological and emotional distress, animal attacks, sexual violence during the journey to water sources, spousal violence, and conflicts at water sources. The extensive time invested in water collection came at a significant opportunity cost, impacting women's participation in farming and other essential non-farming tasks crucial for their livelihoods. Out-of-pocket payments were common as communities pooled resources to maintain and construct water facilities. Additionally, women faced nutritional and hygiene issues due to poor water access, disrupting household chores and activities. Overall, this study highlighted the intricate intersection of health impacts, security threats, socioeconomic challenges, nutrition, and hygiene consequences women face due to water access challenges. By utilizing Apatinga et al.'s integrated framework, this research addressed the complexity of drinking water access issues rural women face, emphasizing the substantial health and socioeconomic repercussions. The key takeaway from this chapter is the critical need for stakeholders to enhance their initiatives and expand efforts to achieve equitable water access in rural regions. To alleviate these challenges, minimizing the distance women must travel to fetch water is imperative. This can be achieved by providing in-house piped water systems or situating water sources near households in rural communities, thereby improving water access and reducing associated health, safety, nutritional, and socioeconomic challenges.

Chapter 6 continues the discussion initiated in Chapter 5 by exploring how rural women manage and address suboptimal water access and the need to travel long distances to obtain water. A combination of surveys, FGDs, and the coupled systems framework examined these issues comprehensively. This investigation reveals that women employed various coping strategies when faced with suboptimal water access and distant water collection. These strategies often fall into three categories; exit, loyalty, and voice strategies, which are employed either concurrently or interchangeably.

Women frequently resort to exit strategies, which involve seeking alternative water sources such as wells, engaging in water-sharing practices with others in the community, or even purchasing water when necessary. They also employed loyalty strategies to cope with suboptimal water access. These strategies encompass efforts to manage existing water resources more effectively. This includes reducing or prioritizing water use, rescheduling domestic activities to optimize water availability, and adopting water treatment and storage practices.

Moreover, women employed the voice strategy to address water access challenges. The voice strategy involves collective action by pooling resources within the community to enhance water accessibility. Additionally, women and community members may lodge complaints with water authorities, particularly the government, to address their water access challenges. It is crucial to note that adopting these coping strategies varies among women with different socioeconomic backgrounds. While these findings highlight the resilience and determination of women in the face of water insecurity, they also underscore the ongoing nature of water insecurity in rural regions. This compels women to employ various mechanisms to meet their household water needs and fulfill their gender-specific obligations. However, a significant concern arises that some coping strategies may be maladaptive and ineffective for a long time. This exposes women to detrimental consequences, illustrating the double burden they face in dealing with water inaccessibility and the challenges of coping with it. These findings underscore the imperative to improve equitable access to safely managed water in rural regions. Doing so is crucial to alleviate the burden women experience in accessing water and ensure that their coping mechanisms are sustainable and do not lead to further hardships. Addressing water insecurity in rural areas remains a pressing issue that requires concerted efforts to create lasting solutions and improve the well-being of women and communities.

7.2 Research contributions

This study aimed to provide valuable insights into the challenges that women in the rural Kologo community of Ghana face in accessing and collecting water from remote locations. It sought to reveal the underlying drivers, resulting consequences, and coping strategies, as well as the feedback loops that sustain water inaccessibility and exacerbate the difficulties of collecting water. This thesis' substantive chapters highlight the significant contributions made by this research in shedding light on the complexities surrounding water access and collection, particularly in rural sub-Saharan Africa. They underscore the dearth of empirical research on the causes, gendered experiences, consequences, and coping strategies related to water inaccessibility and distant water collection, while emphasizing the need for a more comprehensive and multifaceted approach.

First, this research fills critical gaps in the existing literature by taking a holistic view of the issue. Previous studies focused on isolated aspects, such as demographic (e.g., Adams et al., 2016) and socioeconomic (e.g., Agbadi et al., 2019). However, this research recognizes that additionally water inaccessibility is influenced by many interconnected factors spanning environmental, systemic, and individual dimensions. The study's findings underscore the intricate interplay between these factors in shaping women's experiences of water inaccessibility and the subsequent consequences. It reveals how environmental changes, systemic challenges like poverty and inadequate infrastructure, and individual circumstances such as poor health collectively impact water access and contribute to health and socioeconomic challenges. By applying a coupled systems framework, this research offers a novel perspective that enriches our understanding of the multifaceted influences on water inaccessibility and distant water collection. It provides valuable insights into the spatial and temporal patterns of health and socioeconomic consequences and coping strategies.

Second, this research exemplifies the application of theory to inform research design, data collection, and analysis. The conceptual framework, drawing from diverse disciplines, guided the research process, from conceptualization to interpretation, enhancing the rigour and relevance of the study. In contrast to relying solely on traditional quantitative or qualitative methods, this research demonstrates the effectiveness of an integrated mixed-methods design. The use of surveys alongside FGDs yielded nuanced and robust evidence, showcasing the value of innovative methods in advancing evidence-based water research.

Further, the study demonstrates the importance of collecting and analyzing gender-disaggregated data. This approach is crucial for policy formulation and implementation, as it allows for a more comprehensive understanding of the challenges and solutions related to gender-specific water issues. It ensures that the voices and experiences of both men and women are considered, facilitating more informed and equitable policies and programs.

Moreover, while the study was conducted in rural Kologo, Ghana, its findings have broader relevance. Similar sociocultural and economic conditions exist in neighbouring communities and many other rural areas in Ghana. Consequently, the lessons drawn from this research can be applied to women facing similar water challenges in these contexts. Furthermore, the study's insights may benefit small communities in developed nations grappling with water issues.

As a result of exploring the drivers, consequences, and coping strategies related to water inaccessibility and distant water collection among rural women in sub-Saharan Africa, this research significantly contributes to our understanding of these access challenges. It emphasizes the need for a comprehensive, multi-dimensional approach. It provides valuable insights for researchers, policymakers, and practitioners working to address water access disparities and improve the well-being of communities, particularly rural women. These insights can positively impact the attainment of the Sustainable Development Goals, particularly Goals 6 (clean water and sanitation), 5 (gender equality), and 3 (good health and well-being).

7.3 Implications for policy and practice

Rural areas continue to grapple with the challenge of securing sustainable access to clean, reliable, and affordable water. This struggle is especially pronounced in sub-Saharan Africa, where many communities face water insecurity. It is crucial to recognize that water security extends beyond a mere physical necessity; it holds profound social, cultural, emotional, and gender-related implications for women, families, and communities.

World leaders have committed to advancing access to safely managed and adequate drinking water through the United Nations Sustainable Development Goals, acknowledging the pivotal role of water in human life and development across all dimensions. This commitment underscores member states' urgent need for collective action to ensure that no one is left behind in the pursuit of sustainable development, particularly those living in underserved and unserved rural areas. This research contributes to the broader sustainable development agenda by offering evidence-based insights into the gendered impacts of water inaccessibility and distant water collection for women in rural sub-Saharan Africa. Employing an integrated and cross-sectional framework, the findings illuminate the enduring water insecurity prevalent in rural areas, with women disproportionately bearing the brunt of this persistent challenge. These difficulties in water access are influenced by a multitude of factors spanning environmental, systemic, and individual dimensions. Given the overwhelming burden shouldered by rural women in procuring, purifying, and distributing water, often driven by deeply ingrained sociocultural norms, governments, policymakers, and stakeholders must redouble their efforts to enhance equitable water access in rural regions. This is not just a matter of improving water security, but also entails dismantling local and national institutions and structures that perpetuate gender norms and inequalities. More importantly, it is at the local level that deeply ingrained gender norms lead to the marginalization and disempowerment of women. Therefore, it is essential to channel resources and efforts to initiate change at this level. Steps to achieve this include empowering women through education and leadership programs, promoting gender-sensitive practices, engaging men and boys in gender equality initiatives, supporting grassroots organizations, and implementing community-based programs. This research has the potential to significantly influence policy decisions at both national and local levels, thereby enhancing rural water security and alleviating the challenges women face in accessing and collecting water. National policies can be revised to allocate resources to improve water access in rural areas, while local authorities and grassroots initiatives can translate these policies into practical water management strategies that directly address the needs of rural communities.

In response to water inaccessibility and distant water collection, women employ exit, loyalty, and voice strategies to cope with suboptimal water access and address related challenges. While some of these strategies may yield short-term benefits, others may lead to detrimental long-term consequences, compounding women's difficulties. This underscores the urgent need to identify practical, sustainable strategies to empower women in dealing with water access challenges. Water inaccessibility and its intricate relationship with gender and power dynamics are multifaceted and interconnected across various dimensions. Addressing these issues necessitates integrated, cross-sectional, and collaborative approaches to translate knowledge into actionable policies and practices. The household water security framework (Apatinga et al.,

2022) offered in this thesis provides a critical lens to understand and address the drivers of water inaccessibility, its consequences, and feedback loops. This approach can engage governments and policymakers in enacting policy reforms and local initiatives to improve safe water access in rural areas, ultimately promoting gender equity, empowering women, and reducing gender-related threats and challenges within coupled social-ecological systems.

While this research primarily focuses on rural sub-Saharan Africa, its insights can be applied to similar contexts in other low- and middle-income settings. The findings are relevant to communities with shared sociocultural and economic conditions, transcending geographical boundaries. This research also demonstrates the practical application of theory in informing research design, data collection, and analysis, emphasizing the importance of theory-driven research. Collecting and analyzing gender-disaggregated data, as demonstrated in this study, is essential for policy formulation and implementation. A significant barrier to gender-inclusive water-related policies and programs is the lack of comparable data on gender and sex indicators. By incorporating these dimensions, policies can better address gender-specific water challenges and solutions, ensuring that no one's voice is lost in the discourse. This research serves as a call to action. It highlights the persistent water access challenges rural women and marginalized communities face. It urges stakeholders to embrace a coupled systems framework for research and policy action on household water insecurity. By doing so, we can improve women's and population health and well-being, particularly in rural and underserved areas, and ultimately contribute to a more equitable and sustainable future for all in line with the Sustainable Development Agenda’s goal of leaving no one behind.

7.4 Limitations

While this research has yielded valuable insights, it is essential to acknowledge its limitations, which encompass various aspects of the study design and context: First, one notable limitation stems from the cross-sectional design employed in this study, which primarily focused on data collection during the wet season. This design constraint restricts examining potential changes in water access over time, particularly during the dry season when access challenges may differ. The study's temporal scope may only partially capture the dynamic nature of water availability and its implications throughout the year. Second, the generalizability of the findings is a concern, given that women's experiences in the Kologo community may vary significantly from those in diverse geographical and social-cultural contexts. Contextual factors are pivotal in shaping water access challenges, making it challenging to extrapolate the study's findings to the broader population. Geographical factors such as terrain and proximity to water facilities vary across communities. In communities, some women have the convenience of nearby water sources, resulting in shorter walks, while others must traverse greater distances to access more remote water sources. Consequently, there is a need for further research in various social-cultural settings to validate and expand upon the current findings. Moreover, social desirability bias represents another potential limitation. Participants may have altered their responses based on societal expectations or cultural norms. Some individuals may have exaggerated difficulties accessing and collecting water to seek favour, while others may have underreported their experiences due to gender-related norms and sensitivities. For instance, incidents of spousal violence associated with inadequate water access may have been underreported by men to protect their family's reputation or avoid disclosing violence linked to water issues. Future research endeavours should strive to overcome these constraints, expanding the study's scope to diverse settings to enhance the robustness and applicability of findings in addressing water access disparities.

7.5 Recommendations and directions for future research

Convenient access to safe, reliable, and affordable water is not just a necessity, but a fundamental human right. Previous scholarship demonstrates that poor water access is linked to a multitude of health and socioeconomic issues, with women disproportionately bearing the burden, especially in sub-Saharan Africa. In this region, gender norms and roles often dictate that women are responsible for providing water for domestic use to maintain social acceptance and fulfill gendered obligations. This research, conducted in Ghana, confirms and advances knowledge on the complex and overlapping factors contributing to inadequate water access and the resulting consequences, as well as the maladaptive and ineffective coping strategies that rural women are forced to adopt. Based on these findings, the following recommendations are proposed to support the development of effective water-related interventions and programs aimed at improving water security study area (rural Kologo) and across Ghana, ensuring that every individual's right to safe and accessible water is upheld.

7.5.1 National level

The national study identified climate change variables as significant environmental factors influencing access to improved water sources. To advance in enhancing water access, it is crucial to adapt to and build resilience against the impacts of climate change. The mean temperature in Ghana is projected to increase between 1.0°C and 3.0°C (IPCC, 2023), with the northern regions (e.g., Upper East, Upper West and Northern regions), which are drier, experiencing a more rapid rate of warming compared to coastal areas. Enhancing climate monitoring and early warning systems can enable communities to better anticipate and adapt to changing rainfall patterns, ensuring that infrastructure, management practices, and community actions remain effective amidst climate variability. This approach will help protect water access for vulnerable populations and ensure that water resources are preserved and sustained for future generations.

Second, the national study revealed that ecological variations contribute to disparities in access to water, with Ghana's savannah ecological zone, which experiences the lowest annual rainfall, lagging behind significantly. This zone, already suffering from arid conditions, also significantly lags behind in Ghana's progress towards growth and poverty reduction due to poor policies of post independence governments and a substantial infrastructure deficit (Dongzagla et al., 2022; Jatoe et al., 2018). Investing in resilient systems like reliable water supply networks and rainwater harvesting can guarantee a consistent water supply despite the arid conditions, thus bridging the gap between the savannah zone and the other zones (transitional, evergreen, deciduous forest and coastal savannah zones). Improving water infrastructure is essential as it strengthens comprehensive water management strategies, guaranteeing long-term access to water resources for every community.

Third, maximizing the advantages of these infrastructure investments requires the adoption of Integrated Water Resource Management (IWRM) practices, which are currently not well developed or implemented in water management strategies in Ghana (Mensah, 2010; Owusu et al., 2016). IWRM not only guarantees fair distribution of water across regions, but also supplements enhanced infrastructure by improving watershed management, thereby decreasing runoff and increasing groundwater recharge. These practices are vital for maintaining water supplies and addressing challenges such as flooding and droughts, which pose risks to water facilities and contaminates sources, particularly in flood and drought-prone areas like the Greater Accra Region and the northern regions (e.g., Upper East, and Upper West Regions), respectively.

Also, concentrating on semi-arid and rural regions, such as the savannah zone, naturally aligns with this approach. By giving priority to water supply in these areas, we tackle the critical need for dependable water sources where water is scarce and evaporation rates are high. Increased investments in water projects by the government and NGOs, which can enhance water access by 50% in rural Ghana, along with the development of accessible boreholes and groundwater extraction techniques, can mitigate these challenges. Directing investments and fostering public-private partnerships will ensure that rural communities, currently comprising 56% of the population in Ghana (Owusu et al., 2016), equitably share in the national water resources. This will address significant geographic disparities in water access, with rural areas having water access rates 40% lower than urban areas (Apatinga et al. forthcoming; Dongzagla et al., 2022), and also alleviate disparities between different ethnic groups, as identified in the national study.

Given that poverty emerged as one of the primary systemic factors in the national study, socioeconomic equity needs to be a central focus of these initiatives. Poverty is widespread throughout Ghana, with over 25% of the population living below the poverty line, particularly affecting rural areas, where poverty rates are as high as 54% (UNDP, 2023), and informal urban settlements. Implementing pro-poor policies that offer affordable and dependable water sources is crucial for ensuring that low-income households can access essential water services. This strategy not only supports infrastructure development, but also empowers communities by improving income-generating opportunities and creating employment programs, which are essential in rural areas, where unemployment rates can exceed 30% (Ghana Statistical Service, 2024). Additionally, the national study identified religion as a factor significantly influencing access to improved water sources. Ghana's religious diversity—comprising a majority of

Christians (71%), a substantial Muslim population (20%), traditional worshippers (3%), and others, including those with no religious affiliation (6%) (Ghana Statistical Service, 2021)—offers a unique opportunity to engage religious leaders and institutions. These leaders hold considerable influence and trust within their communities, enabling them to effectively mobilize their congregations and advocate for sustainable water use practices. By leveraging their authority and resources, religious leaders can heighten awareness about the importance of improved water sources and promote best practices in water management. This strategy can enhance community engagement and amplify the impact of water-related initiatives.

Furthermore, the national study identified educational attainment as a key individual factor in enhancing access to improved water sources. This highlights the critical role of education and awareness in linking community involvement to sustainable water management practices. Regular educational initiatives and community outreach efforts can foster a culture of water conservation, underscoring the advantages of accessing improved water sources.

7.5.2 Local level

At the local level, addressing the challenges that women in Kologo face is critical, as they frequently endure long and difficult journeys through rough terrains to collect water. Collaboration among national and local governments, along with NGOs, is necessary to invest in sustainable water infrastructure. Constructing and maintaining boreholes, wells, and piped water systems can greatly enhance access. Almost all women and over 50% of men, even those not directly involved in water collection, express concern over the long distances to water sources. The hardships faced by women in these communities can be significantly reduced if water is available on premises or nearby. Prioritizing the installation of in-house piped water systems or establishing closer water sources can greatly improve the lives of these women. Additionally, interim measures such as mobile water supply services can ensure a steady provision of safe water, reducing the physical and safety burdens on women who must trek long distances. For example, community water carts could provide a simple, cost-effective solution for daily water needs, especially for those in areas with challenging terrain, thus minimizing the distance women need to travel and alleviating their burden.

Second, residents in rural Kologo, particularly women, face significant challenges in accessing water due to factors such as poor governance, adverse environmental conditions, and economic constraints, beyond their control. In response to these challenges, women and residents undertake the initiative to construct wells, invest in water storage facilities, and engage in rainwater harvesting. Over 80% of these women resort to strategies such as reducing water use, postponing domestic activities, and accessing unsafe sources due to limited access and distant water sources. While these methods provide short-term relief, they can lead to long-term health risks and nutritional deficiencies. Addressing inadequate water access in Kologo requires promoting beneficial coping strategies while discouraging or eliminating harmful ones. These local efforts underscore the necessity for governmental and non-governmental organizations to provide essential tools, technical expertise, and financial resources to support these initiatives. Education and awareness campaigns on water conservation, safe storage, and hygiene are crucial, along with infrastructure development to enhance access to safe water sources. Conversely, detrimental strategies to discourage involve reliance on unsafe water sources and compromising personal hygiene due to reduced water availability. These initiatives can enhance women’s capacity to manage water resources effectively and minimize health risks.

Third, economic constraints significantly hinder access to clean water in Kologo. More than 70% of women in these communities are unable to afford improved water solutions due to financial limitations. Implementing sustainable microfinance programs and savings schemes tailored to these women can provide the necessary capital for better water access. Furthermore, supporting women's economic opportunities by offering income-generating activities can increase their financial capacity, allowing them to access safer water options and reducing their reliance on inadequate alternatives. Considering farming as the predominant livelihood activity in Kologo, providing agricultural support, such as machinery and subsidies, can help women enhance their income and improve their ability to manage water access challenges.

Moreover, Kologo and its surrounding communities face severe poverty, lacking essential social services, economic opportunities, and resources. The residents primarily engage in small-scale farming, which is mainly for subsistence and only occasionally for commercial purposes. The semi-arid climate, characterized by erratic rainfall, further complicates farming, making it a challenging endeavour. Consequently, poverty is widespread, often preventing households from installing water pipes. This forces women to rely on unsafe water sources. Over 70% of both women and men stressed that due to poverty, households are unable to tap water from a centralized water tank, compelling women to resort to unsafe alternatives. Financial aid programs are necessary to assist low-income families in acquiring clean water, thereby reducing the reliance on unsafe alternatives. These interventions are crucial for enhancing overall water access and aligning economic solutions with health outcomes.

Additionally, as women in Kologo often collect water from unimproved sources, introducing affordable water purification technologies can significantly enhance household water quality, reducing health risks. Leveraging Kologo’s high temperatures, cost-effective solarpowered water systems can offer sustainable solutions to water insecurity, while empowering women as key stakeholders. This approach links technological advancements to practical, community-based solutions, enhancing water security and women's roles in water management.

Further, gender attitudes and behaviors in Kologo and its surrounding communities are deeply ingrained, disproportionately affecting women who bear the brunt of water inaccessibility and distant water collection. As a result, many men lack awareness of the burdens placed on women, reflecting a gender system that marginalizes women's experiences. This highlights the need for educational and sensitization programs, particularly targeting men, to dismantle stereotypes and challenge norms. Understanding the implications of gender roles is crucial for facilitating meaningful change and promoting gender equality. It is crucial to encourage men to take part in unpaid, time-consuming domestic water collection and other household tasks, as this can help alleviate the burden that women often bear. When men take on these responsibilities, they will gain a better understanding of the difficulties that women face and become more supportive of gender and social inclusive policies that promote equality, including those related to water resources.

Furthermore, the patriarchal culture of Kologo, coupled with enduring poverty that affects women more severely, underscores that men predominantly make community-level decisions, including those concerning water resources. Over 50% of both Kologo women and men acknowledge that men dominate decision-making processes, while women are primarily responsible for household chores. Increasing women’s involvement in water decision-making processes would be essential. Establishing women-led water committees or integrating women into existing management bodies ensures their voices are heard and their contributions valued. Water management committees should strive for gender balance, with women in leadership roles, to reflect their critical insights and experiences. Women's perspectives on the risks and challenges associated with collecting water from distant sources can lead to practical, specific solutions such as local water points or community-led safety initiatives. Empowering women in this manner promotes broader social change, enabling them to advocate for their rights and participate more fully in community governance.

Lastly, the chief and local leaders, as gatekeepers of Kologo and its subcommunities, are ideally positioned to improve water security. They should leverage their influence to: (1) establish community-based water management committees that promote local ownership of water facilities, ensuring inclusive and equitable water access initiatives; (2) integrate and enforce traditional laws and customs that safeguard water bodies from pollution and overuse, ensuring that modern water management practices are harmonized with cultural values; and (3) act as intermediaries between their communities and external organizations, advocating for water projects. Given the critical water situation in Kologo, local leaders should push for smaller, accessible, and cost-effective water solutions such as water trucking services, mobile water tanks, mobile water bowsers, water distribution trailers, mobile water purification units, and community water carts. These temporary measures can provide immediate relief while working with the national government and other agencies to secure larger water infrastructure projects. These actions link leadership roles to community-driven water security initiatives, fostering a holistic approach to improve water access in Kologo.

7.5.3 Proposed future studies

Addressing water inaccessibility requires more empirical research to inform policies and programs. Understanding the specific needs and challenges of rural communities through data and insights is crucial for developing targeted, effective interventions. By grounding policies in empirical evidence, we can engage governments, policymakers and stakeholders to better address the water crisis and ensure equitable access for all. Therefore, this research points towards several promising avenues for future research. These directions aim to bridge existing gaps in the literature and provide nuanced insights into the gendered experiences of water inaccessibility and distant water collection.

First, a notable research gap lies in understanding the gendered livelihood implications of water inaccessibility and distant water collection. Future studies should explore how these challenges affect rural women's economic activities, income, and overall well-being. Investigating the intersection of water insecurity and livelihoods is essential to understand its impact comprehensively. Second, another underexplored area pertains to the coping strategies employed by women in response to water inaccessibility. Research should delve into these strategies' effectiveness, sustainability, and gender-specific consequences. Additionally, the link between water-related challenges and domestic violence experiences warrants further investigation to shed light on this critical issue.

Moreover, given the increasing complexity of contemporary and water issues, future research should embrace complex tools and transdisciplinary approaches. This approach is essential to effectively unravel the multifaceted nature of social phenomena related to water access. Integrating qualitative and quantitative data can provide a more nuanced understanding of the intricate dynamics.

Further, the developed household water security framework, which offers a holistic view of drivers, consequences, coping strategies, and feedback loops, should be applied to other areas of water insecurity. Expanding the use of this framework can significantly contribute to the evolving field of gender and water studies. Given the intricate, intersectional, and overlapping nature of factors influencing drinking water access, the continuous refinement and application of such broad frameworks is pivotal in comprehending the cascading effects of water inaccessibility. These future research directions not only address critical gaps but also align with the evolving complexities of the world. To effect meaningful change and translate knowledge into actionable solutions, research endeavours must continue to advance and embrace comprehensive, multidisciplinary frameworks to unravel the intricate dimensions of water access and its implications, particularly in the context of gender.

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APPENDICES

Appendix I – Survey instrument for women

Introduction and Instructions

Survey ID [W-interviewer initials-day-month-survey #]

Hello. I am _______________________ and this is _______________________

Thank you for agreeing to participate in this questionnaire. This research project is conducted by a research group from the University of Saskatchewan, Canada, to understand how water access and water collection affect women in your community. The questionnaire consists mainly of close-ended questions, with some short open-ended questions. There are 82 questions, which will take approximately an hour to complete. The data collected will be secured, remain confidential and deleted after the research timeframe. You do not have to answer any questions that you do not want to. We know you are very busy. Participation is your choice, and it is okay to say no. You have the right to withdraw from the study anytime without any consequences. We do not have money to give you. The consent form contains our contact if you have concerns following the study. Would you still like to participate in the survey?

Socio-demographic information

Was the participant informed?

Yes ____ No______

Is she willing to participate?

Yes ____ No ______

I would like to begin by asking you some general questions.

1. What is your age ________________________

2. What is your ethnicity?

Ghana: Akan_____ Ga/Dangme ____ Ewe _____ Guan____ Mole-Dagbani_____ Grusi___ Gurma____ Mande____ Other (specify)______

3. How many people live in your household? ___________________________

4. Can you tell me the age and gender of each member of your household?

Household member	**Age**	**Gender**	
		Man	Woman
1			
2			
3			
4			
5			

6			
7			
8			
9			
10			

5. Have you been to school?

Yes ______ No __________ Don't know________

5a. If yes, how far did you go in school?

Some primary ______ Complete primary _______ Some secondary_______

Complete secondary ________ Beyond secondary _________

6. How healthy would you say you are?

Very healthy____ Mostly healthy_____ Not very healthy______ Unhealthy_____ Very unhealthy__

7. Do you have any activity from which you earn money?

Yes ______ No ______ Don't know _______

7a. If yes, what type of activities ____

8. What do you estimate your average household weekly income to be? ____ [GHS]

9. Based on this average, would you rank your income as:

Above average _______ Average _________ Below average ____________

Gender roles and gender equality

Thank you. The next set of questions is about your idea of gender roles and gender equality.

10. Is there any difference in what men and women do in the household?

Yes __________ No _________ Don't know __________

If yes, what are some differences? ____

11. What do you think causes these differences?

____

12. Do you believe that men and women *should* perform different duties in the household?

Yes ________ No_____ Don't know _____________

Why or why not? ____

13. Do men and women have the same input into household decisions?

Yes ______ No________ Don't know _________

Why or why not?____

14. Do you believe that men and women should have the same input into household decisions?

Yes_______ No__________ Don't know________

Why or why not? ____

15. What does it mean to be a man and a woman in your community?

____

____

____

16. Do you think men and women *should* be equal in the community?

Yes ______ No_____ Don't know _________

Why or why not? ____

17. Have you ever been criticized, judged, or shamed for being a woman?

Yes _____ No________ Don't know ___________

If yes, what happened? ____

18. Do you think that women are respected and fully heard in your society?

Yes _________ No ________ Don't know __________

Why or why not? ____

19. Do you think women *should* be respected and allowed to work like men?

Yes _______ No ___________ Don't know __________

Why or why not? ____

Water Access and Use

Thank you. In this section, I would like to ask some questions about accessing water and what you use water for in your households and community

20. What are the main sources of drinking water for your household and how often do you use them?

Source of drinking water	[*tick the correct box*]		Number of times in a week	
	Yes	No	Wet	Dry
Public tap/standpipe				

Tube well/borehole				
Protected dug well				
Unprotected dug well				
Protected spring				
Unprotected spring				
Rainwater				
Bottled water				
Cart with a small tank				
Tanker-truck				
Surface water (river, dam, lake, pond, stream, canal, irrigation channel				
Other(s) (specify):				

21. Are you the only person in your household who fetches water?

    Yes_______ No_________

21a. If not, who else fetches water? ____

    What is their relationship to you? ____________________________

22. Do you go together or take it in turns?

    Together___ In turns ____

23. How many times a day do you usually go? ________________________

24. How many [jerrycans/buckets/pots] (20 litres) do you fill each time? ________

24a. Do you have to pay for this water used for your household?

    Yes____ No______ Don't know ______

24b. If yes, what do you estimate your average weekly cost of water used for your household to be? ____ [GHS]

24c. If yes, how do you get money?

    ____

    ____

25. What do you use the water for? (tick all that apply)

    Drinking___ Bathing ___ Cooking____ Washing ______ Gardening______

26. Do you do any of these activities at water sources? (tick all that apply)

Washing _____ Bathing _____ Swimming____

27. Do you always go to the same water source each day?

Yes ______ No___________

27a. If not, how many different ones do you go to in a day? _______________

28. How much time do you spend collecting water each day in the **wet season**?

______ hours ________ minutes

29. How much time do you spend collecting water each day in the **dry season**?

______ hours ________ minutes

30. Do you worry about how safe your water is to drink?

Yes____ No______ Don't know ______

31. Do members of your family get sick from drinking the water?

Yes_____ No______ Don't know ______

31a. If yes, who gets sick most often?

Elderly___ adults___ teenagers___ children___ children under 5____ babies____

Why this group? ____

31b. How often do they get sick?

Every week ____every month_____every couple of months ____ every year_______

31c. What do they get sick with? _______________________________________

32. Do you do anything to your water to make it safer?

Yes _____ No______ Don't know _________

32a. If yes, what do you do to your water? [prompt: how do you treat it?] ________________

33. How is drinking water stored in your home?

Jerri can_____ Tank _____ Pot___ Other (please specify) _________

34. What other household work is your responsibility?

____

35. How much time do you spend each day on all of your household work?

______ hours ________ minutes

36. If you spend less time doing household work, what else would you like to do?

____

Water access, health, and livelihoods

Thank you. The next set of questions is about the relationship between water collection, health, and livelihood activities.

37. What time do you or anyone in your household go to fetch water?

Early Morning____ Afternoon____ Evening ____ Mid-night______

37a. Why this time? ____

38. Is it difficult to fetch water from outside your home/compound?

Yes ___ No ___ Don't know ____

38a. If yes, how difficult is it to fetch water from outside your home/compound?

very easy ___easy____ mostly easy____ difficult_____ very difficult_______

39. What factors make it difficult to fetch water from outside your home/compound?

____

40. How dangerous is it to fetch water from outside your home/compound?

Very safe___ safe___ mostly safe_____ dangerous______very dangerous_______

40a. If dangerous, what are some of the dangers?

____

41. Have you or any member of your household experienced physical health problems due to collecting water from outside your home/compound?

Yes_____ No _______ Don't know____

If yes, how? ____

42. Have you or any member of your household suffered back and body pains because of collecting water?

Yes_____ No_____ Don't know_______

If yes, what happened? ____

43. Does water collection from outside the home/compound have health benefits?

Yes_____ No_______ Don't know_______

If yes, how? ____

44. Does water collection from outside the home/compound have social benefits?

Yes____ No____ Don't know _______

If yes, please explain ____

45. Has water collection prevented you or anyone in your household from doing their work?

Yes_____ No________ Don't know________

If yes, how? ____

46. Has water collection prevented you or anyone in your household from participating in social activities and gatherings?

Yes_______ No_______ Don't know_____

If yes, how? ____

47. Do you worry about going to fetch water from outside the home/ compound?

Always___ Sometimes___ Rarely____ Never___

If so, what do you worry about?

____

48. Have you or anyone in your household been attacked on their way to fetch water?

Yes_____ No____ Don't know______

If yes, please explain ____

49. Have you or anyone in your household quarreled at water points?

Yes____ No_____ Don't know______

If yes, please explain ____

50. Do you worry that you won't get enough water for all of your household needs?

Yes______ No_______ Don't know________

What do you worry about?

____

51. Have you reduced the amount of water you use for household activities because there was not enough water or because it was too difficult to collect water?

Yes______ No_______ Don't know_________

If yes, explain ____

52. Have you postponed household activities because there was not enough water or because it was difficult to collect water?

Yes______ No______ Don't know _________

What activities have you postponed? ____

53. Have you ever not cooked a desirable food because there was not enough water, or it was difficult to collect water?

Yes_____ No______ Don't know________

If yes, explain ____

54. Have you been unable to cook enough food because there was not enough water, or it was difficult to collect water?

Yes _____ No______ Don't know________

If yes, explain ____

55. Does water collection or water shortage affect boys' school attendance and performance?

Yes_____ No______ Don't know_______

If yes, explain ____

56. Does water collection or water shortage affect girls' school attendance and performance?

Yes_____ No______ Don't Know______

If, yes, explain ____

57. Between boys and girls in your household, who does water shortage or water collection affect the most in terms of school attendance and school performance ______________

Why ____

58. Did you or any member of your household collect water from an undesirable or dirty source because you could not collect from your preferred source?

Yes______ No______ Don't know__________

If yes, explain ____

59. Have you or any member of your household collected water from a neighbour because of water shortages?

Yes_____ No ______ Don't know__________

60. Has anyone outside your household used water from your household because of shortage of water or it was difficult to collect water?

Yes______ No______ Don't know_________

If yes, explain ____

61. Have people moved away from this community because of water problems?

Yes_____ No______ Don't know__________

If yes, explain ____

62. Have you had quarrels or problems with your husband about the water needs of your household?

Yes____ No____ Don't know________

If yes, explain____

63. Have you had a quarrel with your husband about not completing daily tasks because of a lack of water or it was difficult to collect water?

Yes______ No______ Don't know______

If yes, explain____

64. Are disabled persons able to access water in your community?

Yes_______ No________ Don't know __________

If no, why____

65. Are pregnant women able to access water in your community?

Yes____ No______Don't know____

If no, why? ____

66. Are sick people able to access water in your community?

Yes____ No______ Don't know________

If no, why ____

67. Are old people able to access water in your community?

Yes ____ No _____ Don't know ____

If no, why ____

Decision-making concerning water and ways to address water problems

Now let us talk about decision-making concerning water resources and ways to address water problems

68. Have you participated in making decisions about water in your community?

Yes ________ No _______ Don't Know ________

Why or why not? ____

69. Are you interested in engaging in water issues in your community?

Yes______ No_______ Don't know________

Why or why not? ____

70. Do you feel you can help to solve any water issues in your community?

Yes______ No_____ Don't know_________

Why or why not? ____

71. Do you discuss water issues with others in your community?

Yes______ No_______ Don't know__________

Why or why not?____

72. Has the community tried to get people together to address what problems?

Yes_____ No_______ Don't know___________

Why or why not? ____

73. Have you attended any community meeting concerning water?

Yes____ No_______ Don't know_________

Why or why not?

74. Did you speak in the meetings?

Yes_______ No______

Why or why not?____

75. Do women participate in water decision-making at the community level?

Yes_____ No_______ Don't know______

Why or why ____

76. In your opinion, should women participate in water decision-making at the community level?

Yes______ No_____ Don't know________

Why or why not? ____

77. Do disabled persons contribute to decision-making regarding water resources?

Yes__________ No __________ Don't know ________

Why or why not? ____

78. Should disabled persons participate in decision-making regarding water resources?

Yes _________ No ____________ Don't know ___________

Why or why not? ____

79. In your opinion, is the government doing well in providing sufficient water for your community?

Yes______ No_______ Don't know_________

If no, why? ____

80. What do you suggest government should do to help promote water access and water security in your community?

____

81. In your opinion, are local communities assisting in providing water for your community?

Yes_____ No_____ Don't know_____

Why or why not? ____

82. What do you suggest local communities should do to help promote access to water?

____

Appendix II – Survey instrument for men

Introduction and Instructions

Survey ID [M-interviewer initials-day-month-survey #]

Hello. I am ______________________ and this is ______________________

Thank you for agreeing to participate in this questionnaire. This research project is conducted by a research group from the University of Saskatchewan, Canada, to understand how water access and water collection affect women in your community. The questionnaire consists mainly of close-ended questions, with some short open-ended questions. There are 82 questions, which will take approximately an hour to complete. The data collected will be secured, remain confidential and deleted after the research timeframe. You do not have to answer any questions that you do not want to. We know you are very busy. Participation is your choice, and it is okay to say no. You have the right to withdraw from the study anytime without any consequences. We do not have money to give you. The consent form contains our contact if you have concerns following the study. Would you still like to participate in the survey?

Socio-demographic information

Was the participant informed?

Yes ____ No______

Is he willing to participate?

Yes ____ No ______

I would like to begin by asking you some general questions.

1. What is your age ________________________

2. What is your ethnicity?

Ghana: Akan_____ Ga/Dangme ____ Ewe _____ Guan____ Mole-Dagbani_____ Grusi___ Gurma____ Mande____ Other (specify)______

3. How many people live in your household? ___________________________

4. Can you tell me the age and gender of each member of your household?

Household member	Age	Gender	
		Man	Woman
1			
2			
3			
4			
5			
6			

7			
8			
9			
10			

5. Have you been to school?

Yes ______ No __________ Don’t know________

5a. If yes, how far did you go in school?

Some primary ______ Complete primary _______ Some secondary_______

Complete secondary ________ Beyond secondary _________

6. How healthy would you say you are?

Very healthy____ Mostly healthy_____ Not very healthy______ Unhealthy_____ Very unhealthy__

7. Do you have any activity from which you earn money?

Yes ______ No ______ Don’t know _______

7a. If yes, what type of activities ____

8. What do you estimate your average household weekly income to be? ____ [GHS]

9. Based on this average, would you rank your income as:

Above average _______ Average _________ Below average ____________

Gender roles and gender equality

Thank you. The next set of questions is about your idea of gender roles and gender equality.

10. Is there any difference in what men and women do in the household?

Yes __________ No _________ Don’t know __________

If yes, what are some differences? ____

10a. What do you think causes these differences?

____

11. Do you believe that men and women *should* perform different duties in the household?

Yes ________ No ___________ Don’t know _____________

Why or why not?

____

12. Do you believe that women and men have the same input into households' decision?

Yes ______ No________ Don't know _________

Why or why not?

____

13. Do you believe that men and women *should* have the same input into household decisions?

Yes ______ No_______ Don't know_______

Why or why not? ____

14. What does it mean to be a man and a woman in your community?

____

____

____

15. Do you think women and men *should* be equal in the community?

Yes _____ No ______ Don't know _________

Why or why not

____

____

16. Have you ever been criticized, judged, or shamed for not being man enough?

Yes _____ No________ Don't know ___________

If yes, what happened? ____

17. Do you think that women are respected and fully heard in your society?

Yes _________ No ________ Don't know __________

Why or why not?____

18. Do you think women *should* be respected and allowed to work like men?

Yes _______ No ___________ Don't know __________

Why or why not?

____

Water Access and Use

Thank you. In this section, I would like to ask some questions about accessing water and what your household and community use water for

19. What are the main sources of drinking water for your household and how often do they use them?

Source of drinking water	[*tick the correct box*]		Number of times a week	
	Yes	No	Wet	Dry
Public tap/standpipe				
Tube well/borehole				
Protected dug well				
Unprotected dug well				
Protected spring				
Unprotected spring				
Rainwater				
Bottled water				
Cart with a small tank				
Tanker-truck				
Surface water (river, dam, lake, pond, stream, canal, irrigation channel				
Other(s) (specify):				

20. Who is responsible for collecting water in your household?

Adult women in household ___ Adult men in household___ Girl child in household____
Boy child in household_____ Other (specify)__

Why this group? ____

20a. Do you have to pay for this water used for your household?

Yes____ No______ Don't know ______

20b. If yes, what do you estimate your average weekly cost of water used for your household to be? ____ [GHS]

21. Do you or your household worry about how safe your water is to drink?

Yes____ No______ Don't know ______

If yes, what do you or they worry about? ____

22. What is water used for in your household? ____

23. Do you use water for other purposes outside of the household?

Yes____ No______ Don't know ______

23a. If yes, what do you use it for? ____

23b. Where do you get this water from?

Source of drinking water	[*tick the correct box*]		Number of times a week	
	Yes	No	Wet	Dry
Public tap/standpipe				
Tube well/borehole				
Protected dug well				
Unprotected dug well				
Protected spring				
Unprotected spring				
Rainwater				
Bottled water				
Cart with a small tank				
Tanker-truck				
Surface water (river, dam, lake, pond, stream, canal, irrigation channel				
Other(s) (specify):				

23c. Who is responsible for obtaining this water?

Adult women in household___ Adult men in household_____ Girl child in household ____ Boy child in household _____ Other (specify)_______

Why this group? ____

23d. Do you have to pay for this water used outside of your household?

Yes____ No______ Don't know ______

23e. If yes, what do you estimate your average weekly cost of water used outside of the household to be? ____ [GHS]

Water access, health, and livelihoods

Thank you. The next set of questions is to understand how water collection affects health and livelihood activities

24. What time does your household go to fetch water?

Early Morning____ Afternoon____ Evening ____ Mid-night______

24a. Why this time? ____

25. Is it difficult for your household to fetch water outside your home/compound?

Yes _____ No _____ Don't know ___

25a.If yes, how difficult is it?

very easy ___easy____ mostly easy____ difficult_____ very difficult_______

25b. What factors make it difficult for your household to fetch water from outside your home/compound?

____

26. Has any member of your household experienced physical health problems due to collecting water outside your home/compound?

Yes_____ No _______ Don't know____

If yes, how? ____

27.Has any member of your household suffered back and body pains because of collecting water from outside your home/compound?

Yes_____ No_____ Don't know_______

If yes, what happened? ____

28. In your opinion, does water collection from outside your home/compound have health benefits?

Yes_____ No_______ Don't know_______

If yes, how? ____

29. In your opinion, does water collection outside your home/compound have social benefits?

Yes____ No____ Don't know _______

If yes, please explain ____

30. Does water collection from outside your home/compound prevent anyone in your household from doing their work?

Yes_____ No________ Don't know________

If yes, how? ____

31. Does water collection from outside your home/compound prevent anyone in your household from participating in social activities and gatherings?

Yes_______ No_______ Don't know_____

If yes, how? ____

32. Has anyone in your household been attacked on their way to fetch water?

Yes_____ No____ Don't know______

If yes, please explain ____

33. Does your household worry about water shortages or going to fetch water from outside your home/compound?

Yes_______ No_______ Don't know_________

If yes, please explain ____

34. Does your household reduce the amount of water used for household activities because of water shortages or difficulty to fetch water?

Yes______ No_______ Don't know_________

If yes, explain ____

35. Does your household postpone domestic activities because of water shortages or difficulty to fetch water?

Yes______ No______ Don't know _________

If yes, what activities have they postponed?

____

36. Has your household ever not cooked a desirable food because of water shortages or difficulty to fetch water?

Yes_____ No______ Don't know________

If yes, explain ____

37. Has your household been unable to cook enough food because of water shortages or difficulty to fetch water?

Yes______ No____ Don't know _____

If yes, explain ____

38. Does water shortage or water collection affect boys' school attendance and performance?

Yes_____ No______ Don't know_______

If yes, explain ____

39. Does water shortage or water collection affect girls' school attendance and performance?

Yes_____ No______ Don't Know______

If, yes, explain ____

40. Between boys and girls in your household, who does water shortage or water collection affect the most in terms of school attendance and school performance ______________

Why ____

41. Have people moved away from this community because of water problems? ___ No______ Don't know__________

If yes, explain ____

42. Have you had quarrels or problems with your wife(s) about the water needs of your household?

Yes____ No____ Don't know________

If yes, explain____

43. Have you had a quarrel with your wife(s) about not completing daily tasks because of a lack of water or it was difficult to collect water?

Yes______ No______ Don't know______

If yes, explain____

44. Does your household worry that you do not enough water to meet your household needs?

Yes_____ No_______ Don't know_______

If yes, explain____

45. Are disabled persons able to access water in your community?

Yes_______ No________ Don't __________

If no, why____

46. Are pregnant women able to access water in your community?

Yes _____ No____ Don't know _______

If no, why ____

47. Are sick people able to access water in your community?

Yes ______ No ____ Don't know ___

If no, why ____

48. Are old people able to access water in your community?

Yes ____ No ______ Don't know _____

If no, why? ____

Decision-making concerning water and ways to address water problems

Now let us talk about decision-making concerning water resources and ways to address water problems

49. Have you participated in making decisions about water in your community?

Yes ________ No _______ Don't Know ________

Why or why not ____

50. Are you interested in engaging in water issues in your community?

Yes______ No_______ Don't know________

Why or why not? ____

51. Do you feel you can help solve any water issues in your community?

Yes______ No_____ Don't know_________

Why or why not? ____

52. Do you discuss with others water issues in your community?

Yes______ No_______ Don't know__________

Why or why not____

53. Has the community tried to get people together to address water problems?

Yes_____ No_______ Don't know___________

If yes, how? ____

54. Have you attended any community meeting concerning water?

Yes____ No_______ Don't know_________

55. Did you speak in the meetings?

Yes_______ No______

If no, why ____

56. Do women participate in water decision-making at the community level?

Yes_____ No_______ Don't know______

If no, why ____

57. In your opinion, should women participate in water decision-making at the household and community levels?

Yes______ No_____ Don't know________

[if yes or no] Why do you think this?

____

58. Do disabled persons contribute to decision-making regarding water resources?

Yes__________ No __________ Don't know ________

If no, why?____

59. In your opinion, should disabled persons participate in decision-making regarding water resources?

Yes _________ No ____________ Don't know ___________

[if yes or no] Why do you think this?

____

60. In your opinion, is the government doing well in providing sufficient water for your community?

Yes______ No_______ Don't know_________

If no, explain ____

61. What do you suggest government should do to help promote water access and water security in your community?

____

62. In your opinion, are local communities assisting in providing water for your community?

Yes_____ No_____ Don't know_____

If no, explain ____

63. What do you suggest local communities should do to help promote access to water?

____

Appendix III – Focus group discussion script

Introduction

Hello. I am ______________________

Thank you for agreeing to take part in this discussion. I want us to talk about some issues about you and your community. You are not forced to say anything if you don't want to. If at any point in the discussion, you don't understand anything, please let me know. Also, if you don't want to hear what others are saying or the things you are saying are disturbing you, please let me know. You can also withdraw from the study anytime without consequences. Moreover, whatever you say here will not be given to anyone, and it will be only be used for this research.

Community Information

In this part of the study, I would like us to talk about your community. I would like to ask you to get information about your community. Please feel free to talk about your community. We are trying to understand how you feel and think about your community.

(Questions for both men and women)

1. What are the major challenges facing your community right now?
2. Are they different from the challenges you have faced in the past? How?
3. How does the community cope with these challenges?

Water Access, Health and Livelihoods

Now I would like to ask some questions about water collection and access among women in this community. These questions will enable us to learn from you about women's experiences of poor water access and water collection from distant sources. Again, I will encourage you to feel in control of your answers. If you do not feel like answering a particular question, you can let me know, so we skip it. However, I encourage you to answer as much as possible because all your answers are crucial for the research.

Questions for women's groups

1. Where do women fetch household drinking water from in this community? Why these sources? How much time and what methods do women use in collecting water and with what frequency? Who can decide on the use and management of water resources? What are all the things you do in a day that require water? Which uses are given the highest priority? How much water do you need to use for a day?

2. Are women able to fetch and bring sufficient quantity and quality of water home for their domestic activities? If not, what do you do to try to fix this? How do women respond to

water shortages? What are the different choices women make in their response to water shortages?

3. Can you tell me about women's experiences of water shortages and collecting water from distant sources? Is it easy for women to access water? If not, what makes it difficult for women to access water? How and how often do water shortages and collecting of water from outside the home affect women? What are the risks of water shortages and collecting of water from remote sources among women? How can these problems be minimized?

4. How is the operation and maintenance of drinking water facilities arranged in this community? Who is responsible? Who decides on the use and maintenance of the facilities? Are the views of everyone, including women and old and disabled persons, taken into account in the provision of water points? If no, why? What would you do if you were in charge of water management in this community?

5. What is the role of government and local communities in the provision of water in this community? Is this adequate in providing water? If no, why? What would you suggest the government and local communities do to promote water access and water security in this community?

Questions for men's groups

1. Where do women in this community get water from? Why these sources? Who can decide on the use and management of water resources? What do women use water for in your households? Which uses are given the highest priority?
2. What do you think about women collecting water in this community? Would men fetch water and under what conditions? Is it easy for women to access water? If not, what makes it difficult for women to access water? How do water shortages and collecting of water from remote sources affect women in this community? What are the risks of water shortages and collecting of water from remote sources among women? How can these problems be minimized?
3. How is the operation and maintenance of the drinking water facilities arranged in this community? Who is responsible? Who decides on the use and maintenance of the

facilities? Are the views of everyone, including women and old and disabled persons, taken into account in the provision of water points? If no, why? What do you think should be done to increase the participation of everyone in water management?

4. What is the role of government and local communities in the provision of water in this community? Is this adequate in providing water? If no, why? What would you suggest the government and local communities do to promote water access and water security in this community?

Appendix IV: Supplementary File 1

Data source: Climate Data.org.https://en.climate-data.org/africa/ghana-121/

Variables of interest

Average Total Annual Rainfall (MM)
Average Monthly Maximum Rainfall (MM)
Average Monthly Minimum Rainfall (MM)
Average Rainfall Range (Max. Rainfall - Min. Rainfall) (MM)
Average Maximum Rainy Days in a month (days)
Average Minimum Rainy Days in a month (days)
Average Rainy Days Range (Max. Rainy Days - Min. Rainy Days)

Note: TAR—Total Annual Rainfall; Av.MMx.R.—Average Monthly Maximum Rainfall; Av. MMn. R--Average Monthly Minimum Rainfall; Av. RR—Average Rainfall Range
TARD—Total Annual Rainy Days; MMax. RD—Monthly Maximum Rainy Days; MMin. RD—Monthly Minimum Rainy Days; Av. RDR--- Average Rainy Days Range

Ashanti Region																
	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R**	**Av.MMn. R**	**Av. RR**
Kumasi	24	47	100	109	125	140	119	106	153	131	67	26	1147	153	24	129
Obuasi	28	50	102	111	151	167	134	106	150	160	76	32	1267	167	28	139
Pirabong	24	47	100	109	125	140	119	106	153	131	67	26	1147	153	24	129
Bekwai	27	50	105	113	139	158	131	107	152	144	69	30	1225	158	27	131
Betinko	23	48	98	110	127	144	116	106	146	127	66	24	1135	146	23	123
Average	**25.2**	**48.4**	**101.0**	**110.4**	**133.4**	**149.8**	**123.8**	**106.2**	**150.8**	**138.6**	**69.0**	**27.6**	**1184.2**	**155.4**	**25.2**	**130.2**
	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**Av.RDR**
Kumasi	3	6	12	13	15	17	16	16	19	17	10	4	148	19	3	16
Obuasi	5	7	13	14	17	19	18	17	19	19	12	6	166	19	5	14
Pirabong	3	6	12	12	15	17	16	16	19	17	10	4	147	19	3	16

Bekwai	4	7	13	14	16	18	17	16	19	18	11	5	158	19	4	15
Betinko	3	6	11	13	16	18	17	17	19	18	10	4	152	19	3	16
Average	3.6	6.4	12.2	13.2	15.8	17.8	16.8	16.4	19	17.8	10.6	4.6	154.2	19.0	3.6	15.4

Greater Accra Region

	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R**	**Av.MMn. R**	**Av. RR**
Kokrobite	17	19	31	54	129	183	75	39	50	65	54	32	748	183	17	166
Bortianor	17	19	31	54	129	183	75	39	50	65	54	32	748	183	17	166
Oblogo	17	19	31	54	129	183	75	39	50	65	54	32	748	183	17	166
Medie	31	41	60	71	116	160	95	68	111	110	62	38	963	160	31	129
Berekuso	31	41	60	71	116	160	95	68	111	110	62	38	963	160	31	129
Accra	17	19	31	54	129	183	75	39	50	65	54	32	748	183	17	166
Tema	19	23	37	52	100	146	69	43	65	70	41	26	691	146	19	127
Kpone	19	23	37	52	100	146	69	43	65	70	41	26	691	146	19	127
Average	**21.0**	**25.5**	**39.75**	**57.75**	**118.5**	**168**	**78.5**	**47.25**	**69.0**	**77.5**	**52.75**	**32.0**	**793.14**	**168.0**	**21.0**	**147.0**
	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**AV.RD R**
Kokrobite	3	4	6	9	16	17	10	6	8	12	13	7	111	17	3	14
Bortianor	3	4	6	9	16	17	10	6	8	12	13	7	111	17	3	14
Oblogo	3	4	6	9	16	17	10	6	8	12	13	7	111	17	3	14
Medie	6	7	10	11	16	17	15	14	16	16	13	8	149	17	6	11
Berekuso	6	7	10	11	16	17	15	14	16	16	13	8	149	17	6	11
Accra	3	4	6	9	16	17	10	6	8	12	13	7	111	17	3	14
Tema	4	4	6	9	14	16	10	8	10	11	9	5	106	16	4	12
Kpone	4	4	6	9	14	16	10	8	10	11	9	5	106	16	4	12
Average	**4.0**	**4.75**	**7.0**	**9.5**	**15.5**	**16.75**	**11.25**	**8.5**	**10.5**	**12.75**	**12.0**	**6.75**	**119.25**	**16.75**	**4.0**	**12.75**

Volta Region

	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R**	**Av.MMn. R**	**Av. RR**
Wli Afegame	31	53	104	132	195	224	227	235	273	218	98	39	1829	273	31	242
Hohoe	32	57	110	143	209	242	242	253	292	246	115	44	1985	292	32	260
Aflao	16	21	34	56	152	206	91	49	71	96	53	27	872	206	16	190
Gbledi Gbogame	31	53	104	132	195	224	227	235	273	218	98	39	1829	273	31	242
Ve Koloenu	31	53	104	132	195	224	227	235	273	218	98	39	1829	273	31	242
Average	**28.2**	**47.4**	**91.2**	**119**	**189.2**	**224**	**202.8**	**201.4**	**236.4**	**199.2**	**92.4**	**37.6**	**1668.8**	**263.4**	**28.2**	**235.2**

	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**AV.RDR**
Wli Afegame	4	7	14	16	19	20	20	21	21	20	13	6	181	21	4	17
Hohoe	4	6	13	17	20	20	21	21	21	20	13	6	182	21	4	17
Aflao	3	4	7	9	17	18	11	7	10	13	11	6	116	18	3	15
Gbledi Gbogame	4	7	14	16	19	20	20	21	21	20	13	6	181	21	4	17
Ve Koloenu	4	7	14	16	19	20	20	21	21	20	13	6	181	21	4	17
Average	**3.8**	**6.2**	**12.4**	**14.8**	**18.8**	**19.6**	**18.4**	**18.2**	**18.8**	**18.6**	**12.6**	**6.0**	**168.2**	**20.4**	**3.8**	**16.6**

Brong Ahafo Region

	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R**	**Av.MMn. R**	**Av. RR**
Sunyani	17	40	86	106	106	111	94	102	143	125	64	24	1018	143	17	126
Nkronza	16	35	86	109	108	106	100	115	166	123	51	18	1033	166	16	150
Kintampo	14	37	91	147	157	151	153	187	247	162	44	15	1405	247	14	233
Buni	15	37	86	113	114	109	105	126	164	125	56	17	1067	164	15	149
Mayara	15	37	86	113	114	109	105	126	164	125	56	17	1067	164	15	149
Average	**15.4**	**37.2**	**87**	**117.6**	**119.8**	**117.2**	**111.4**	**131.2**	**176.8**	**132**	**54.2**	**18.2**	**1118.0**	**176.8**	**15.4**	**161.4**

	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**AV.RDR**
Sunyani	3	5	10	12	14	15	15	14	18	17	9	3	135	18	3	15
Nkronza	2	4	10	13	13	14	14	14	18	16	7	3	128	18	2	16
Kintampo	2	4	9	14	16	16	17	17	20	17	6	2	140	20	2	18
Buni	2	4	10	13	14	14	15	16	18	17	8	3	134	18	2	16
Mayara	2	4	10	13	14	14	15	16	18	17	8	3	134	18	2	16
Average	**2.2**	**4.2**	**9.8**	**13**	**14.2**	**14.6**	**15.2**	**15.4**	**18.4**	**16.8**	**7.6**	**2.8**	**134.2**	**18.4**	**2.2**	**16.2**

Northern Region

	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R**	**Av.MMn. R**	**Av. RR**
Tamale	2	6	22	54	71	85	155	234	182	72	8	2	893	234	2	232
Kanvili	2	6	22	54	71	85	155	234	182	72	8	2	893	234	2	232
Palung	1	4	18	50	69	81	151	228	174	64	6	1	847	228	1	227
Banvim	2	7	25	61	80	94	156	220	190	84	11	2	932	220	2	218
Nakpali	4	13	37	72	95	111	190	253	242	157	28	5	1207	253	4	249
Average	**2.2**	**7.2**	**24.8**	**58.2**	**77.2**	**91.2**	**161.4**	**233.8**	**194**	**89.8**	**12.2**	**2.4**	**954.4**	**233.8**	**2.2**	**231.6**

	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**AV.RDR**
Tamale	0	1	3	7	9	10	16	19	17	8	1	0	91	19	0	19
Kanvili	0	1	3	7	9	10	16	19	17	8	1	0	91	19	0	19
Palung	0	1	3	6	9	10	15	18	16	8	1	0	87	18	0	18
Banvim	0	1	3	8	9	11	16	19	18	9	2	0	96	19	0	19
Nakpali	1	1	5	9	12	14	18	20	19	16	4	1	120	20	1	19
Average	**0.2**	**1.0**	**3.4**	**7.4**	**9.6**	**11**	**16.2**	**19**	**17.4**	**9.8**	**1.8**	**0.2**	**97.0**	**19.0**	**0.2**	**18.8**

Western Region

	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R**	**Av.MMn. R**	**Av. RR**
Busua	52	53	76	109	229	270	116	69	116	124	103	73	1390	270	52	218
Amaful	50	59	82	108	203	246	116	76	119	137	103	67	1366	246	50	196
Apowa	50	59	82	108	203	246	116	76	119	137	103	67	1366	246	50	196
Sekondi-Takoradi	50	59	82	108	203	246	116	76	119	137	103	67	1366	246	50	196
Aboesi	50	59	82	108	203	246	116	76	119	137	103	67	1366	246	50	196
Axim	62	74	117	144	252	286	131	85	137	135	110	80	1613	286	62	224
Beyin	61	72	104	129	225	290	147	84	129	137	120	84	1582	290	61	229
Tarkwa	103	133	200	209	278	295	187	136	234	272	198	118	2363	295	103	192
Half Assini	60	68	97	127	229	284	140	79	110	129	111	79	1513	284	60	224
Tikobo Number One	60	68	99	129	231	296	148	81	118	130	113	81	1554	296	60	236
Average	**59.8**	**70.4**	**102.1**	**127.9**	**225.6**	**270.5**	**133.3**	**83.8**	**132.0**	**147.5**	**116.7**	**78.3**	**1547.9**	**270.5**	**59.8**	**210.7**

	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**AV.RDR**
Busua	11	10	13	16	20	19	17	15	17	20	18	15	191	20	11	9
Amaful	10	11	15	17	21	20	17	17	19	20	18	14	199	21	10	11
Apowa	10	11	15	17	21	20	17	17	19	20	18	14	199	21	10	11
Sekondi-Takoradi	10	11	15	17	21	20	17	17	19	20	18	14	199	21	10	11
Aboesi	10	11	15	17	21	20	17	17	19	20	18	14	199	21	10	11
Axim	13	14	18	19	21	20	17	17	19	21	19	17	215	21	13	8
Beyin	13	14	18	19	21	20	18	16	19	21	20	17	216	21	13	8
Tarkwa	13	15	19	19	21	21	19	20	20	21	20	16	224	21	13	8
Half Assini	12	13	17	18	21	20	17	15	18	20	19	16	206	21	12	9
Tikobo Number One	13	13	17	18	21	20	17	16	18	21	19	16	209	21	13	8
Average	**11.5**	**12.3**	**16.2**	**17.7**	**20.9**	**20.0**	**17.3**	**16.7**	**18.7**	**20.4**	**18.7**	**15.3**	**205.7**	**20.9**	**11.5**	**9.4**

Central Region

	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R**	**Av.MMn. R**	**Av. RR**
Senya Bereku	26	32	48	66	128	185	93	60	93	97	59	35	922	185	26	159
Gomoa Fetteh	26	32	48	66	128	185	93	60	93	97	59	35	922	185	26	159
Agona Swedru	44	53	79	102	166	212	116	84	140	152	92	56	1296	212	44	168
Kasoa	26	32	48	66	128	185	93	60	93	97	59	35	922	185	26	159
Ampenyi	37	47	68	98	187	229	94	56	91	111	86	54	1158	229	37	192
Average	**31.8**	**39.2**	**58.2**	**79.6**	**147.4**	**199.2**	**97.8**	**64.0**	**102.0**	**110.8**	**71.0**	**43.0**	**1044.0**	**199.2**	**31.8**	**167.4**

	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**AV.RDR**
Senya Bereku	6	7	9	12	18	18	16	14	16	16	13	8	153	18	6	12
Gomoa Fetteh	6	7	9	12	18	18	16	14	16	16	13	8	153	18	6	12
Agona Swedru	9	10	14	15	19	19	18	17	19	19	17	12	188	19	9	10
Kasoa	6	7	9	12	18	18	16	14	16	16	13	8	153	18	6	12
Ampenyi	8	10	14	16	20	19	15	11	15	19	17	12	176	20	8	12
Average	**7.0**	**8.2**	**11.0**	**13.4**	**18.6**	**18.4**	**16.2**	**14.0**	**16.4**	**17.2**	**14.6**	**9.6**	**164.6**	**18.6**	**7.0**	**11.6**

Upper East Region

	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R**	**Av.MMn. R**	**Av. RR**
Bawku	0	1	6	27	53	62	128	201	136	41	2	0	657	201	0	201
Village	0	1	9	35	66	78	147	226	155	53	3	0	773	226	0	226
Pusiga	0	1	6	27	53	62	128	201	136	41	2	0	657	201	0	201
Sugudi	0	1	6	27	53	62	128	201	136	41	2	0	657	201	0	201
Sirigu	0	1	6	33	56	72	147	230	141	47	3	0	736	230	0	230
Average	**0.0**	**1.0**	**6.6**	**29.8**	**56.2**	**67.2**	**135.6**	**211.8**	**140.8**	**44.6**	**2.4**	**0.0**	**696.0**	**211.8**	**0.0**	**211.8**

	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**AV.RDR**
Bawku	0	0	1	4	7	8	14	17	13	6	0	0	70	17	0	17
Village	0	0	1	4	8	9	15	19	14	7	1	0	78	19	0	19
Pusiga	0	0	1	4	7	8	14	17	13	6	0	0	70	17	0	17
Sugudi	0	0	1	4	7	8	14	17	13	6	0	0	70	17	0	17
Sirigu	0	0	1	4	8	9	16	19	14	6	1	0	78	19	0	19
Average	**0.0**	**0.0**	**1.0**	**4.0**	**7.4**	**8.4**	**14.6**	**17.8**	**13.4**	**6.2**	**0.4**	**0.0**	**73.2**	**17.8**	**0.0**	**17.8**

Eastern Region																
	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R.**	**AvM.Mn. R**	**Av. RR**
Nsumia	31	41	60	71	116	160	95	68	111	110	62	38	963	160	31	129
Senchi	21	36	74	96	153	189	140	127	191	162	68	25	1282	191	21	170
Kitase	31	41	60	71	116	160	95	68	111	110	62	38	963	160	31	129
Aburi	31	41	60	71	116	160	95	68	111	110	62	38	963	160	31	129
Ahwerasi	31	41	60	71	116	160	95	68	111	110	62	38	963	160	31	129
Kibi	37	62	116	134	175	206	155	134	218	188	83	39	1547	218	37	181
Asikam	37	62	116	134	175	206	155	134	218	188	83	39	1547	218	37	181
Average	**31.29**	**46.29**	**78**	**92.57**	**138.142**	**177.28**	**118.57**	**95.28**	**153**	**139.71**	**68.86**	**36.43**	**1175.43**	**181.0**	**31.29**	**149.71**
	Monthly Rainy Days Recordings															
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TARD**	**MMax. RD**	**MMin. RD**	**AV.RDR**
Nsumia	6	7	10	11	16	17	15	14	16	16	13	8	149	17	6	11
Senchi	3	6	11	13	17	18	17	16	19	18	10	4	152	19	3	16
Kitase	6	7	10	11	16	17	15	14	16	16	13	8	149	17	6	11
Aburi	6	7	10	11	16	17	15	14	16	16	13	8	149	17	6	11
Ahwerasi	6	7	10	11	16	17	15	14	16	16	13	8	149	17	6	11
Kibi	6	8	14	16	19	19	18	18	20	20	13	7	178	20	6	14
Asikam	6	8	14	16	19	19	18	18	20	20	13	7	178	20	6	14
Average	**5.57**	**7.14**	**11.29**	**12.71**	**17.0**	**17.71**	**16.1**	**15.4**	**17.57**	**17.43**	**12.57**	**7.14**	**157.71**	**18.14**	**5.57**	**12.57**
Upper West Region																
	Average Monthly Rainfall Recordings															
Area	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**TAR**	**Av.MMx.R.R**	**Av.MMn. R**	**Av. RR**
Bamahu	1	6	26	73	104	108	165	232	195	89	12	0	1011	232	1	231
Gberi	0	4	16	55	77	85	153	227	154	65	5	1	842	227	0	227
Dikpwie	0	3	13	47	70	80	148	225	144	58	5	0	793	225	0	225
Lawra	0	3	13	47	70	80	148	225	144	58	5	0	793	225	0	225
Olbini	0	3	13	47	70	80	148	225	144	58	5	0	793	225	0	225
Average	**0.2**	**3.8**	**16.2**	**53.8**	**78.2**	**86.6**	**152.4**	**226.8**	**156.2**	**65.6**	**6.4**	**0.2**	**846.4**	**226.8**	**0.2**	**226.6**
	Monthly Rainy Days Recordings															

	J	F	M	A	M	J	J	A	S	O	N	D	TARD	MMax. RD	MMin. RD	AV.RD R
Bamahu	0	1	3	8	11	12	16	19	18	11	2	0	101	19	0	19
Gberi	0	1	2	7	9	11	16	18	16	9	1	0	90	18	0	18
Dikpwie	0	1	2	6	10	11	15	18	15	8	1	0	87	18	0	18
Lawra	0	1	2	6	10	11	15	18	15	8	1	0	87	18	0	18
Olbini	0	1	2	6	10	11	15	18	15	8	1	0	87	18	0	18
Average	**0.0**	**1.0**	**2.2**	**6.6**	**10**	**11.2**	**15.4**	**18.2**	**15.8**	**8.8**	**1.2**	**0.0**	**90.4**	**18.2**	**0.0**	**18.2**

Appendix V: Supplementary File 2

	Income Status		Educational Status		Occupation			Household Size			Location of Residence		Access to Media	
	Poor	Rich	Uneducated	Educated	Not Working	Formal Work	Informal Work	1-3 Members	4-6 Members	7+ Members	Urban	Rural	No	Yes
Sex of Household Head	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Female	2647 (40)	3973 (60)	1491 (31.7)	3218 (68.3)	658 (9.9)	3298 (49.9)	2658 (40.2)	2572 (38.9)	3268 (49.4)	780 (11.8)	3337 (50.4)	3283 (49.6)	2311 (35.7)	4163 (64.3)
Male	10145 (61.5)	6353 (38.5)	3222 (37.4)	5383 (62.6)	1747 (10.6)	5917 (35.9)	8803 (53.5)	1484 (9.0)	8097 (49.1)	6917 (41.9)	5835 (35.4)	10663 (64.6)	3376 (20.6)	12973 (79.4)
Ethnicity														
Akan	3318 (36.9)	5668 (63.1)	2160 (29.5)	5172 (70.5)	836 (9.3)	4571 (50.9)	3571 (39.8)	2164 (24.1)	4782 (53.2)	2040 (22.7)	4120 (45.8)	4866 (54.2)	1720 (19.5)	7093 (80.5)
Ga/Dangme	363 (31.8)	780 (68.2)	312 (34.4)	594 (65.6)	152 (13.3)	615 (53.8)	376 (32.9)	248 (21.7)	711 (62.2)	184 (16.1)	639 (55.9)	504 (44.1)	223 (19.8)	906 (80.2)
Ewe	1216 (48.9)	1272 (51.1)	690 (36.3)	1210 (63.7)	321 (12.9)	1063 (42.8)	1100 (44.3)	492 (19.8)	1320 (53.1)	676 (27.2)	967 (38.9)	1521 (61.1)	577 (23.3)	1903 (76.7)
Guan	320 (49.9)	321 (50.1)	128 (30.5)	292 (69.5)	42 (7.1)	224 (35.3)	366 (57.6)	148 (23.1)	307 (47.9)	186 (29.0)	247 (38.5)	394 (61.5)	144 (22.6)	492 (77.4)
Mole-Dagbani	4546 (74.4)	1563 (25.6)	910 (51.9)	843 (48.1)	695 (11.4)	1902 (31.2)	3502 (57.4)	697 (11.4)	2841 (46.5)	2571 (42.1)	2186 (35.8)	3923 (64.2)	1615 (26.7)	4425 (73.3)
Grusi	757 (75.2)	250 (24.8)	181 (44.4)	227 (55.6)	69 (6.9)	340 (33.9)	593 (59.2)	126 (12.5)	487 (48.4)	2571 (42.1)	354 (35.2)	653 (64.8)	264 (26.5)	733 (73.5)
Gurma	1927 (92.8)	150 (7.2)	205 (60.7)	133 (39.3)	151 (7.3)	217 (10.5)	1705 (82.2)	102 (4.9)	591 (28.5)	1384 (66.6)	283 (13.6)	1794 (86.4)	1003 (48.3)	1073 (51.7)
Mande	187 (67.3)	91 (32.7)	65 (71.4)	26 (28.6)	37 (13.3)	100 (36)	141 (50.7)	28 (10.1)	120 (43.2)	130 (46.8)	135 (48.6)	143 (51.4)	65 (23.6)	211 (76.4)
Other	158 (40.7)	230 (59.3)	62 (37.6)	103 (62.4)	99 (25.5)	182 (46.9)	107 (27.6)	50 (12.9)	206 (53.1)	132 (34.0)	240 (61.9)	148 (38.1)	76 (20.3)	299 (79.7)
Occupation														
Unemployed	1137 (47.3)	1268 (52.7)	478 (31.8)	1023 (68.2)				484 (20.1)	1178 (49.0)	743 (30.9)			558 (23.9)	1775 (76.1)
Formal Work	2771 (30.1)	6444 (69.9)	1932 (28.4)	4874 (71.6)				2130 (23.1)	4859 (52.7)	2226 (24.2)			1463 (16.1)	7629 (83.9)
Informal Work	8878 (77.5)	2583 (22.5)	2292 (46.1)	2684 (53.9)				1440 (12.6)	5299 (46.2)	4722 (41.2)			3661 (32.2)	7700 (67.8)

Household Size														
1-3 Members	1388 (34.2)	2668 (65.8)	839 (27.8)	2176 (72.2)	484 (11.9)	2130 (52.5)	1440 (35.5)						1025 (25.6)	2973 (74.4)
4-6 Members	5610 (49.4)	5755 (50.6)	2455 (33.8)	4804 (66.2)	1178 (10.4)	4859 (42.9)	5299 (46.7)						2614 (23.3)	8622 (76.7)
7+ Members	5794 (75.3)	1903 (24.7)	1419 (46.7)	1621 (53.3)	743 (9.7)	2226 (28.9)	4722 (61.4)						2048 (27.0)	5541 (73.0)
Marital Status														
Never Married/Single	9683 (58.1)	6994 (41.9)	3193 (36.7)	5515 (63.3)	1602 (9.6)	6453 (38.8)	8593 (51.6)	2159 (12.9)	8253 (49.5)	6265 (37.6)	6475 (38.8)	10202 (61.2)	3619 (21.9)	12874 (78.1)
Married	2497 (53.3)	2192 (46.7)	1093 (34.8)	2047 (65.2)	502 (10.7)	1794 (38.3)	2385 (51)	1177 (25.1)	2375 (50.7)	1137 (24.2)	1750 (37.3)	2939 (62.7)	1469 (31.8)	3152 (68.2)
Ever Married	333 (32.5)	691 (67.5)	282 (34.4)	538 (65.6)	115 (11.2)	617 (60.3)	292 (28.5)	451 (44)	443 (43.3)	130 (12.7)	564 (55.1)	460 (44.9)	397 (39.7)	602 (60.3)
Location of Residence														
Urban	1819 (19.8)	7353 (80.2)	1713 (26.0)	4864 (74.0)	1139 (12.5)	5642 (61.7)	2362 (25.8)	2088 (22.8)	4978 (54.3)	2106 (23.0)			1494 (16.5)	7577 (83.5)
Rural	10973 (78.7)	2973 (21.3)	3000 (44.5)	3737 (55.5)	1266 (9.1)	3573 (25.6)	9099 (65.3)	1968 (14.1)	6387 (45.8)	5591 (40.1)			4193 (30.5)	9559 (69.5)
Ecological Zone														
Evergreen Zone	836 (36.4)	1459 (63.6)	621 (36.7)	1071 (63.3)	226 (9.9)	1075 (46.9)	990 (43.2)	589 (25.7)	1168 (50.9)	538 (23.4)	768 (33.5)	1527 (66.5)	428 (19.1)	1818 (80.9)
Savannah Zone	6332 (83.6)	1239 (16.4)	972 (50.7)	946 (49.3)	809 (10.7)	1894 (25.1)	4856 (64.2)	718 (9.5)	3201 (42.3)	3652 (48.2)	2142 (28.3)	5429 (71.7)	2530 (33.7)	4976 (66.3)
Deciduous Forest Zone	1810 (38.3)	2912 (61.7)	1200 (31.9)	2566 (68.1)	483 (10.2)	2452 (52.0)	1779 (37.7)	1019 (21.6)	2477 (52.5)	1226 (26.0)	2313 (49.0)	2409 (51.0)	861 (18.5)	3788 (81.5)
Coastal Savannah Zone	1124 (27.4)	2978 (72.6)	871 (27.8)	2263 (72.2)	458 (11.2)	2358 (57.6)	1275 (31.2)	876 (21.4)	2309 (56.3)	917 (22.4)	2372 (57.8)	1730 (42.2)	680 (16.8)	3357 (83.2)
Transitional Zone	2690 (60.7)	1738 (39.3)	1049 (37.4)	1755 (62.6)	429 (9.7)	1436 (32.4)	2561 (57.9)	854 (19.3)	2210 (49.9)	1364 (30.8)	1577 (35.6)	2851 (64.4)	1188 (27.1)	3197 (72.9)
Educational Status														
Uneducated	2726 (57.8)	1987 (42.2)			478 (10.2)	1932 (41.1)	2292 (48.7)						1327 (28.5)	3326 (71.5)
Educated	2350 (27.3)	6251 (72.7)			1023 (11.9)	4874 (56.8)	2684 (31.3)						1108 (13.1)	7346 (86.9)

Data Source: 2014 Ghana Demographic and Health Survey